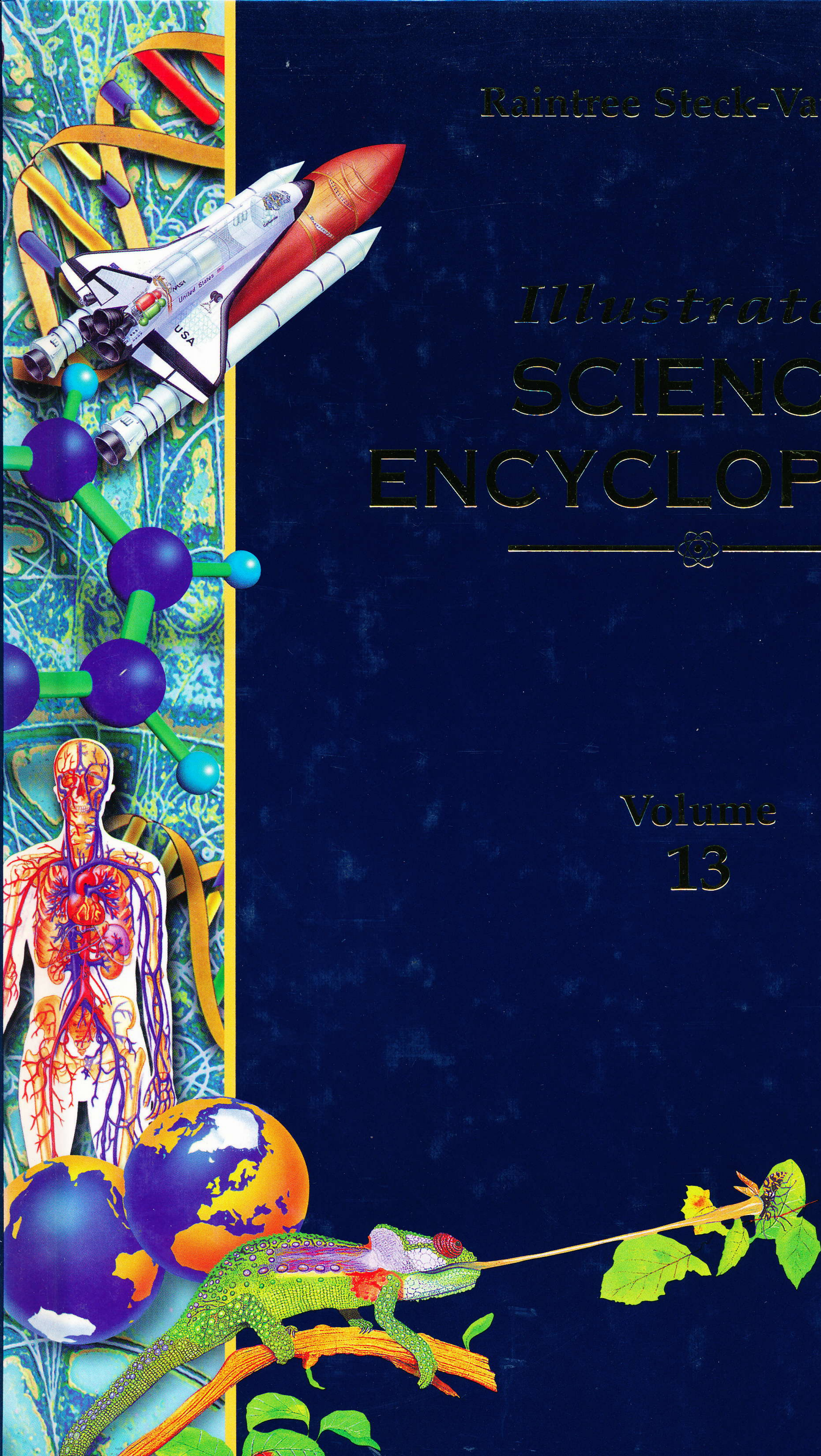
Raintree Steck-Vaughn

Illustrated SCIENCE ENCYCLOPEDIA

Volume 13



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MAR – MON

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MARSUPIAL

A marsupial (mär so͞o′ pē əl) is any of 250 species of pouch-bearing mammals belonging to the order Marsupialia (see MAMMAL). Marsupials differ from the more numerous placental mammals in that the unborn young are not nourished by a placenta and, when born, are extremely underdeveloped (see PLACENTA).

Newborn marsupials are very tiny and are not developed enough to survive outside the mother's marsupium, or pouch. After birth, the young marsupial crawls from the birth canal, through the mother's fur, to the pouch on the mother's belly. Once inside the pouch, the newborn baby attaches to a teat, or nipple, from the mammary (milk-producing) glands. The baby stays there, clinging to the nipple with its mouth until it is big enough and strong enough to leave the pouch. If there are more offspring than there are nipples, the extra offspring will die.

Young marsupials are not able to suck milk from

LIFE IN A POUCH

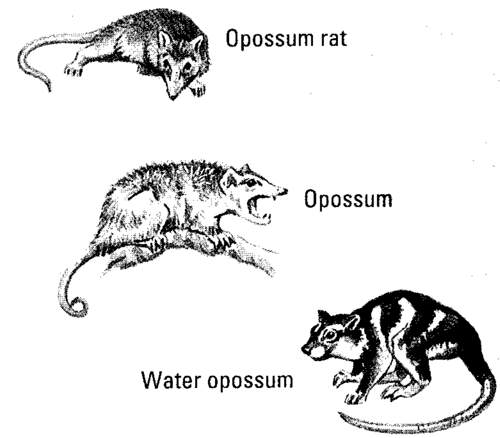
Like most young marsupials, this baby red-necked wallaby stays in its mother's pouch until it is big enough to take care of itself.

the nipples. Instead, milk squirts out of the nipples at regular intervals. The milk flows into the marsupial's mouth as long as it remains firmly attached to the nipple. When the young marsupial is developed enough to survive on its own, it leaves the pouch.

Most marsupials live in Australia and New Guinea, or on the islands in the immediate region. Several species of marsupials live in Mexico and in Central and South America. The only marsupial native to the United States is the common opossum (see OPOSSUM).

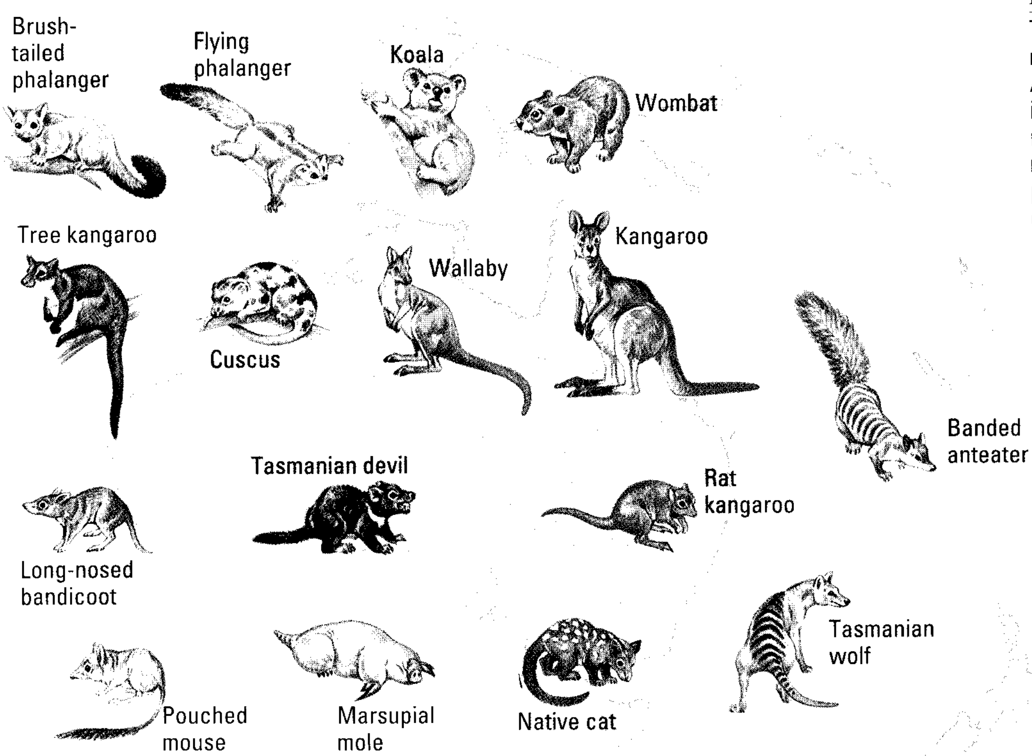
During the Mesozoic era, 245 to 65 million years ago, marsupials were numerous and lived on all the continents. However, during the course of evolution, they were largely replaced by placental mammals (see EVOLUTION; MESOZOIC ERA). It is probably because of the isolation of Australia and South America that marsupials were not forced into extinction by the more advanced mammals (see EXTINCTION). Some of the best-known marsupials are the bandicoot, kangaroo, wombat, koala, Tasmanian devil, and wallaby.

Since 1900, the number of marsupial species has decreased greatly. Some species that were once numerous are now extinct. This has been mostly due to human beings who introduced new predators, such as dogs, cats, and foxes, into areas where the marsupials previously had no predators. In addition, many farmers hunt or trap marsupials (especially kangaroos) because they consider these animals to be pests.



AMERICAN MARSUPIALS

Some marsupial species live in Mexico and Central America. Most of them are known as opossums.



AUSTRALIAN MARSUPIALS

The greatest number of marsupial species live in Australia and nearby islands. Some marsupials resemble squirrels, rats, moles, wolves, and other placental mammals in different parts of the world.

MARTEN

The stone marten (top) is heavier and grayer than the pine marten (bottom). The stone marten hunts mainly on the ground, whereas the pine marten hunts and catches its prey in the trees.

MARTEN The marten is a slender, fur-covered mammal belonging to the weasel family, Mustelidae (see WEASEL). Martens live in the forest regions of North America, Europe, and Asia, and they are very agile climbers. Martens are most often solitary.

The pine marten, sometimes called the American sable, is probably the best known of the American martens. It is about 2 ft. [61 cm] in length, including the tail. The pine marten feeds on mice, squirrels, and birds. This species has soft, grayish brown fur. From November to March, the pine marten's coat is very thick. During this season, marten trappers in Canada and the United States kill thousands of these animals. The fur is sold for use in coats, muffs, and hats.

The closely related stone marten is a slightly heavier animal.
See also SABLE.

MARTIN Martin is the name for several species of small birds belonging to the swallow family (see SWALLOW). The purple martin is widely known in North America, but it migrates to Central and South America for the winter. The European house martin migrates to Africa.

Purple martins often live in birdhouses that people have made for them. The birds often return to the same birdhouse year after year. Some martins, however, build their nests in trees far away from people. The female purple martin lays from three to eight eggs. Purple martins help people by eating insects that humans consider pests. In New England, house sparrows and starlings have driven most of the purple martins from their homes.
See also SPARROW; STARLING.

MARTIN

These house martins have hitched a ride on a ship during their long migration from Europe to southern Africa.

MASER (mā′ zər) The word *maser* is short for "*M*icrowave *A*mplification by *S*timulated *E*mission of *R*adiation." Microwaves are a form of electromagnetic radiation (see ELECTROMAGNETIC RADIATION; MICROWAVE). A maser is an instrument that produces or amplifies (strengthens) microwaves.

The frequency of a wave is the number of times that it vibrates in a second (see FREQUENCY). A maser produces microwaves with just one frequency rather than a range of frequencies. For this reason, the maser is used as a very accurate timing device. It can be accurate to one second in 100,000 years. Masers are also used in astronomy. They are used to amplify radio waves coming from stars and planets.

The maser was invented in 1953 by the American scientist Charles H. Townes. Seven years later, a

similar instrument called a laser was invented. The laser produces light of a single wavelength, rather than microwaves of the same frequency.
See also LASER.

MASS Mass is the amount of matter in a body. Mass is very similar to weight (see WEIGHT). There is, however, an important difference between weight and mass. Weight is caused by the force of gravity acting on a body (see GRAVITY). If the gravity changes, the weight changes. Mass, on the other hand, does not depend on gravity. It remains constant even if the force of gravity acting on it changes. For example, on the moon the mass of a body is the same as its mass on the earth. However, its weight is not the same. Gravity on the moon is six times weaker than it is on the earth. Therefore, the weight of the body on the moon is one-sixth its weight on Earth. The customary system of measurement uses ounces, pounds, and tons for both weight and mass. However, in the metric system, mass is usually measured in grams, kilograms, and metric tons, while weight is measured in newtons. For weight measurements on Earth, sometimes the metric units of mass are used for convenience (see METRIC SYSTEM).

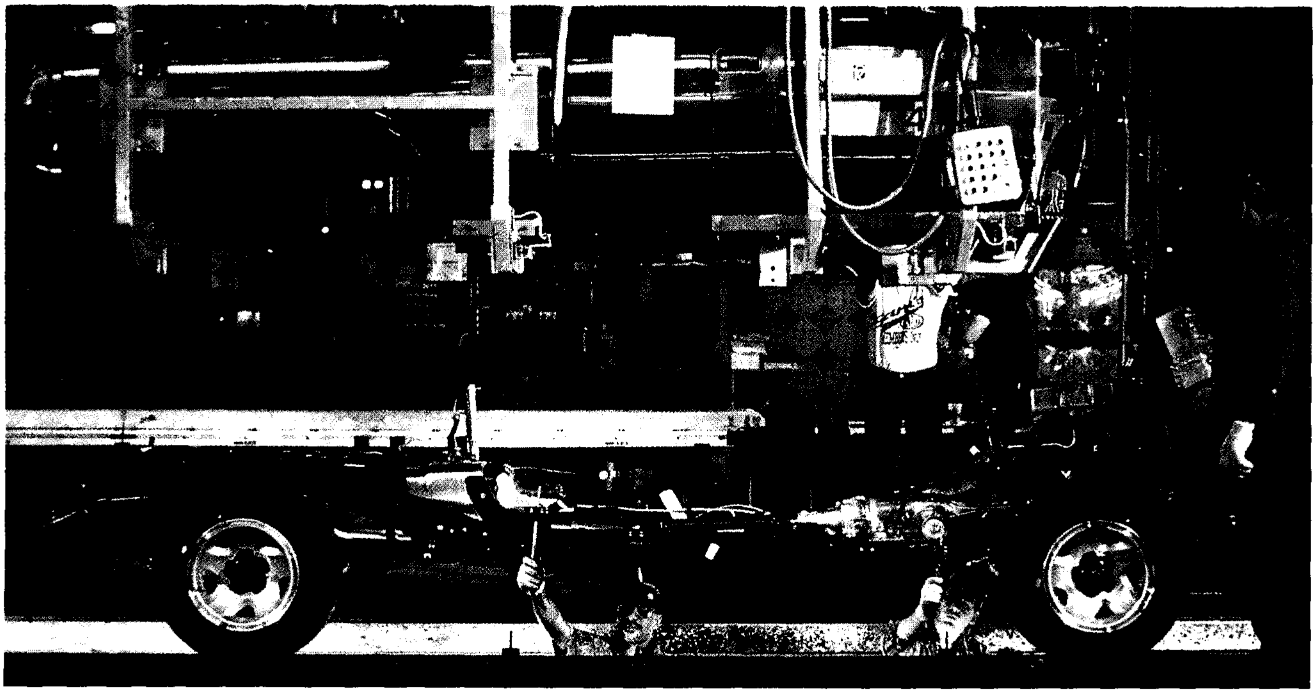
Physicists once thought that the mass of a body could never change. It is now known that this is not quite true. The theory of relativity states that the mass of a body increases with its velocity (speed in one direction) (see RELATIVITY). For low speeds, the increase is very small. However, for speeds close to the speed of light, the increase is significant.

The theory of relativity shows that mass is a form of energy. In special cases, mass can be turned into energy. A small mass can produce a huge amount of energy. This happens in nuclear power plants, in the sun, and in other stars. This energy is called thermonuclear energy. PROJECT 32

MASS PRODUCTION Mass production is the manufacturing of the same or similar articles quickly and continuously. Mass production makes it possible to manufacture more items faster. This lowers the selling price for the item. Mass production also means that when a part on a mass-produced item breaks down, a replacement part that fits perfectly can be obtained.

Mass-produced articles are made in factories that use assembly line methods. Workers are stationed at many points along a moving conveyor system (see CONVEYOR). As the product to be put together

MASS PRODUCTION
These workers are on an assembly line in a factory that makes trucks.



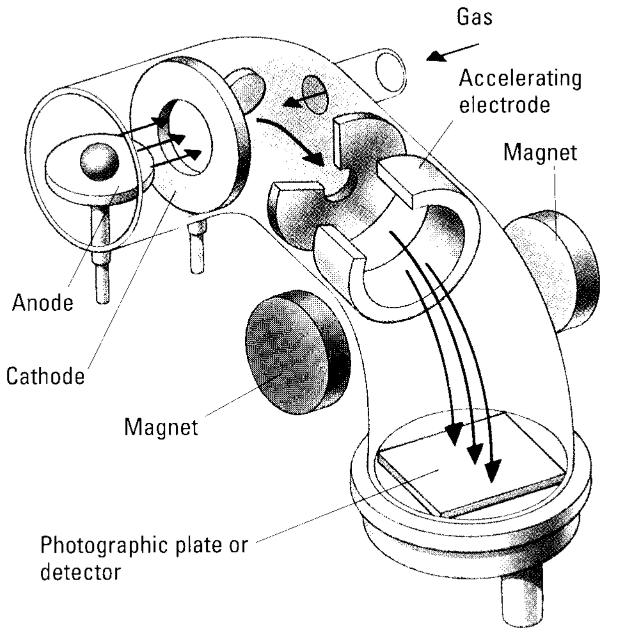
moves along the line, each worker or group of workers performs a single operation or installs a part. By the time the product reaches the end of the assembly line, it may have been worked on by one hundred or more workers. Many assembly lines are partly or completely automated. Robots or other machines automatically perform some or all of the tasks (see AUTOMATION; ROBOTICS).

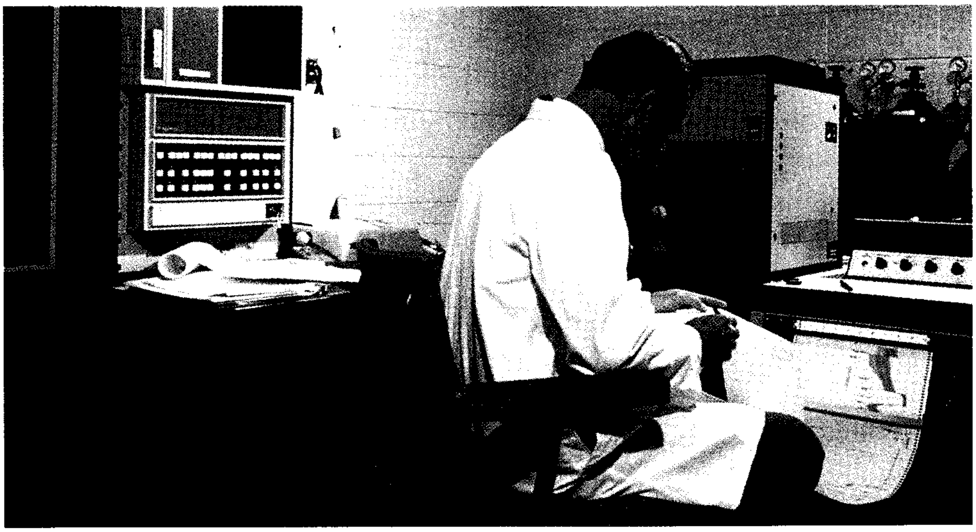
Henry Ford, founder of the Ford Motor Company, is generally credited with using the first large-scale, mass-production assembly line in the early 1900s (see FORD, HENRY). However, mass-production assembly lines actually began much earlier. Eli Whitney, the inventor of the cotton gin, built special machine tools to mass-produce guns called muskets for the United States government in 1798 (see WHITNEY, ELI). Until then, muskets had been built by hand, one at a time. Once Whitney had his machines set up, he could produce ten thousand muskets during the time it took a regular gunsmith to produce one.
See also AUTOMOBILE.

MASS SPECTROMETER (măs spĕk trŏm′ ĭ tər) A mass spectrometer is an instrument that is used to analyze substances. It finds out what different kinds of atoms and molecules are in a substance. It also finds out how much of each kind of atom and molecule the substance contains (see ATOM; ISOTOPE; MOLECULE).

The first step in the analysis is to change the substance into a gas if it is not already. Then the atoms and molecules in the substance are ionized (see IONS AND IONIZATION). This means that electrons are added or removed from the atoms and molecules, and the atoms and molecules become charged. Ionizing is done by bombarding the gas with a beam of electrons. Such bombardment subtracts electrons from or adds electrons to the atoms and molecules. In that way, the atoms and molecules become ions.

The ions are then accelerated. This is done by passing them through an electric field. Then the ions pass through a magnetic field (see FIELD). Since the ions are charged, they are deflected by the magnetic field. If the charge is positive, they are deflected one way. If it is negative, they are





MASS SPECTROMETER
A mass spectrometer (above) analyzes a substance by separating its ions, which have different masses. The results are plotted on a graph (left), known as a mass spectrogram.

deflected in the opposite direction. The amount of deflection depends on the masses of the ions. The heavier the mass, the less the deflection (see MASS). This spreads the ions out. Only those ions with the same mass and charge stay together. The ions then hit a photographic plate or detector. The electrical output from the detector passes to a chart recorder. The recorder draws a graph with a series of peaks. Each peak corresponds to a different kind of ion.
See also CHEMICAL ANALYSIS.

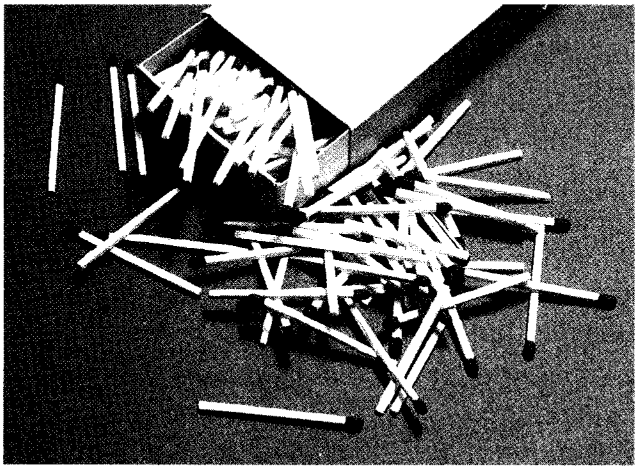
MASTODON (măs′tə dŏn′) The mastodon is an extinct, elephantlike animal belonging to the family Mammutidae. More than a thousand species of mastodons existed during the 2 million years that the mastodons roamed the earth. Among these species were the American mastodon (*Mammut americanum*) and the European mastodon (*Mammut angustidens*).

Mastodons first appeared during the early Miocene epoch, about 20 million years ago (see MIOCENE EPOCH). They ranged throughout the northern continents. Scientists believe that mastodons existed in North America until the end of the Pleistocene epoch, 15,000 to 10,000 years ago. They may have even been hunted by early Native Americans.

Mastodons had curved tusks and elephantlike trunks. Their teeth were about 3 in. [8 cm] wide and 6 in. [15 cm] long. Mastodons were shorter and had smaller ears than the modern elephant. Mastodons were covered with long hair that may have been black or reddish-brown.

Mastodons fed on leaves and other plant foods. They were related to the larger mammoth (see MAMMOTH). The reason for the extinction of the mastodons is still unknown.
See also EXTINCTION.

MATCH A match is a narrow piece of wood or cardboard with a tip made of a chemical mixture that burns easily. Matches are used to produce fire. When the tip is rubbed against a rough or specially prepared surface, the chemicals burst into flame and ignite the match. There are two main types of matches: strike-anywhere matches and safety matches.



MATCH
Matches are strips of wood or cardboard that have a tip coated with a chemical that burns easily. The tip bursts into flame when it is struck against a certain type of surface.

Strike-anywhere matches light when rubbed against any rough surface. The match is basically a wood splint about 3 in. [8 cm] long and about 0.12 in. [0.3 cm] in diameter. It may have a tip of two colors, red and white or blue and white. The small white tip, called the eye, contains a firing substance made chiefly of sesquisulfide of phosphorus. The remainder of the tip, the red or blue part, does not ignite by being rubbed against a rough surface. It only burns when the flaming eye sets it afire. This carries the flame to the rest of the matchstick, which is coated with paraffin to make it burn faster. Wooden strike-anywhere matches are made by automatic machines that manufacture and package more than a million matches an hour.

Safety matches can only be lighted by striking them against a special surface. The surface is usually located on the box or folder in which the matches come. The tip of the safety match is made of a substance containing chlorate of potash. When the match tip rubs against the striking surface, which is made of red phosphorus and sand, the tip quickly ignites. The most common type of safety matches are book matches. They are made of paper and bound into a folding paper cover. The striking surface is on the outside. The user is supposed to close the cover before striking a match. This prevents the other matches in the pack from catching fire.

The first match was made in 1827 by John Walker, an English pharmacist. It was a splint of wood about 3 in. [8 cm] long and tipped with antimony sulfide, chlorate of potash, gum arabic, and starch. The match burst into flames with a series of small explosions that showered its user with sparks. The first safety matches were invented in 1844 by Gustave E. Pasch, a Swedish chemist. Book matches were introduced in 1892 by Joshua Pusey, a Philadelphia lawyer.

The United States ranks as the world's leading producer of matches. France, Russia, and Sweden also have large match industries.

MATERIAL Material is the matter from which a thing is made. The hull of a giant oil tanker is made from steel. Steel is a very strong material. Other materials, such as some plastics, are quite soft and easily torn.

Scientists study the strength of materials. When a new bridge is constructed, it is very important to know just how strong it is. To do this, metal samples are stretched in special machines until they break. This measures the force necessary to break the materials.

Most materials expand when they are heated. The metal that reinforces the concrete used to construct tall buildings expands significantly as the sun rises and sets. The building actually leans away from the sun.

New materials such as carbon fiber are used in aircraft manufacture to make the structure strong as well as light. Other materials, for example the plastic Kevlar, are as strong as steel and can be woven into bullet-proof armor.
See also MATTER.

MATHEMATICS Mathematics is the study of numbers, including their operations and interrelations, and the study of spatial configurations (figures in space) and their structures. Mathematics can be divided into two major branches: pure mathematics and applied mathematics.

Pure and applied mathematics Pure mathematics is the study of numbers and spatial configurations in abstract terms. The study of numbers and how they combine is called arithmetic. Sometimes symbols are used to represent numbers. The study of how these symbols relate is called algebra. The study of spatial configurations is called geometry (see ALGEBRA; ARITHMETIC; GEOMETRY; NUMBER).

Since the end of the 1800s, many new branches of mathematics have been developed. These branches are based on quantities called sets (see SET THEORY). These new branches of mathematics are called modern mathematics. By using sets, modern mathematics can solve many more problems than the old mathematics.

Pure mathematics is not a branch of science. Science studies the real world. Pure mathematics is concerned only with abstract quantities and spatial configurations. Whether these elements occur in the real world does not concern a pure mathematician. Nevertheless, many ideas in pure mathematics are useful in science, especially in physics.

In contrast with pure mathematics, applied mathematics does deal with problems in the real world. Applied mathematics uses ideas from pure mathematics to solve practical problems. Most of applied mathematics is concerned with problems in physics. This is because physics is the most mathematical of all sciences (see PHYSICS). Applied mathematics is also useful in biology, chemistry, and economics, and in solving social problems.

History of mathematics Numbers have been used for thousands of years. By 3000 B.C., the Egyptians and Babylonians were measuring lengths and using numbers for calculating. The Babylonians were the first to divide the circle into 360 degrees. They also were the first to divide the day into hours, minutes, and seconds. Their systems of measuring the circle and dividing time are still in use today.

The ancient Greeks made great advances in mathematics. The first great Greek mathematician was Thales of Miletus, who lived from about 640 to 546 B.C. He studied geometry. One of the greatest of the Greek mathematicians was Pythagoras. Pythagoras and his followers made many important discoveries in geometry (see PYTHAGORAS' THEOREM). They also discovered a relation between the notes of a musical scale.

In 300 B.C., a mathematician named Euclid wrote a famous book called *The Elements.* This book contained everything that was known about geometry at that time. His book was still being used in schools in the 1800s.

Another important Greek mathematician was Archimedes (see ARCHIMEDES). He lived in the 200s B.C. He developed a value for pi (π), which allowed people to calculate quantities related to circles and spheres. Archimedes also made many discoveries in physics. For example, he discovered laws of levers and hydrostatics (see HYDROSTATICS; MACHINE, SIMPLE).

During the last few centuries B.C., the civilization of the Greeks declined. However, their knowledge was preserved by the Arabs. This knowledge passed on to Europe in about A.D. 1000. Until the 1600s, mathematicians in Europe made very few discoveries of their own.

Then, in the 1600s, Galileo made discoveries in dynamics, and John Napier invented logarithms (see GALILEO; LOGARITHM). In the same century, calculus was invented by two people at the same time, the English scientist, Sir Isaac Newton, and Gottfried Leibniz, a German philosopher (see CALCULUS; NEWTON, SIR ISAAC). Calculus is a very useful method of solving problems. Another important invention during the 1600s was analytic geometry. It was invented by a Frenchman, René Descartes (see DESCARTES, RENÉ).

The most important mathematician during the 1700s and 1800s was a German, Karl Friedrich Gauss. He made important discoveries in all branches of mathematics, particularly in geometry, algebra, probability, and statistics (see GAUSS, KARL FRIEDRICH; PROBABILITY; STATISTICS). He also made discoveries in physics and surveying.

During the 1800s, mathematicians started to apply a branch of philosophy called logic to mathematics. This made mathematics much more powerful. It also led to the use of sets in mathematics. Originally, sets were used only in logic. Whole new areas of mathematics were developed using sets, such as topology and game theory (see TOPOLOGY). Game theory was invented by an American, John von Neumann. Game theory played an important part in the development of computers. It is also used in economics and in determining military strategies.

MATRIX In mathematics, a matrix is a "grid" or "box" of numbers. For example:

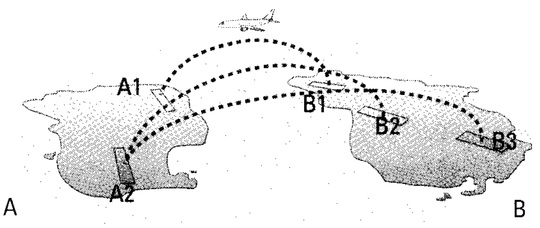
$$\begin{pmatrix} 1 & 3 & 0 \\ 2 & 1 & 5 \end{pmatrix}$$

is a matrix. It is called a 2 x 3 matrix because it has two rows and three columns.

$$\begin{pmatrix} 2 & 1 \\ 3 & 4 \end{pmatrix}$$

is another matrix. It has two rows and two columns and thus is a 2 x 2 matrix. It is called a square matrix because it has the same number of rows and columns. A matrix can have any number of rows and columns.

Matrices (plural of *matrix*) are widely used in mathematics and science. They are frequently used to show the connection between two objects or situations. For example, the diagram below has two islands, A and B. Island A has two airports: A1 and A2. Island B has three airports: Bl, B2, and B3. The



red lines show the air routes that connect the airports. These routes can be represented by a matrix. Zero (0) means that there is no route between two airports, 2 means that there are two routes, and so on.

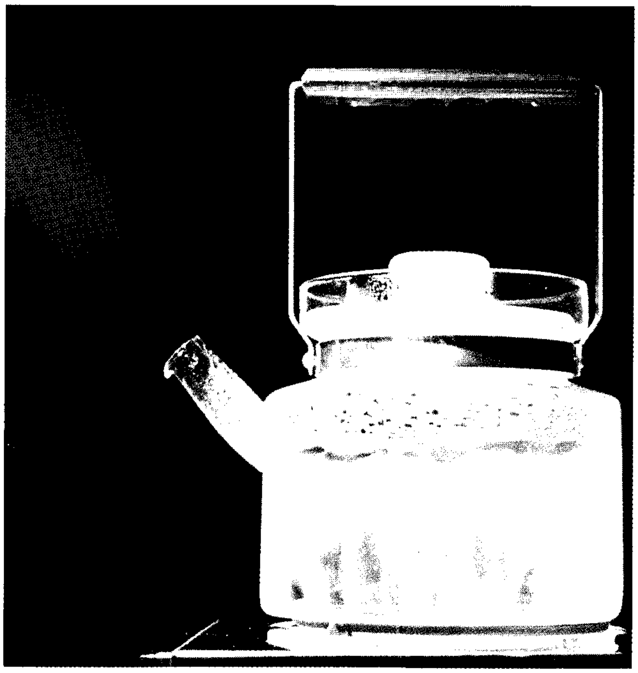
$$\begin{array}{c} \\ A1 \\ A2 \end{array} \begin{array}{c} \begin{array}{ccc} B1 & B2 & B3 \end{array} \\ \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 1 \end{pmatrix} \end{array}$$

The top left entry means that there is one route from Al to Bl. The top right entry means that there is no route from A1 to B3, and so on.

Matrices can be added, subtracted, and multiplied to form new matrices. Such operations help show a variety of relationships between the elements in a matrix. In this way, matrices are a powerful tool in mathematics.

MATTER Everything that can be seen or touched is made of matter. The air we breathe is matter. Most scientists define matter as anything that occupies space. Scientists also say that matter has inertia. Inertia is a resistance to change of position or motion (see INERTIA). All objects are made up of matter. The measure of the amount of matter in an object is called its mass (see MASS).

Until the time of Albert Einstein, scientists believed that matter could not be destroyed or created. This idea was called the conservation of matter. However, Einstein proved that matter and energy can change into one another (see EINSTEIN, ALBERT). For example, matter changes into energy when radioactive elements disintegrate (break down) or when atomic bombs explode. Because of Einstein's work, scientists now prefer to talk of the conservation of mass-energy. Mass-energy cannot be created or destroyed, but each may change into the other.



MATTER
Liquid water can be turned into a gas (water vapor) if heated to 212°F [100°C].

Properties of matter All matter has properties. The properties are divided into two kinds—physical and chemical.

Physical properties are those that can be found by direct use of the senses and by weighing and measuring. Color, smell, shape, roughness, smoothness, sweetness, and saltiness are examples of physical properties. Elasticity (stretchiness or springiness) and tension (how much force is needed to make an object break) are physical properties that can be measured. Another physical property of matter is density, which is the amount of matter in a unit of volume (amount of space). Because of the difference in density, a tennis ball weighs less than a rock of the same size. Solubility and conductivity are also physical properties. Solubility is the ability of one kind of matter to dissolve in another. Conductivity is the ability of matter to conduct heat or electricity (see COLOR; CONDUCTION, HEAT; CONDUCTION OF ELECTRICITY; DENSITY; ELASTICITY; SOLUTION AND SOLUBILITY).

Chemical properties of matter involve how a substance acts when it undergoes a chemical change. For example, one chemical property of oxygen is its ability to combine with many metals to form compounds called oxides (see COMPOUND; OXIDE). Oxygen combines with iron. When this happens, a new substance called iron oxide (rust) appears (see CHEMICAL REACTION).

Physical and chemical properties are determined by matter's atomic structure. Different atoms and molecules have different properties (see ATOM; MOLECULE).

States of matter In its familiar form, matter can exist in three physical states—solid, liquid, or gas. A substance can take on these various states depending on its temperature and on the pressure exerted on it. For instance, water (a liquid at atmospheric pressure and room temperature) can be frozen solid to ice at 32°F [0°C] or turned to a gas (water vapor) at 212°F [100°C]. Scientists also define a fourth state of matter, called plasma. Plasma exists under special conditions.

See also PLASMA (PHYSICS); STATES OF MATTER.

MAXWELL, JAMES CLERK (1831–1879) James Maxwell was a Scottish mathematician and physicist. He was born and educated in Edinburgh, Scotland. When he was only fifteen years old, he had a paper published by the Royal Society of Edinburgh, a prestigious scientific institution.

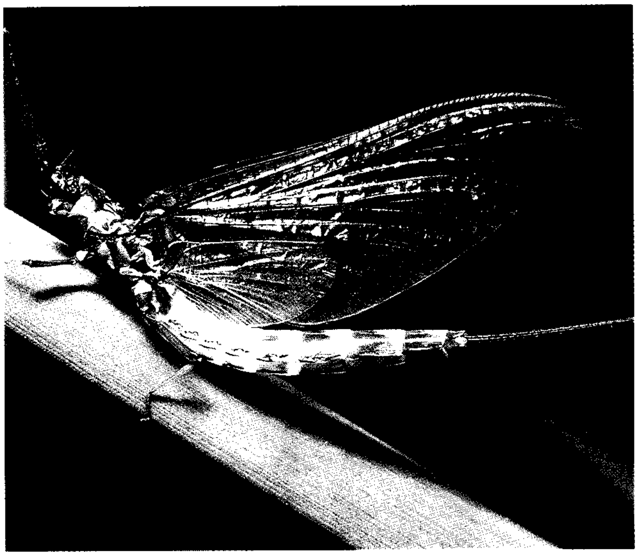
Maxwell was interested in energy. First he worked on heat, then on electricity and magnetism. In 1864, he published his ideas on the latter topic and proposed the idea of electromagnetic waves (see ELECTROMAGNETIC RADIATION). Using his mathematical skill, he predicted forms of electromagnetic radiation that had not been discovered. He said there would be a whole range of electromagnetic waves, all with different wavelengths. Maxwell wrote a set of equations that described the properties of electromagnetic waves. Based on Maxwell's predictions, Heinrich Hertz proved the existence of radio waves about ten years later (see HERTZ, HEINRICH). This discovery helped confirm Maxwell's theory.

Maxwell also worked on light. He studied color vision and developed the electromagnetic theory of light.

See also LIGHT; SPECTRUM.

MAYFLY The mayfly is any of about 2,000 species of insects belonging to the order Ephemeroptera. The adult is usually less than 1.5 in. [4 cm] long, including its two or three long, threadlike tails. It usually has four wings: two large, triangular forewings and two smaller, oval hindwings although the hindwings are missing on some species. The adult lives for only a few hours or days—just long enough to mate and (for the female) to lay eggs. The adult has no mouth and is unable to eat during its short life. Because of its short life, the mayfly is sometimes called the dayfly.

Mayflies lay their eggs in streams or ponds. The eggs hatch into three-tailed nymphs. Mayfly nymphs live underwater and breathe through gills (see NYMPH). The nymphs feed on algae and other underwater organisms and may live for as long as two or three years in this form. After molting many times, the nymph comes to the surface, sheds its skin, and becomes a subimago, or dun. The subimago is a winged creature that is a stage between the nymph and the adult. It is covered with tiny hairs and is rather drab in color. The mayfly is the only insect to pass through this stage during its metamorphosis (see METAMORPHOSIS; MOLTING). Within a few hours, the subimago molts again and becomes a shiny adult.



MAYFLY

The subimago form of a mayfly, known as a dun, is a favorite food of fish if it strays too close to the water.

Although mayflies are most common in May and June, they may be seen as late as September or October. The nymphs are a source of food for fish and are sometimes used as bait by fishers. Fishers often make artificial lures that look like mayflies.

See also INSECT.

ME ME stands for myalgic encephalomyelitis. It has also been called the "yuppie flu." The illness affects the muscles, the brain, and the nervous system. It causes muscle pain and fatigue brought on by exercise, and a malfunction in the brain that prevents any sustained (long-term) mental effort. There is loss of concentration and recent memory, which can often be restored by complete rest. The disease usually affects young adults after a flulike illness.

Although many people with ME fully recover eventually, while they have the disease they find most sustained physical or mental tasks impossible. This makes it very hard for them to hold down a job or run a home.

ME is caused by a viral infection that periodically flares up within the body (reactivates). Although there is currently no effective treatment, people with ME can help themselves by relaxing, resting, and adapting their lifestyles to match their abilities.

MARGARET MEAD
Margaret Mead wrote books about the peoples who live in the South Pacific.

MEAD, MARGARET (1901–1978) Margaret Mead was an American anthropologist (see ANTHROPOLOGY). She wrote many best-selling books that introduced the American public to cultures in the South Pacific. Her books also raised questions about the changing nature of society in the United States.

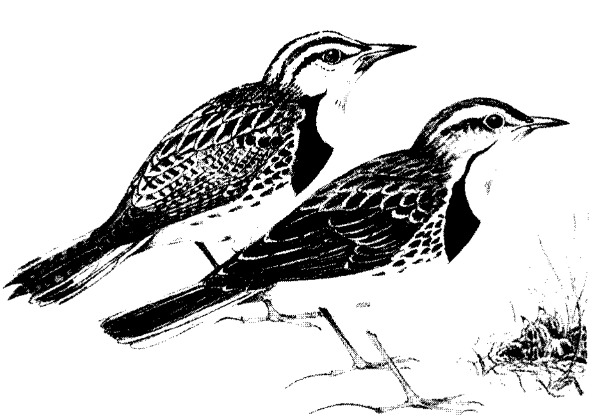
Mead was born in Philadelphia, Pennsylvania. She received her master's degree in psychology from Columbia University in New York City. After several expeditions to the South Pacific, she received her doctoral degree in anthropology from Columbia in 1929. She became associated with New York City's American Museum of Natural History in 1926. Mead eventually held the post of curator there from 1964 to 1969. A curator is the head of all or part of a museum.

Mead's curiosity about other societies took her to such places as the Admiralty Islands, American Samoa, Bali, and New Guinea. Her first books, *Coming of Age in Samoa* and *Growing Up in New Guinea*, explored the pressures of childhood and adolescence in American Samoa. Mead became the first anthropologist to examine the lives of women and how children are raised by comparing the methods of different cultures. Mead examined how one's personality develops because of childhood events and cultural pressures.

By 1940, Mead turned her attention to civilization in the United States. She became involved in programs to improve diet, education, and mental health. Mead said that schools should be part of the whole community and should educate people throughout their lives. She also expressed her views on other topics, such as the environment, nuclear weapons, and overpopulation.

Mead received twenty-eight honorary degrees in law, the humanities, and science. She received more than forty awards for science and citizenship. After her death, she was awarded the Presidential Medal of Freedom.

MEADOWLARK The meadowlark, which is not a true lark, is a common North American bird belonging to the blackbird family, Icteridae. The meadowlark is usually found in meadows, grassy fields, and marshes and is about the size of a robin. The meadowlark, however, has a thicker body, longer bill, and shorter tail than a robin. Its throat and underparts are bright yellow, with a black crescent across the breast. White outer tail feathers flash when the bird is in flight. Its song is a clear, tuneful whistle.



MEADOWLARK
The meadowlark (left) and the yellow-throated longclaw (right) are remarkably similar in appearance and habits, although they live on different continents.

The meadowlark builds its nest on the ground. A roof of grass often covers the nest to hide the eggs. The female lays three to seven white eggs with rust-colored spots. Meadowlarks feed on seeds and insects.

The meadowlark has a remarkable look-alike in the yellow-throated longclaw, a smaller bird that lives in African grasslands.

MEAN, MEDIAN, AND MODE The mean, median, and mode are different kinds of typical values for a set of collected items or numbers.

The mean is usually referred to as the "average." It is determined by dividing the total value of all the items by the number of items. So, the mean of the series of numbers 2, 4, 6, and 8 is found by adding 2 + 4 + 6 + 8, and dividing the total, 20, by 4. This gives the mean value, 5.

The median is found by arranging all of the numbers in order of size, then finding the middle number, or the value halfway between the middle two if there are an even number of items. So, the median of the series of numbers 2, 2, 4, 6, and 8 is 4.

The mode is the value that occurs the most often in the set. In the series 2, 2, 4, 6, 8, 8, 8, and 10, the mode is 8.

Each of these has different uses in real life. The mean is the value used most commonly, but it can easily be distorted by unusually high or low values. Choosing which method to use is important in many calculations of statistical numbers.

MEASLES Measles, also called rubeola, is a disease caused by a virus (see VIRUS). It is very contagious (easily spread from person to person) and occurs throughout the world. Before the measles vaccine came into common use, most children in the United States and Europe caught the disease before they reached the age of ten.

The measles virus can be spread through the air by sneezing or coughing. The first symptoms show up about ten days after the virus enters the body. At first, the symptoms are like those of a cold—fever, cough, runny nose, and sore throat. Small pink spots with gray-white centers (called Koplick's spots) appear in the mouth. Four days later, the pink spots show up on the neck and forehead and then spread to the rest of the body. The spots grow in size and join to form blotches. When the rash reaches the feet, the cough, runny nose, and fever begin to disappear, and the rash fades. This occurs about ten days after the first symptoms appear. Measles is contagious from a week before the rash appears until the symptoms begin to disappear. Once a person has had measles, he or she cannot catch the disease again. The person becomes immune to the virus (see IMMUNITY).

MEASLES
The chief symptom of measles is a pink, blotchy rash. It begins on the neck and forehead but soon spreads to cover the rest of the body. Measles is contagious until the rash disappears.

Before the introduction of the measles vaccine in the United States in 1963, an epidemic of measles broke out about every two years (see EPIDEMIC; VACCINATION). Since the introduction of the vaccine, the number of children who catch the disease has been reduced by nine-tenths. In the 1980s a nationwide immunization program against measles went into effect. Scientists at the Centers for Disease Control in Atlanta, Georgia, hope that the

program will eventually eliminate measles from the United States.
See also GERMAN MEASLES.

MEASUREMENT Measurement is the process of finding the amount, dimension, weight, mass, color, temperature, or other distinct physical or chemical characteristics of a substance. Units of measurement include meters, inches, grams, pounds, and hours. Measurement is one of humanity's oldest skills.

Almost everyone uses measurement daily. The food we eat, the clothes we wear, the work we do, and the games we play involve measurement. For example, shoppers often buy fruit by the pound or kilogram. Many workers are paid by the hour. Contractors building a house must build doorways and windows to the exact dimensions specified by the architect. An athlete who runs one hundred meters in the shortest time wins the race.

People also use measurement to help them communicate well. For example, a man could describe himself as being tall and heavy. However, people would have a better idea of what he meant if he said he was 6 ft. 6 in. tall and weighed 250 pounds.

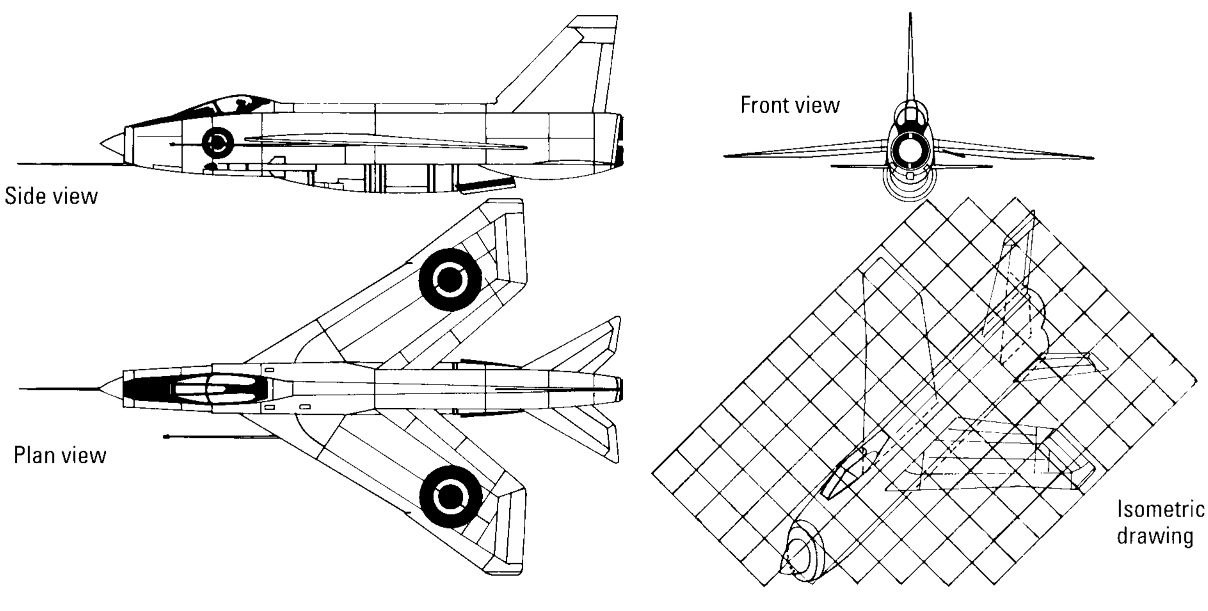
Many measurements are made by comparing the object to be measured with a scale of units on a measuring tool. A ruler, for example, is one of the most common measuring tools. Clocks, weight scales, tape measures, speedometers, and thermometers are other commonly used measuring devices.

Sometimes it is not practical to use a measuring tool to measure an object. Then the measurement must be made indirectly. For example, the amount of water in a swimming pool can be determined mathematically by finding the volume of the pool in cubic units. This indirect method is quicker and easier than dipping all the water out of the pool with a measured container.

Surveyors indirectly measure long distances on land by measuring angles and by applying mathematical principles such as trigonometry. Astronomers also indirectly measure the distances to the stars and other heavenly bodies.
See also METRIC SYSTEM; NAVIGATION; TIME.

MECHANICAL DRAWING (mĭ kăn′ ĭ kəl drô′ ĭng) Whenever a product is made, an accurate, detailed drawing of it is needed. These drawings are called mechanical drawings. They are widely used in engineering and industry. Mechanical drawings show the product from several different angles so that its shape may be seen. Sometimes they have cross sections of the product to show the inside. For a large or complicated structure, such as a ship, hundreds of drawings may be needed. Some of

MECHANICAL DRAWING
Pictured here are different kinds of mechanical drawings of an airplane.



these drawings show the design of individual parts. Others show how these parts fit together.

Mechanical drawings are made by draftspersons. They work with many different instruments, such as set squares, dividers, protractors, and compasses. These instruments enable them to draw a design very accurately and to scale. The scale of a drawing may be, for example, 1 in. to 10 in. [2.5 cm to 25 cm]. This means that 1 in. [2.5 cm] on the drawing represents 10 in. [25 cm] on the structure itself. Usually a draftsperson draws an object from the front, the side, and the top. A view from the top is called the plan. The views from the side and the front are called elevations. Another kind of mechanical drawing is the isometric drawing. This shows the whole object, with all its parts drawn to the same scale.

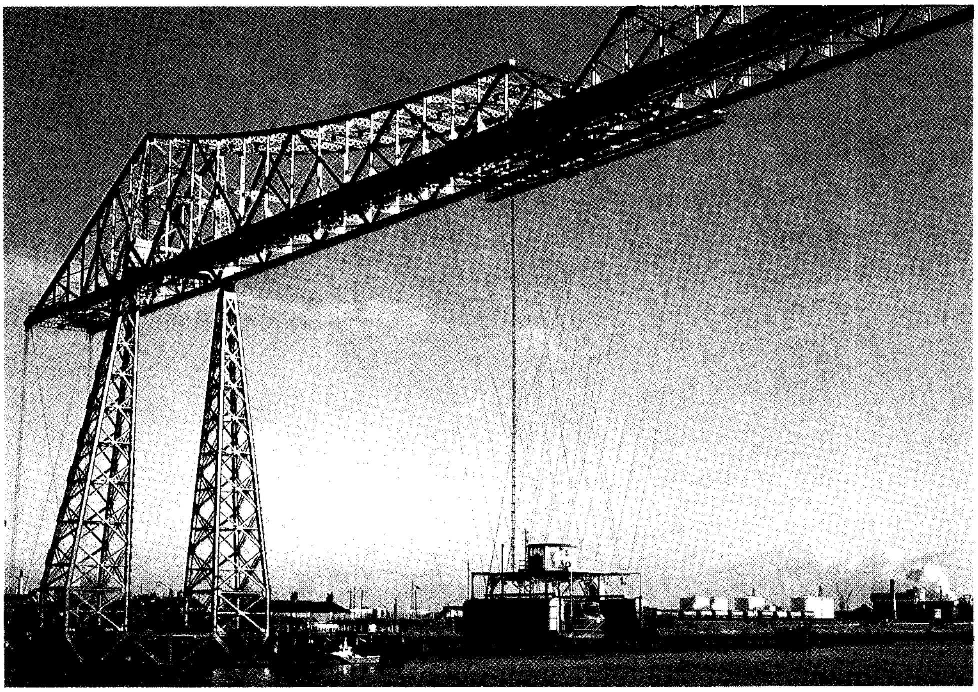
The use of computer-aided design (CAD) allows a draftsperson to make accurate drawings of buildings and other structures very quickly. The computer can also display positions and shapes that cannot always be shown by a draftsperson working with traditional tools.
See also COMPUTER.

MECHANICS (mĭ kăn′ ĭks) Mechanics is the study of forces and how they affect bodies or fluids at rest or in motion. It is concerned with such things as the flight of airplanes, stresses on bridges, and the motion of engines.

Classical mechanics is divided into a number of branches. The action of forces on solid bodies is studied in dynamics and statics. Dynamics is concerned with forces that cause bodies to move (see DYNAMICS). Statics is the study of forces acting on bodies that are at rest or moving with constant velocity (speed in one direction). Another branch of mechanics is called fluid mechanics. Fluid mechanics is divided into several branches, including hydrodynamics, hydrostatics, and aerodynamics. Hydrodynamics (also called hydrokinetics) is the study of liquids in motion. Hydrostatics is the study of liquids at rest. Aerodynamics is the study of gases in motion (see AERODYNAMICS; HYDRAULICS; HYDROSTATICS).

The basic laws of classical mechanics were determined about three hundred years ago by Galileo and Sir Isaac Newton (see GALILEO; NEWTON, SIR ISAAC). These ideas remained unchanged until this century. Then Albert Einstein produced his theory of relativity (see EINSTEIN, ALBERT; RELATIVITY). His theory changed the study of mechanics for objects moving at very high speeds or in very strong gravitational fields. However, the older laws of mechanics of Newton and Galileo are still used today in most circumstances.

PROJECT 46



MECHANICS
Engineers who design bridges make use of statics, the branch of mechanics concerned with forces in structures that do not move. The trusses in this transporter bridge have to be strong enough to carry cars and trucks in the cradle slung below it.

MECHANISM (měk′ ə nĭz′ əm) *Mechanism* can have several different meanings. In chemistry, a mechanism may be the way in which a particular chemical reaction occurs. It usually takes place step by step. Often, chemical equations are used to describe the mechanism. For example, the equation $C + O_2 \rightarrow CO_2$ describes the overall mechanism by which one atom of the element carbon combines with an atom of oxygen to form a molecule of the compound carbon dioxide.

In terms of mechanical constructions and machines, the mechanism is the means, or the collection of parts or components, that is used to transmit and modify motion in any machine. In machine mechanisms, the movements of all the parts are related, and the movement of each part is controlled by the movement of all the other parts. The type of movement that can occur in a mechanism is determined by the number of parts that make up the mechanism and the way they are connected. Mechanisms are the basic building blocks of all types of machines, even very complicated ones. The way a machine works can be understood more easily by studying the way the individual mechanisms work and their relationships to each other.

MEDICAL ENGINEERING Medical engineering is the construction and use of machines and other equipment to help identify and treat diseases. It is sometimes called biomedical engineering or bioengineering. The use of an artificial part to replace one of the body's own parts is a branch of biomedical engineering known as prosthetics.

Machines for diagnosis Diagnosis is the identification of diseases. To aid doctors in this task, there are many different machines and other devices. Some of them, such as X-ray machines, are designed to show the inside of the body. They produce pictures of internal organs and other parts that cannot be examined easily without the machines. X-ray machines work by sending a beam of X rays through the body (see X RAY). Dense parts of the body, such as the bones, tend to stop X rays from passing through. These parts show up as light areas on an X-ray film or screen. With a standard X ray, broken bones are easy to diagnose. Other types of X rays are made by having the patient injest substances that block X rays. Then, it is possible to use X rays to show the outlines of other internal structures, such as the intestines and kidneys.

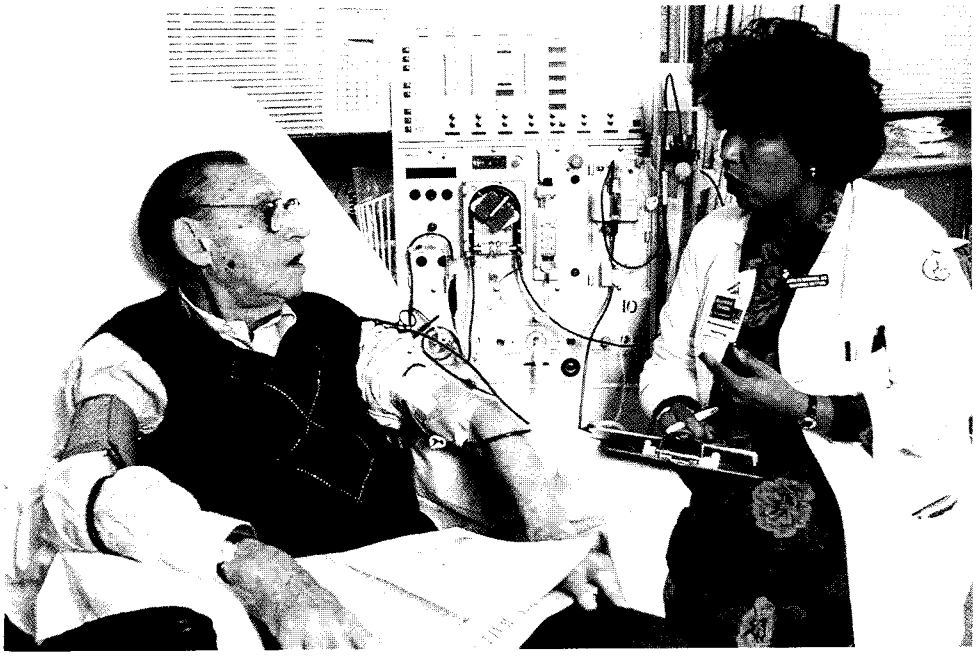
MEDICAL ENGINEERING—Scanner
A nurse explains to a young patient the procedure involved in having a brain scan.

Sound waves may also be used to make pictures of the inside of the body. They are especially useful to see fluid-filled structures. The sound waves that are used are of very short wavelength (see ULTRASOUND). They may be sent right through the body, like X rays, or reflected back as echoes.

Infrared rays from different parts of the body can be used to make photographs (see INFRARED RAY). Infrared radiation highlights areas of the body that are unusually warm or cold. They help physicians diagnose tumors (abnormal growths), inflamed joints, and blocked blood vessels. The study is called thermography (see THERMOGRAPHY).

Radioactive substances that have been injected into the body can be followed in their travels by special scanning machines. Again, pictures can be made that reveal diseased or damaged organs inside the body (see NUCLEAR MEDICINE; RADIOLOGY).

In all these techniques, computers can be used to help produce clear pictures. Computers are widely used in hospitals to aid diagnosis. Some



MEDICAL ENGINEERING
—Kidney machine

This man is undergoing dialysis. Blood from an artery in his arm passes into the kidney machine. There wastes are removed from the blood before it is returned to a vein in the man's arm.

computer-controlled machines perform a series of chemical tests on blood samples and print out the result.

Other instruments may be used to record the electrical activity of the body's organs. The working of the heart is recorded by means of an electrocardiograph. Brain waves are recorded by an electroencephalograph (see ELECTROCARDIOGRAM; ELECTROENCEPHALOGRAPH). The readings may be in the form of wave tracings on paper strips or traces on a screen.

Optical instruments called endoscopes are used to look inside the body directly. They are narrow tubes with lenses and lights. A gastroscope is used to examine the inside of the stomach. A bronchoscope is used to examine the air passages and lungs. These are both endoscopes. Most endoscopes use fine optical fibers to transmit light (see ENDOSCOPY; FIBER OPTICS).

Machines for treatment One of the earliest lifesaving machines was the iron lung. This aids the breathing of someone whose chest muscles are paralyzed. It has an airtight chamber to enclose the patient's trunk. By altering the pressure inside the chamber, the patient is helped to breathe in and out.

During operations on the heart, a heart-lung machine is often used. This machine takes over the function of the patient's heart and lungs. The surgeon is able to stop the heart safely to perform surgery on it. Heart-assist devices and artificial pacemakers help the heart pump regularly if it is diseased or damaged. Artificial valves may be sewn into the heart to replace ones that do not work properly. Continual progress is being made in developing artificial hearts, the first of which was implanted in a human being in 1982.

Another very important machine is the artificial kidney, or dialysis, machine (see DIALYSIS). It saves the lives of thousands of patients whose kidneys are damaged. In dialysis, the patient's blood goes through the machine, which filters wastes. The cleaned blood is then returned to the patient's body. A kidney machine generally must be used for several hours twice a week.

The making of artificial limbs and joints is an important medical engineering specialty. Artificial hip and knee joints are made from plastic and metal. They are implanted to replace joints that are worn out or diseased (see IMPLANTATION). Artificial limbs may be implanted if the natural limb needs to be replaced. Such limbs are set in motion by electric motors and are controlled by electric signals picked up from the nerves in the patient's body. Lifelike artificial hands with a wide range of motion have been developed. They are constantly being improved (see PROSTHETICS).

See also BIOPHYSICS.

Medicine is the science of preventing, diagnosing, and treating disease. It involves a thorough understanding of the body's structure and the ways in which its workings can go wrong. It involves knowledge of the causes of disease and study of the results of all forms of treatment.

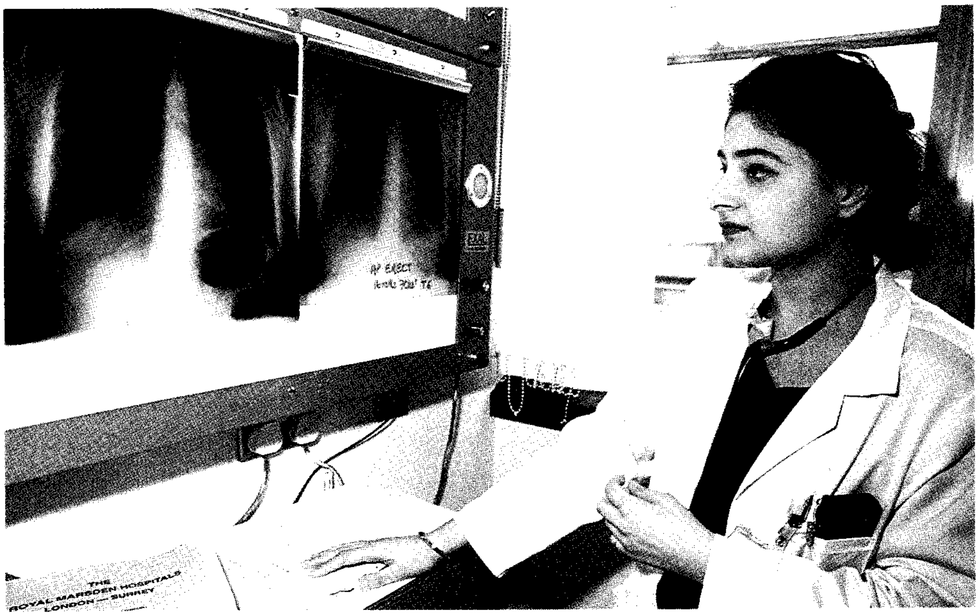
There are two main types of medical specialist. Surgeons usually deal with cases where it is necessary to cut into the body to undertake treatment (see SURGERY). Physicians deal with cases that can be treated without surgery.

There are many branches of medicine. Preventive medicine deals with removing the causes of disease. Pathology deals with the changes in the tissues of the body that diseases cause. Gynecology is the study of women's diseases, and obstetrics is concerned with childbirth. Psychiatry deals with mental disorders. Anesthesiologists are experts in drugs that relieve pain and produce unconsciousness during surgery. Radiologists are concerned with the effects of radiation on the body. These are only a few of the specialized branches of medicine.

Diagnosis Diagnosis is the process of determining a person's illness. Physicians can find out the cause of an illness by listening to patients' accounts of what they find wrong with themselves and by examining the patients. The changes that the patients report are called symptoms. Things that physicians find to be unusual are called signs. Together, the signs and symptoms will point to a possible cause, or causes, for the illness.

To confirm their diagnoses, physicians may ask for special tests to be carried out on patients. They may ask radiologists to X-ray parts of the body (see RADIOLOGY). They may study samples of cells taken from an organ. They may examine body fluids such as the urine, blood, or spinal fluid. Many machines and other devices are available to aid physicians. The electrocardiogram tells them about the electrical activity of the heart. The electroencephalogram gives them a picture of the electrical changes in the brain (see MEDICAL ENGINEERING). Physicians can call upon many different specialists to help them reach a correct diagnosis.

Treatment The aim of treatment is to remove the cause of the illness that has been diagnosed and to help the patient overcome whatever is wrong. Surgeons may be able to cut out a diseased part of the body. They may remove a tumor (an abnormal growth) or an ulcer (a sore, often in the stomach or intestine). They may even replace a faulty heart valve. Physicians will often prescribe drugs to help cure a patient. Antibiotics can be used to conquer infections caused by bacteria. Other drugs may be



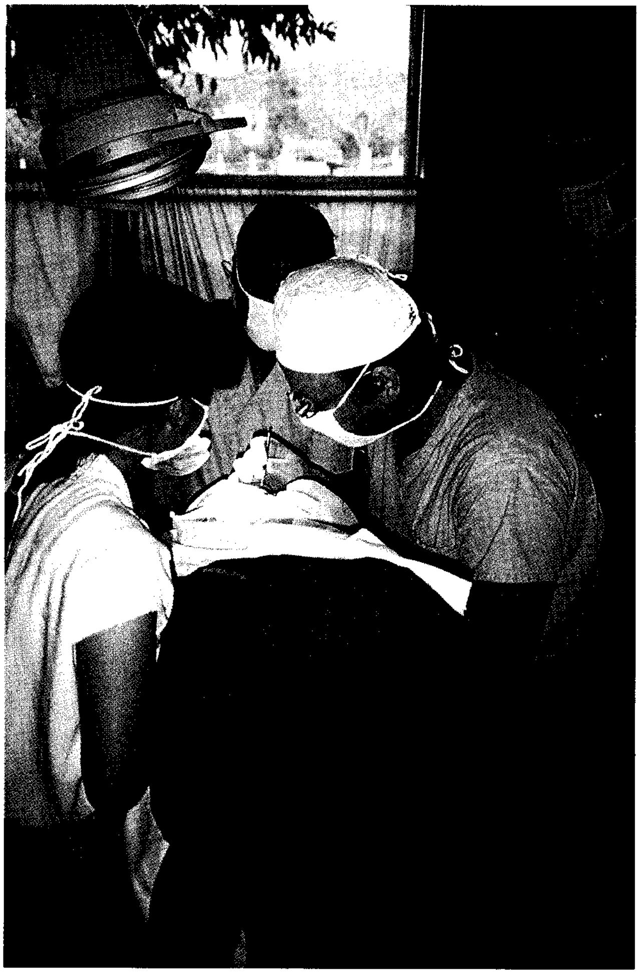
DIAGNOSIS

Physicians use various tests, X rays, and tissue samples to diagnose disorders. For example, they may measure the levels of certain chemicals in the blood.

used to correct upsets of the body's chemistry (see ANTIBIOTIC; DRUG).

Another term for treatment is *therapy.* Different kinds of therapy have their own names. Radiation therapy is the use of X rays or other radiation to treat and cure disease (see RADIATION THERAPY). Chemotherapy is the use of drugs. Psychotherapy is the treatment of mental disorders (see PSYCHIATRY). Physical therapy is the treatment of disease by means of water, light, heat, sound, electricity, massage, or exercise (see PHYSIOTHERAPY). It is the doctor's responsibility to decide what the best form of therapy is for the patient.

History Early humans did not understand disease. Illnesses were mysterious. They were regarded as evil. Treatment consisted of magic and ritual that was based on superstition. Witch doctors or medicine men were often part of early cultures. These early doctors often used herbal medicines to cure some ailments (see HERB). By about 3000 B.C., Mesopotamian physicians had recorded a long list of effective herbs and drugs. By 2800 B.C., the Chinese had a similar record.



TREATMENT

An ophthalmic surgeon operates on a patient's eyes in a hospital in Thailand. Surgery is one major form of treatment. Another is chemotherapy, or the use of medicinal drugs.

The Egyptians took the first steps toward a controlled, scientific practice of medicine. From 3000 to 1000 B.C., they developed ways to measure the pulse, and they understood how blood circulates. They knew the importance of changes in body temperature, used splints for broken bones, and prescribed a wide variety of drugs, although their knowledge of anatomy was limited.

The Greeks continued the scientific approach to medicine. They learned how the human body functioned by examining or dissecting dead bodies. The Greek teacher Hippocrates recorded much of what was learned and composed the first standard of professional ethics for those who practiced medicine (see HIPPOCRATES).

The Romans also recorded their medical knowledge. When the Roman Empire fell, the information was preserved by the Arabs.

During the Middle Ages, the practice of medicine progressed little. It was not until the Renaissance that scientific medical practice began again, using experimentation, observation, reason, and logic.

Tremendous progress was made in medicine from 1700 to 1900. The inventions of the microscope, thermometer, and stethoscope aided physicians' understanding of how the human body works. These instruments also helped people learn about the causes of disease. Other advances included the discovery of anesthesia and X rays and the formulation of the principles of antiseptic surgery (see ANESTHETIC; ANTISEPTIC). By 1900, doctors also knew about immunization and sanitation for the prevention of illness (see VACCINATION).

In the twentieth century, development of antibiotics has conquered many infectious diseases. The new science of medical engineering has produced such wonders as the artificial heart.

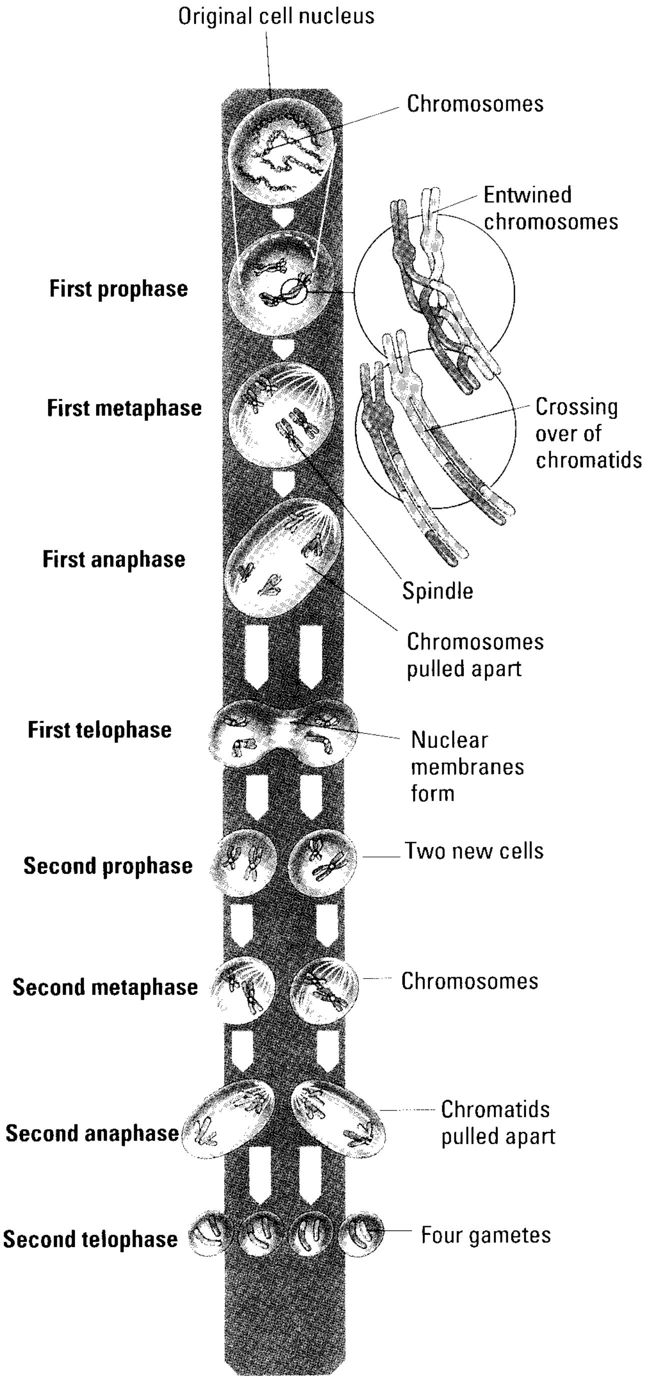
See also DENTISTRY; DISEASE; INFECTION; MENTAL ILLNESS; PATHOLOGY; VETERINARY MEDICINE.

MEDULLA (mə dŭl′ ə) The medulla is the inner part of an organ or structure. For example, the medulla of a bone is the bone marrow (see BONE). The medulla of the kidney contains the longest parts of the nephrons, which filter waste products from the blood (see KIDNEY). The medulla of the lymph nodes consists of cords of connective tissue enclosing many smaller spaces called sinuses, in which blood lymphocytes called T cells mature (see CONNECTIVE TISSUE; IMMUNITY; LYMPH; LYMPHATIC SYSTEM; SINUS). The spinal medulla is the spinal cord (see NERVOUS SYSTEM).

Medulla also refers to the medulla oblongata. The medulla oblongata lies at the base of the brain and is part of the brain stem (see BRAIN). It contains nerve cells responsible for many vital functions, such as respiration and circulation.

MEIOSIS (mī ō′ sĭs) Meiosis is the process of cell division leading to the production of sex cells or gametes (see CELL; CHROMOSOME; GAMETE).

Chromosomes exist in pairs in the nucleus of a cell. There are twenty-three pairs in human cells. When meiosis begins (first prophase), the chromosomes line up in pairs along the midline of the nucleus. Each chromosome then becomes shorter and thicker and twines around its partner. Each one then splits lengthwise to form two identical chromatids, although the chromatids remain attached to each other at several points. It is at this stage that there may be some crossing over, or exchange of genetic material between the chromosome pairs (see HEREDITY). The membrane around the nucleus then disappears and a spindle of protein fibers forms (first metaphase). One fiber becomes attached to each chromosome, and the fibers then shorten and pull the paired chromosomes apart (first anaphase). One of each pair goes to each end of the cell. Each cluster now has just 23 chromosomes instead of 23 pairs, although each chromosome is still in the form of two chromatids. A new nuclear membrane forms around each cluster (first telophase), and the cell then divides into two, producing two new cells each containing just 23 chromosomes. These new cells then immediately divide again, but this time there are no chromosome pairs to come together. The 23 chromosomes arrange themselves near the middle of each cell, and the two chromatids making up each chromosome are pulled apart. One set of



MEIOSIS

Meiosis takes place in a series of stages. The overall result of meiosis is the formation of sex cells (gametes) by the division of a single cell. In animals, the gametes are either ova or eggs (female), or sperm (male). Eggs and sperm contain only half the normal number of chromosomes. The chromosome number is restored when an egg and sperm unite at fertilization to form a zygote.

chromatids, which can now be called chromosomes, goes to each end of the cell. When this second cell division is complete, there are four daughter cells, each with 23 chromosomes—half the number present in the original parent cell. Such a cell, with half the normal number of chromosomes, is called a gamete. During sexual reproduction, a male gamete combines with a female gamete to produce a zygote with the full number of chromosomes. Thus, the zygote gets half of its chromosomes from one parent and half from the other parent.

See also FERTILIZATION; REPRODUCTION; ZYGOTE.

MEITNER, LISE (mīt′ nər, lē′ zə) (1878–1968) Lise Meitner was one of the first women to make significant contributions to the field of physics (see PHYSICS). She is best known for studying the process of nuclear fission. Her discoveries helped lead to the development of fission as a source of energy (see FISSION; NUCLEAR ENERGY).

Meitner was born in Vienna, Austria. She studied at the University of Vienna and earned a doctoral degree in 1906. She was one of the first women to obtain a doctoral degree in physics. From 1908 until 1911, she was an assistant to Max Planck at the University of Berlin. Planck developed the quantum theory (see PLANCK, MAX; QUANTUM THEORY). Meitner was a member of the Kaiser Wilhelm Institute (now the Max Planck Institute) from 1912 until 1938. She also was a professor at the University of Berlin from 1926 until 1938. Meitner worked with Otto Hahn at the institute. In 1917, they discovered the radioactive element protactinium (see ELEMENT; HAHN, OTTO). Meitner also studied the rays emitted by radioactive atoms (see RADIOACTIVITY).

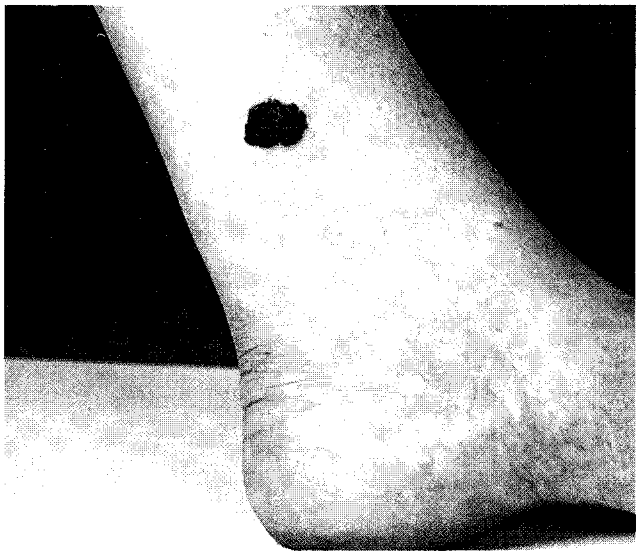
In 1938, Hahn reported that barium had been produced from uranium when it was bombarded by slow-moving neutrons. Shortly after that, during World War II (1939–1945), Meitner fled Germany for Sweden. While working at the Nobel Institute for Physics in Sweden, Meitner and Otto Frisch mathematically explained the appearance of barium. They proved that the uranium atom had been split into smaller barium atoms. Meitner also figured that the splitting of a uranium atom would release a great amount of energy—twenty million times more energy than exploding a single molecule of TNT (see TNT). Meitner named the process of splitting the atom *nuclear fission.*

Many governments tried to build weapons based on nuclear fission. The United States government asked Meitner to be part of their Manhattan Project, which was their attempt to build the first nuclear weapons. However, Meitner declined. She disapproved of using nuclear fission for anything other than peaceful goals.

Meitner was a member of the Swedish Academy of Science and the French Academy of Science. She received various awards for her work. Otto Hahn received a Nobel Prize for the discovery of nuclear fission, but Meitner did not.

MELANOMA (mĕl′ ə nō′ mə) Melanoma is a type of skin cancer (see CANCER). It spreads throughout the body early in its growth. For this reason, it is the most serious of skin cancers, and people with melanoma have the poorest prospects of survival.

Melanoma occurs in the dark-colored parts of the skin called moles. These skin cells contain the black pigment melanin. Once the cells become cancerous, the amount of melanin increases, thus giving



MELANOMA

A melanoma of the skin resembles a large mole. Melanomas are cancerous tumors. They often spread to other parts of the body if not treated promptly.

the tumor a black coloration. Treatment consists of removing the tumor and some of the surrounding healthy tissue. Drugs are then used to attack the cancer cells that have spread in the body. This treatment is called chemotherapy. The chances of survival are improving all the time with the availability of better drugs. The best treatment of all, however, lies in early detection, before the cells have spread, and in avoiding overexposure to the sun. If a mole itches constantly, bleeds, or changes color, see your doctor immediately.

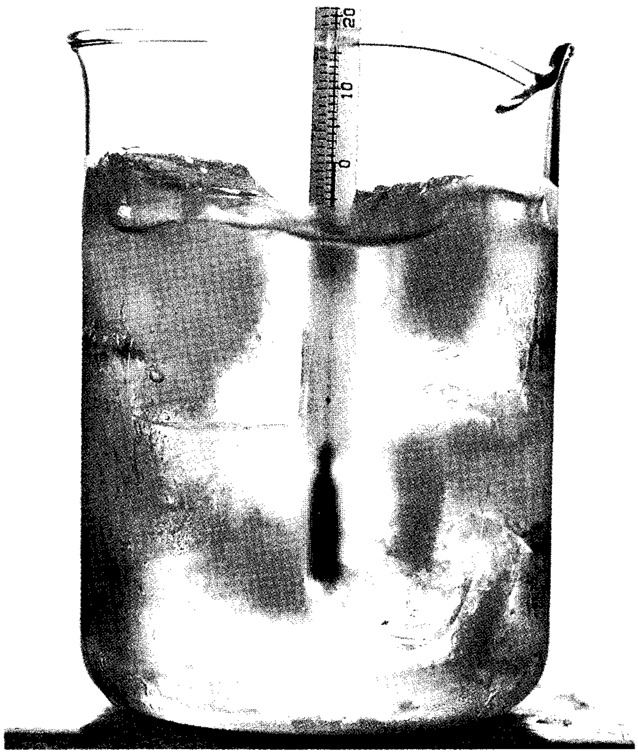
MELON Melons are the fruit of several plants belonging to the gourd family, Cucurbitaceae (see GOURD FAMILY). Melon plants have trailing vines that often climb by attaching themselves to objects by means of tendrils. The tendrils grow from the leaf bases and resemble coiled springs (see TENDRIL).

Melons are round to oblong in shape. They range from 1 in. [2.5 cm] to more than 12 in. [30 cm] across. They are tan, yellow, green, or pink in color. Cantaloupe, muskmelon, honeydew, casaba, and watermelon are all popular types of melons.

Melons were popular fruits even in ancient times. For example, watermelons were cultivated by the ancient Egyptians in the fourteenth and thirteenth centuries B.C.

MELON
Melons are grown in warm regions throughout the world. These are being cultivated near the Kalahari Desert in southern Africa.

MELTING POINT The melting point of a substance is the temperature at which it turns from a solid into a liquid. Melting points vary from one substance to another. They are sometimes used to test the purity of a material. A pure material has a different melting point from one containing impurities. The melting point of any given substance varies with the pressure. For this reason, melting points are usually given for a pressure of one atmosphere (see ATMOSPHERE (UNIT)).
See also MELTING POINTS TABLE, VOL. 23.



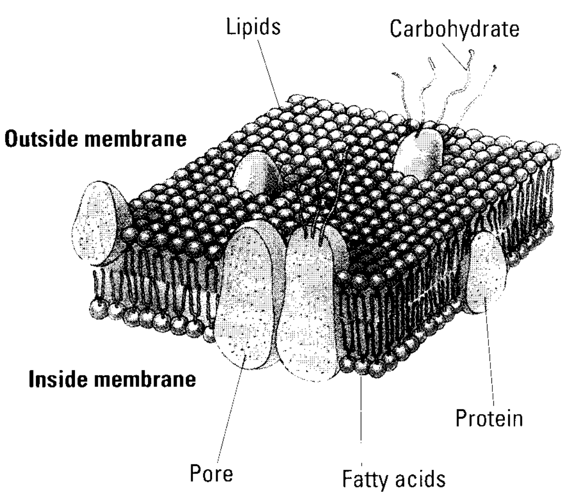
MELTING POINT
The thermometer in a mixture of ice and water shows that ice melts at 0°C [32°F].

MEMBRANE In biology, a membrane is a thin layer surrounding or separating a biological structure. There are two main types of membranes: cellular membranes and body membranes. A cellular membrane is part of a cell. It may enclose the cell, or it may enclose or be part of a structure within the cell. A body membrane is made up of cells. It is a thin sheet of tissue that covers, lines, separates, or connects body structures.

Cellular membranes Every cell is enclosed by a cell membrane, which is also called a plasma membrane (see CELL). In bacterial cells, some structures, such as ribosomes, are attached directly to the cell membrane. Many cells have internal structures, or organelles, that are enclosed by membranes. Some organelles, such as mitochondria, Golgi bodies, and endoplasmic reticulum, are made of folds of membrane. In some cells, such as those of bacteria and plants, the cell membrane is surrounded by a cell wall. The cell wall protects, strengthens, and adds form to the cell.

Cellular membranes are made of a double layer of compounds called lipids in which proteins are embedded. The membranes also contain small amounts of carbohydrates on the surface (see CARBOHYDRATE; PROTEIN). Some, if not all, cellular membranes have the ability to carry an electrical charge. This is due to the presence of ions on both sides of the membrane (see IONS AND IONIZATION). Carrying an electrical charge can be important to the functioning of the cell. In nerve cells, for example, the ability to carry a charge enables the cell to transmit nerve signals (see NERVE CELL).

Cellular membranes are vital to the life of a cell. The cell membrane separates the cell from its environment. It allows some substances, such as food and oxygen, to enter the cell. It allows other substances, such as carbon dioxide and other wastes, to leave the cell. It keeps some substances out of the cell altogether. Because these membranes are selective, they are said to be semipermeable.



MEMBRANE

A double layer of fatlike lipids forms the main structure of a cell membrane. Proteins are embedded in the lipid layer. Carbohydrates are on the surface.

Water usually moves through a membrane by osmosis (see OSMOSIS). Dissolved food particles and other substances diffuse through the membrane, establishing equilibrium on both sides of the membrane (see DIFFUSION). Small solid particles may be carried across the membrane by active transport. Active transport requires energy from the cell in the form of ATP (see ATP). Larger particles, including large molecules, are sometimes moved through a membrane by pinocytosis. In pinocytosis, part of the membrane surrounds a particle, forming a vacuole around the particle (see VACUOLE). Pinocytosis also requires energy from the cell.

Body membranes There are three types of body membranes: fibrous, mucous, and serous. All are thin sheets of tissue made up of various types of specialized cells.

Fibrous membranes are made of tough connective tissue (see CONNECTIVE TISSUE). They strengthen and support many body structures. The periosteum is a fibrous membrane that covers the bones. The dura mater is the membrane that lines the inner surface of the skull.

Mucous membranes line organs and body cavities that open to the outside (see MUCOUS MEMBRANE). They contain special glands that secrete a clear, sticky fluid called mucus. Mucous membranes are found in the mouth, nose, throat, alimentary canal (digestive tract), trachea (windpipe), lungs, reproductive system, eyelids, and inner ear.

Serous membranes line body cavities that do not open to the outside. These membranes contain cells that secrete a watery fluid to keep the body cavities moist. This fluid also keeps the membranes from sticking to each other or to other organs. The pleura is a serous membrane that lines the chest cavity. The peritoneum lines the abdominal cavity. The synovial membrane lines the joints between bones. It produces a fluid called synovial fluid, which lubricates the joints.

PROJECT 14

MEMORY Memory is the retaining (keeping) and recalling of past experiences in the human mind or by an animal. Learning, thought, and reasoning could not occur without memory (see LEARNING AND MEMORY).

Memory is measured by the ability to recall information and the ability to recognize something previously encountered. A simple memory test is to give someone a list to study, then later ask the person to recall the items on the list. In recognition tests, the person is given a list and asked to pick out the items that were on a list studied earlier. The difference between the amount of information learned to begin with and the amount the person can still recall or recognize later shows how much has been remembered.

Amnesia or memory loss may occur after physical injury to the brain, but can also occur without damage to the brain and without loss of the ability to reason. Emotional anxiety can cause memory loss. Amnesia may be temporary, as in epilepsy, or it may be permanent (see EPILEPSY).

MENDEL, GREGOR (1822–1884) Gregor Mendel was an Austrian monk who made important discoveries about heredity (see HEREDITY). In the 1850s, he studied science at the University of Vienna. Then he returned to his monastery at Brunn (Brno), where he taught high-school science.

Mendel used plants that he grew in his monastery garden to do experiments in genetics. His most famous experiments were done with pea plants. He found that heredity followed a simple set of mathematical rules. Mendel interpreted this as meaning that there were tiny particles in living cells that controlled heredity. We now call these particles genes (see GENE). Mendel published a paper describing the results of his experiments in 1866.

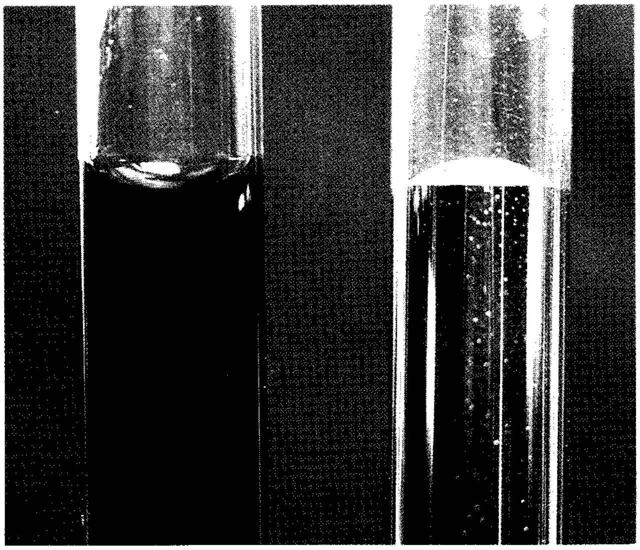
Mendel's discoveries were not noticed by other scientists while he was alive. They were rediscovered by other scientists in 1900. Today, we know that the laws of heredity are more complicated than Mendel thought. However, his basic ideas still hold true.
See also GENETICS.

MENDELEEV, DMITRI (mĕn′ dl ā′ əf, dmyē′ tryē) (1834–1907) Dmitri Mendeleev was a Russian chemist. In 1871, he developed a way of classifying the chemical elements, organizing them into a chart known as the periodic table of elements (see ELEMENT). Mendeleev used the atomic weights of elements (now known as relative atomic masses) to arrange the elements in a special order (see RELATIVE ATOMIC MASS). There were some gaps in Mendeleev's table. He was so sure that his arrangement was correct that he predicted the properties of the missing elements. Three new elements, gallium, scandium, and germanium, filled these gaps in the table when they were discovered twenty years later. We still use a periodic table similar to the one Mendeleev proposed. The table is useful in understanding and predicting the way elements behave (see PERIODIC TABLE, VOL. 23).

DMITRI MENDELEEV
Dmitri Mendeleev was a Russian chemist who developed the periodic table, a way of classifying chemical elements.

MENISCUS (mə nĭs′ kəs) When a liquid is placed in a container, the surface of the liquid becomes curved. This curved surface is called the meniscus. The meniscus can be either concave or convex (see CONCAVE; CONVEX). If the surface curves upward so that the center of the surface bulges up in comparison with the sides to the container, the meniscus is convex. If it curves downward so that the center of the liquid dips down in comparison with the sides of the container, the meniscus is concave. If the meniscus is concave, the liquid is said to wet the container. In glass containers, water and alcohol have a concave meniscus. Therefore, they wet the container. Mercury has a convex meniscus and does not wet glassware.

The molecules in a liquid are attracted to each other. They are also attracted to the molecules in the container (see ADHESION; MOLECULE).

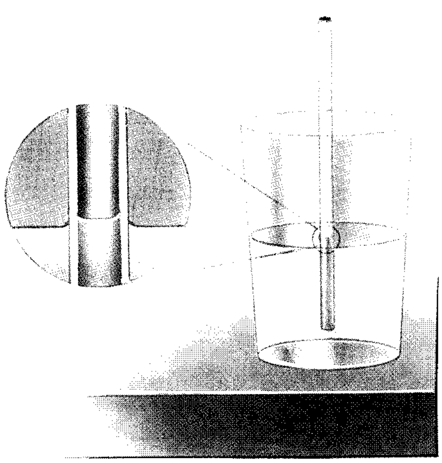


MENISCUS
Water (here dyed red) forms a concave meniscus in a glass tube (left), whereas mercury forms a convex meniscus (right).

Sometimes, the molecules in the liquid are more attracted to the molecules in the container than to each other. The liquid is then pulled a little way up the side of the container because of this attraction. A concave meniscus forms. If the molecules in the liquid are more attracted to each other, the opposite happens. A convex meniscus forms.

The shape of the meniscus depends on what the container is made of. The molecules in a liquid are attracted to different degrees to different molecules that make a container. PROJECT 19

ACTIVITY *See a meniscus*



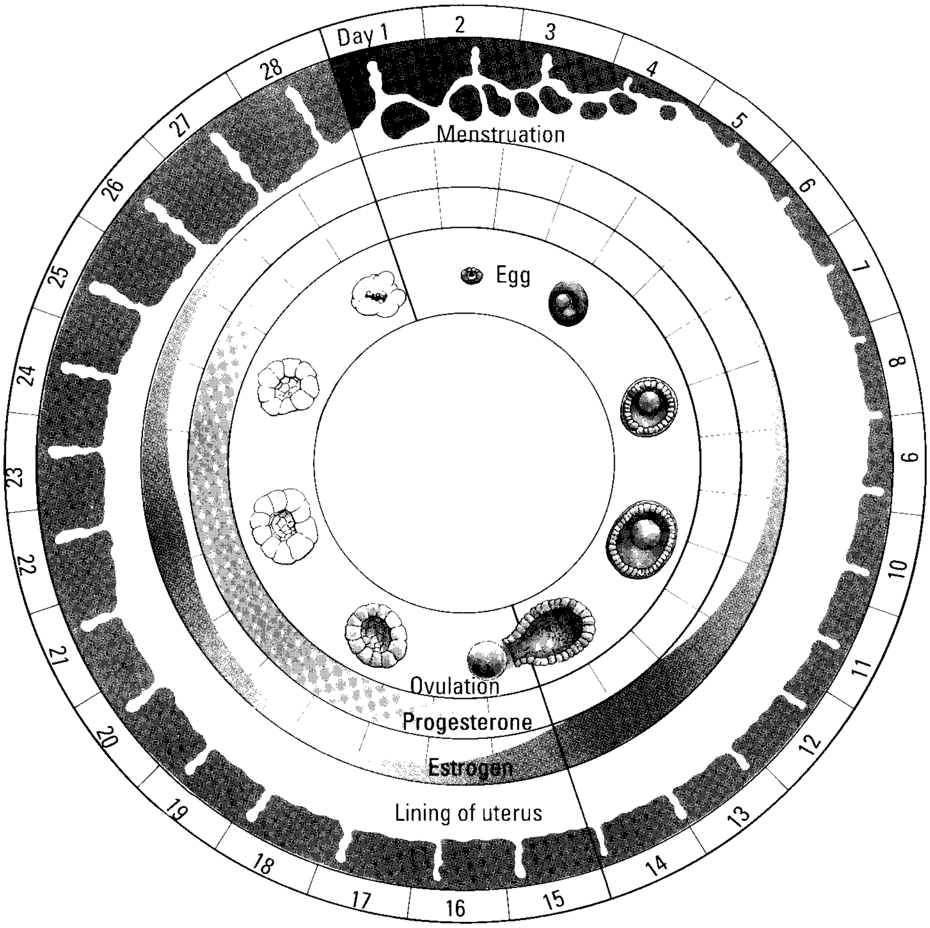
Find a regular clear drinking straw. Fill a drinking glass halfway with water. Hold the straw upright and push the end under the surface of the water. Keep your eye level with the surface of the water and look through the glass. Can you see the meniscus in the straw?

MENSTRUAL CYCLE (mĕn′ strōō əl sī′ kəl)

When a girl is old enough to have a baby, her reproductive system begins to work (see REPRODUCTION; REPRODUCTIVE SYSTEM). This usually happens between the ages of eleven and sixteen and is regulated by chemicals called hormones (see HORMONE; PUBERTY). First an egg (ovum) becomes ripe in the ovary. At the same time, the uterus gets ready in case the egg is fertilized. A fertilized egg grows into a baby in the uterus (see FERTILIZATION). If the egg is not fertilized, it breaks down, and the material in the uterus passes out of the body. This happens about every four weeks and is called the *menstrual cycle,* from the Latin word for "month." The menstrual cycle is not always exactly four weeks long. Sometimes the cycle happens over three weeks, and sometimes it happens over six weeks.

When the uterus is getting ready for the egg, its lining, called the endometrium, thickens and becomes cushiony. Its blood supply increases. This release is caused by a hormone (estrogen), which is released by the ovaries. About two weeks later, a ripe egg is released from one of the ovaries. This release is called ovulation. The part of the ovary where the egg comes from secretes another hormone, called progesterone. This hormone also helps prepare the uterus. If the egg is fertilized, it settles in the soft lining of the uterus and starts to grow.

If the egg is not fertilized, the ovaries stop making estrogen and progesterone for a short time. This allows the uterus to get rid of its contents and prepare itself to receive the next egg. The thick lining is cast off and passes through the vagina and out of the body. Every month, some blood and waste cells flow from the vagina. This is called menstruation, or the menstrual period. It usually lasts between four and six days. Then the cycle starts again, with ovulation taking place about two weeks after the start of menstruation. The amount of blood lost at menstruation is really very small and is not needed by the body.



MENSTRUAL CYCLE
The menstrual cycle is the monthly series of changes that take place in the body of a woman of child-bearing age. Most of the changes take place in the ovary and uterus. They are brought about by changing levels of the hormones estrogen and progesterone.

When a woman is forty-five to fifty, she stops menstruating. There are no more eggs released, and she no longer has menstrual periods. The time when this happens is called menopause.

MENTAL ILLNESS A person's body can be healthy or sick, and so can the mind. Mental illness means sickness of the mind. Persons with mental illness are sick people, just as persons suffering from a bad cold or heart disease are sick people. Like other sick persons, persons with mental illness need special treatment. Mental health includes the prevention of mental disorders and the detection, treatment, and rehabilitation (restoring of mental health) of persons with mental illness. Mental health is also concerned with promoting a sense of well-being.

About two hundred years ago, doctors began to realize that people with mental disorders were sick. Doctors started to study mental illness and to try to treat it, as they did physical illnesses. During the late 1800s, Sigmund Freud worked out his psychoanalytic theory. This theory states that unconscious ideas can affect health (see FREUD, SIGMUND).

Treatment of mental illnesses is constantly improving. However, study of these illnesses is relatively new. Not much is known about them.

Types of mental illnesses Some types of mental disorder are treated not as mental illnesses but as diseases of the nervous system. These include cerebral palsy, epilepsy, and Parkinson's disease. These are diseases in which the cause is definitely known to be damage to the brain. For the many other types of mental illness, however, the cause is uncertain. Most of these illnesses are now broadly divided into anxiety disorders, depressive disorders, schizophrenic disorders, substance abuse, and personality disorders.

In the anxiety disorders, persons with mental illness show signs of great anxiety, and changes in their behavior result. These diseases include phobias (excessive fear of an object or situation), panic attacks, and obsessive behavior.

In depressive disorders, the person with mental illness may become depressed for variable lengths of time, may show alternating periods of deep depression and wild elation (manic-depressive disorder), and may respond by differing degrees to treatment (see DEPRESSION (MENTAL)).

In schizophrenic disorders, the person's thought processes and interpretations of reality become distorted. He or she may become increasingly withdrawn and suffer from hallucinations (sounds or sights that are not real) or delusions (false beliefs). As a result, these persons may become violent toward themselves and others. Persons with schizophrenic mental illness may also become paranoid, falsely believing that others are plotting against them.

Substance abuse covers mental illnesses that are caused by taking substances that alter the thought processes, such as alcohol and some drugs (see ADDICTION; ALCOHOLISM; DRUG).

Personality disorders are those mental illnesses in which the persons show characteristics that cause them and those around them great distress and make them unable to relate to others. Excessive aggression or moodiness, passiveness, or an inability to stand strong emotions in others are examples of this type of mental illness. In another type of personality disorder, conflicting characteristics and memories are so pronounced that there may appear to be several personalities present at different times within the same individual. This is known as multiple personality disorder.

Mental illnesses can be caused by a variety of factors, which can act alone or in combination to cause the illness. These include genetic factors, in which a person's genetic make-up may make him or her mentally ill or more likely to become ill; hormonal factors, in which deficiencies or alterations in hormones cause the illness (see HORMONE); environmental factors, in which a substance in the surroundings is absorbed by the body and causes the mental illness; biological insult, such as a high fever or an accident causing damage to the brain; and early childhood abuse or neglect.

Some mental illnesses have an easily recognized immediate cause, such as alcoholism and other forms of drug addiction, or amnesia (loss of memory) after a head injury. But in most mental illnesses, the exact cause is unknown, and a variety of factors have probably played a part in making the person ill. How severe the mental illness is depends on how impaired the person with the illness becomes.

Treatment of mental illnesses Experts have many different ideas about how to treat mental illnesses. Some medical doctors specialize in mental illnesses. These people are called psychiatrists. For the most part, they use psychotherapy. In psychotherapy, the psychiatrist listens to patients talk about their troubles and then helps the patients understand what is disturbing them. Psychoanalysis is a special form of this method (see PSYCHIATRY; PSYCHOANALYSIS). Other types of psychotherapy include group therapy, in which a group of patients try to help each other. Another type is behavior therapy, which uses methods such as conditioning to teach patients to overcome their problems (see LEARNING AND MEMORY).

Psychosocial rehabilitation includes therapy such as social clubs and job-readiness training to improve the patient's skills with others. Community support such as housing is sometimes offered, so that the person with mental illness can still function as independently as possible.

Medical techniques, such as drugs and electroshock therapy (in which a small electric current is passed through part of the brain), are also used by psychiatrists to treat mental illnesses. Important drugs used for the physical treatment of mental illnesses include antidepressants, which fight depression; tranquilizers, which calm agitated and anxious patients (including many schizophrenics); and sedatives, which help a person sleep.

Most doctors recognize that many factors contribute to mental illnesses. All these factors are considered in treating the patients. The experts also realize that there are other factors which, when known, may lead to further improvements and progress in the treatment of mental illnesses.

See also PSYCHOLOGY.

MENTAL RETARDATION Mental retardation is a condition of below-average intelligence and social functioning. A person is considered mentally retarded if he or she scores below 70 on an intelligence quotient (IQ) test (see INTELLIGENCE). People of average intelligence score between 90 and 109 on IQ tests. People with mental retardation are also less capable of taking care of their needs than others of the same age and cultural group. Three percent of the population is considered to be mentally retarded. People with mental retardation can receive training to cope with their disability. However, there is no cure for the condition.

There are several degrees of retardation. Most people with mental retardation are considered mildly retarded. This means they score between 55 and 69 on IQ tests. People with mild retardation often have difficulty in school. However, they can be taught a skill that they can use in a job. As adults, they often can take care of their own personal needs and can live on their own.

People with moderate retardation have IQs between 40 and 54. People with severe retardation have IQs between 25 to 39. The level of social functioning generally tends to decrease as the IQ decreases. For example, some people with moderate retardation may be able to take care of some of their needs but may not be able to hold a job.

Some people with mental retardation are considered to be profoundly retarded. People with profound retardation score below 25 on IQ tests. They require others to take care of all their needs, including bathing and eating.

Mental retardation can be caused by a variety of factors. These include complications during pregnancy and delivery, such as the fetus suffering from a lack of oxygen. Poisoning in young children may lead to mental retardation. A poor learning environment may also be another factor.

Some mental retardation has a genetic cause. A child may inherit an abnormal X chromosome. This condition is known as the fragile-X syndrome (see CHROMOSOME). Retardation also occurs when a child inherits an extra particular kind of chromosome. This condition is known as Down's syndrome. Besides being mentally retarded, a person with Down's syndrome has certain distinct physical characteristics, such as upward-slanting eyes, flat nose, small head, and small, short-fingered hands (see GENETICS; HEREDITY; X CHROMOSOME).

It was once thought that people with mental retardation could not live in society and had to be placed in special institutions. Today, only those with a very high degree of retardation are placed in institutions. Those adults with retardation who cannot live completely on their own sometimes live in group residences. Group residences are places where daily life is patterned after how a typical family might live. Residents may have their own rooms and may have special duties, such as washing dishes. Trained people, called counselors, also live at the residences. Often, those who live in a group residence hold a job at a sheltered workshop. There, they perform simple assembly work under supervision. People with mental retardation can also sometimes be helped by supported employment in regular settings, where a counselor or job coach helps the person in holding down a regular job.

MENTHOL Menthol is a colorless crystalline substance with the chemical formula $C_{10}H_{20}O$ (see CRYSTAL). Menthol is found in peppermint plants. It can be extracted from these plants or made artificially. Its refreshing odor and taste make it useful as a flavoring in some toothpastes and candies and as a scent in various cosmetics.

Because menthol is a mild painkiller, it is used in some analgesics to numb the skin (see ANALGESIC). It is also found in some cough and cold medicines.

MENTHOL
Menthol is a pleasant substance that is found in the peppermint plant (shown here). Menthol can also be made artificially.

MERCALLI SCALE (mər kä′ lē skāl) The Mercalli scale is a system of measuring the intensity (strength) of an earthquake (see EARTHQUAKE). It goes from intensity I to intensity XII. The levels are based on the damage caused by the earthquake and on the effects that are felt. When an earthquake occurs, people feel it most strongly close to the epicenter, where the intensity is greatest. Farther away, the intensity is less.

The Mercalli scale differs from the Richter scale, which measures the magnitude (size) of the earthquake (see RICHTER SCALE). A particular earthquake will have a single magnitude, and hence only one reading on the Richter scale, but it will have a whole range of readings on the Mercalli scale.

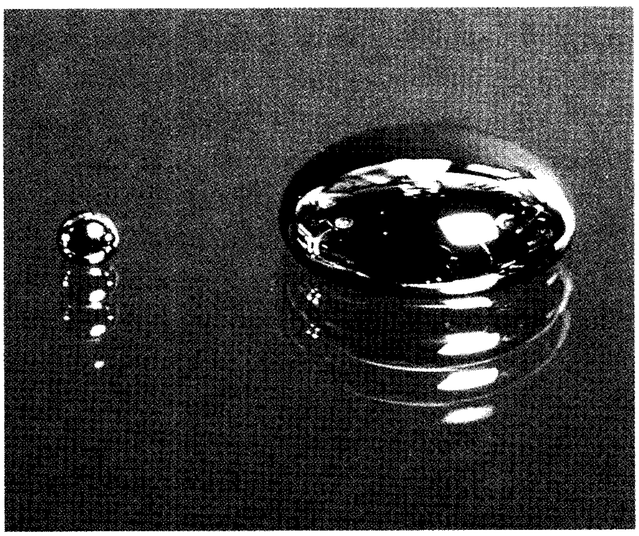
MERCALLI SCALE

Level	*Effects or Damage of Earthquake*
I	The earthquake would be detected only by instruments.
II	You would feel it upstairs in a house.
III	You would feel it anywhere indoors.
IV	Your windows would rattle.
V	You would wake up if you were asleep. Plaster on the walls would crack.
VI	Your windows would break. Things would fall off shelves.
VII	The earthquake would knock you off your feet.
VIII	Chimneys would fall.
[illegible]	The ground would crack, and buildings [illegible]
[illegible]	[illegible]

MERCURY Mercury is a metallic element (see ELEMENT). It is the only metal that is a liquid at normal temperatures. Mercury has been known since ancient times. Its symbol, Hg, comes from its Latin name, *hydrargyrus*, which means "water silver." Mercury is a relatively unreactive metal and is sometimes found uncombined in nature. Most mercury, however, occurs as mercuric sulfide in the mineral cinnabar (see COMPOUND). To extract the mercury, cinnabar is roasted in a current of air. The mercuric sulfide decomposes, and mercury vapor is given off. The mercury vapor is collected and cooled to obtain liquid mercury.

Mercury and its compounds have many different uses. Liquid mercury is used in barometers and thermometers. Mercury vapor lamps are used as street lamps, sunlamps, and fluorescent lamps. In these lamps, an electric current is passed through mercury vapor. The vapor gives off a bright blue-white light and ultraviolet rays (see BAROMETER; FLUORESCENCE; THERMOMETER). Mercury forms alloys with other metals. These alloys are called amalgams (see ALLOY; AMALGAM). Amalgams are used for filling teeth in dentistry. They are also used in industry.

Mercury forms two series of compounds. In one series, mercury has a valence of one (see VALENCE). The compounds in this series are called mercury (I), or mercurous, compounds. The other series of compounds has mercury with a valence of two. They are called mercury (II), or mercuric, compounds. Mercury (I) chloride, or calomel, is used in medicine. Mercury (II) chloride is a strong



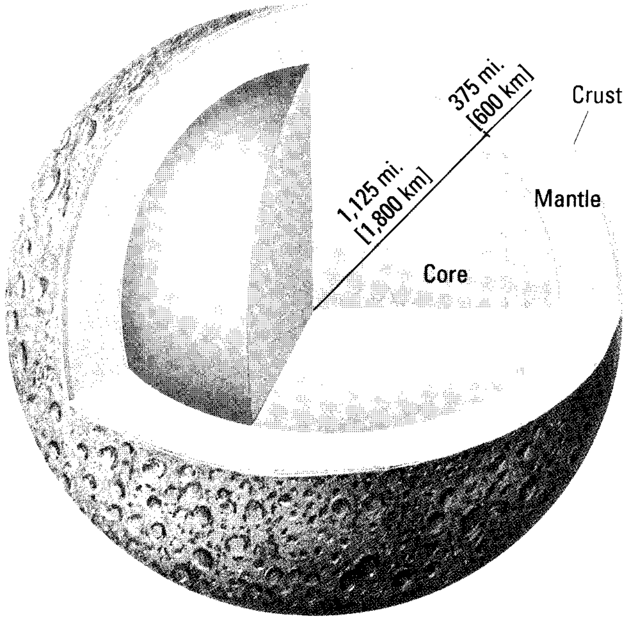
MERCURY

Mercury is the only metal that is a liquid at normal (room) temperatures. On a sheet of glass, it forms droplets. Large droplets are flat at the center. Small droplets take the form of spherical beads.

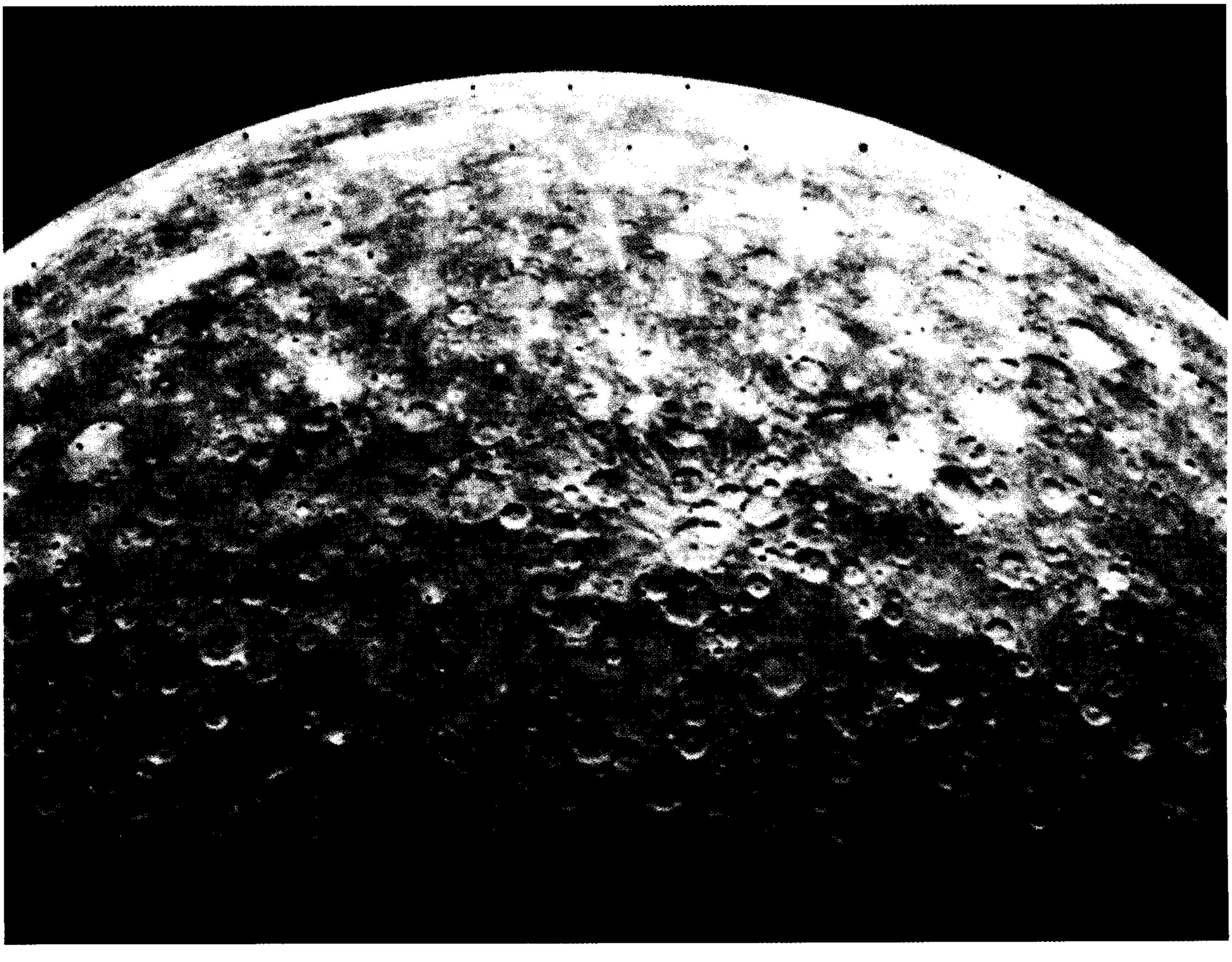
antiseptic (chemical that kills microorganisms) and preservative. It is also known as corrosive sublimate. The red pigment (coloring substance) vermilion consists of mercury (II) chloride. Both mercury and its compounds are very poisonous and must be handled with great care.

The atomic number of mercury is 80, and its relative atomic mass is 200.59. Mercury melts at -38°F [-39°C] and boils at 675° F [357°C]. The relative density of mercury is 13.5 (see RELATIVE DENSITY).

MERCURY (PLANET) Mercury is the planet closest to the sun. Mercury has a diameter of 3,030 mi. [4,880 km], which makes it the second smallest planet of the solar system. Only Pluto is smaller (see PLUTO). Mercury averages 36 million mi. [57.9 million km] from the sun. It takes the planet only eighty-eight earth-days to make a complete orbit around the sun.



MERCURY (PLANET)
Mercury is a small planet, not much larger than the moon. It has a large solid core (top) and a heavily cratered surface (below). The photograph of the surface was taken by the *Mariner X* space probe.



Mercury rotates on its axis once every fifty-nine earth-days. (A planet's axis is the imaginary line running through its center, from pole to pole.) Until 1965, astronomers thought that the time it took Mercury to go around the sun was the same as its rotation period. If this were true, one side of Mercury would always face the sun, and the other side would always be dark. Astronomers used radar to determine that Mercury's rotation period is twenty-nine days less than its year. This means that both sides of Mercury receive light from the sun.

The landscape of Mercury is similar to that of the earth's moon. Mercury has craters, cliffs, and broad plains. Astronomers think that silicate rocks form a thin layer on the planet (see SILICON). The interior of Mercury may contain a large iron-nickel core.

Until a few years ago, Mercury was not thought to have an atmosphere. However, the newer measurements of its surface temperatures have led scientists to different conclusions. Daytime temperatures reach about 800°F [427°C], and nighttime temperatures go down only to about -274°F [-170°C]. The night temperatures are much warmer than predicted. This indicates that Mercury probably has some kind of atmosphere that holds in the heat.

Because of its nearness to the sun and its small size, Mercury is difficult to see without a telescope. Every three to thirteen years, Mercury passes between the sun and the earth. When this happens, Mercury is said to be in transit, and the planet appears as a black spot against the sun. Astronomers gain valuable knowledge about Mercury during these transit periods.

In 1974, the American space probe *Mariner X* flew within 460 mi. [740 km] of Mercury. *Mariner X* took many photographs of Mercury and determined that the planet has a magnetic field (see MAGNETIC FIELD; MAGNETISM). *Mariner X* also took photographs of Venus, thus becoming the first space probe to study two planets.

See also PLANET; SOLAR SYSTEM.

MERGANSER (mər găn′ sər) A merganser is any of various fish-eating ducks. The merganser's bill is hooked at the tip, and notches at the edges help it grasp the fish firmly. Because of this bill, the merganser is frequently called a sawbill. Mergansers dive to catch fish.

MERGANSER

A male red-breasted merganser raises his crest and shows off his bright red mouth in a courtship display.

Mergansers are found in many different parts of the world. Most have tufts of feathers that form a crest on their heads. The males' body and wings are black and white. The females' wings are largely grayish brown.

The common merganser, red-breasted merganser, and hooded merganser are found throughout North America. The males of the first two have a shiny, greenish black head and neck. The male hooded merganser has a black and white head crest. The females of all three species have brown heads.

See also DUCK.

MERISTEM (mĕr′ ĭ stĕm′) Meristems are plant tissues that are made up of cells that are actively dividing and growing. Meristem cells are usually small and almost cube shaped (see CELL).

Meristems are found in the growing regions of vascular plants (see VASCULAR PLANT). Apical meristems, also called primary meristems, are found in the tips of roots and shoots. They cause an increase in length. Lateral meristems, or secondary meristems, are found in the outer regions of roots and shoots (see ROOT; STEM). They cause an increase in width. Intercalary meristems are found in the internodes. Internodes are the spaces along a stem between the points of leaf attachment. Monocotyledons, such as the grasses, sometimes have intercalary meristems (see MONOCOTYLEDON).

If a plant is injured, meristem tissue develops in the injured area. The meristem produces many cells that help heal the wound.

See also GROWTH.

MESA

A mesa is a flat-topped, steep-sided geological formation. It is what is left of a plateau that has been eroded away by wind or water. The rock that is left remains because it is very hard. Mesas are found in the western and southwestern regions of the United States. The one pictured above is located in Arizona.

MESA (mā′ sə) A mesa is a flat-topped, steep-sided land formation left intact after a large plateau has been worn away by erosion. The rock that forms a mesa remains because it is hard and does not erode easily. A small mesa is called a butte.

Mesas are found in the semiarid regions of the western and southwestern United States. They are often covered with grass or scrubby vegetation. The word *mesa* means "table" in Spanish. These landforms were so named because of their table-like shape.

See also EROSION.

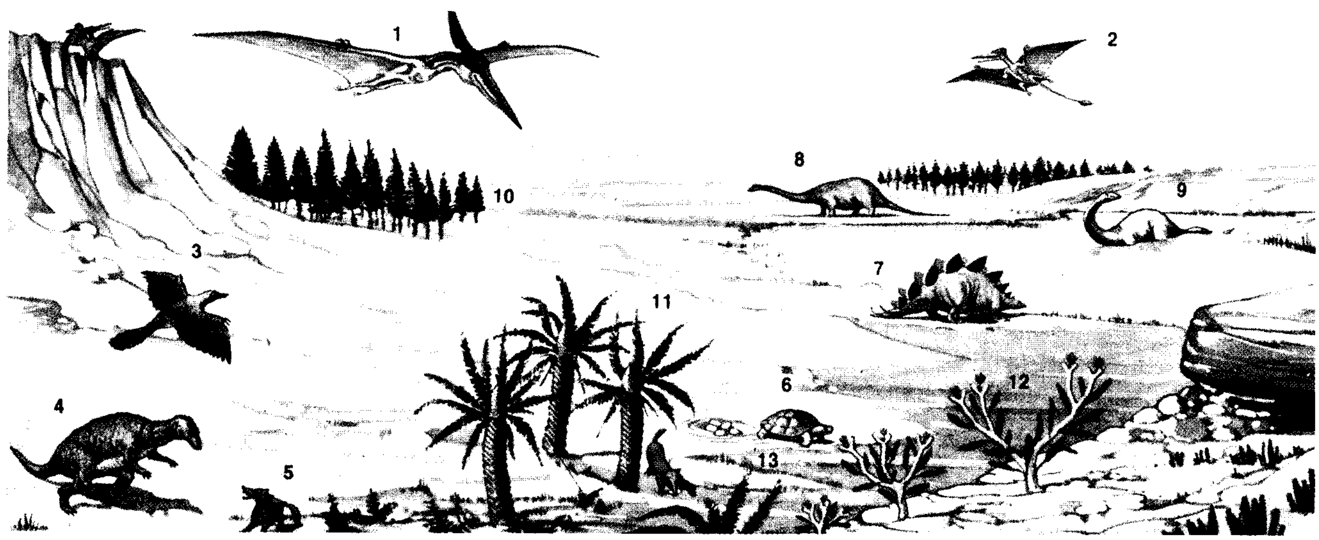
MESON (mĕz′ ŏn′) Mesons are subatomic particles. A subatomic particle is a particle smaller than an atom (see ATOM). Mesons belong to a group of subatomic particles called hadrons (see PARTICLE PHYSICS). Mesons are unstable and quickly break down into other particles. Mesons are lighter than protons or neutrons but heavier than electrons. Scientists have proved mesons exist through experiments with particle accelerators (see ACCELERATORS, PARTICLE). Mesons are formed in accelerators when protons and neutrons collide.

Mesons exist naturally in cosmic rays (see COSMIC RAYS). Mesons were first recognized in 1947 by British physicist Cecil Powell. He conducted an experiment in which he observed the paths that mesons left when cosmic rays passed through a device called a bubble chamber.

Mesons have been shown to consist of two smaller subatomic particles—a quark and an antiquark, which is an antiparticle. Antiparticles are mirror images of their corresponding particles. They may have an opposite electric charge or an opposite direction of spin (see ANTIMATTER; QUARK).

MESOZOIC ERA (mĕz′ ə zō′ ĭk ĕr′ ə) The Mesozoic era is a time in Earth history that began about 245 million years ago and ended about 65 million years ago. It includes the Triassic, Jurassic, and Cretaceous periods.

The first part of the Mesozoic era is the Triassic period. During this time, conifers (cone-bearing plants) became plentiful. The first dinosaurs, turtles, mammals, and crocodiles appeared on Earth. Fish similar to those of today swam in the seas.



MESOZOIC ERA

A Mesozoic scene is pictured. (1) *Pteranodon*, a flying reptile. (2) *Rhamphorhynchus*, a tailed flying reptile. (3) A primitive bird. (4) *Camptosaurus*. (5) *Triconodon*, an early mammal. (6) A tortoise. (7) *Stegosaurus*, an armor-plated dinosaur. (8) *Diplodocus*. (9) *Apatosaurus*. (10) Conifers. (11) Cycads. (12) *Bennetitales* (similar to cycads). (13) Ferns.

The middle section of the Mesozoic era is called the Jurassic period. Dinosaurs reached their largest size at that time. Birds and primitive land mammals also existed.

The Cretaceous period is the last part of the Mesozoic era. Flowering plants spread rapidly during the Cretaceous period. Armored and horned dinosaurs were common. By the end of the Mesozoic era, dinosaurs had become extinct.

See also DINOSAUR; GEOLOGICAL TIME SCALE.

METABOLISM (mə tăb′ə lĭz′ əm) Metabolism is the entire system of chemical reactions that take place in the cells of living organisms. There are two types of metabolism: catabolism and anabolism. Catabolism involves the breaking down of large molecules (mostly carbohydrates and fats) to release energy. This energy is used to heat the body, to allow muscles and nerves to function properly, and to power anabolism. Anabolism involves building large molecules of carbohydrates, proteins, fats, or nucleic acids from smaller building molecules to support growth and to repair or replace worn-out tissues (see CARBOHYDRATE; FAT; NUCLEIC ACID; PROTEIN).

Metabolism is a constant process. If metabolism were to stop, an organism would die. The basal metabolic rate (BMR) is the rate of metabolism of a resting organism. The BMR is most strongly related to the amount of muscle tissue an individual has, but it is also influenced slightly by body fat, sex, and age. It is controlled by many factors. One of the main regulatory hormones of metabolism is thyroxine. Thyroxine is a hormone released by the thyroid gland (see HORMONE).

Scientists are able to measure a person's BMR by measuring the amount of oxygen used while a person is at rest. A low BMR may indicate hypothyroidism, a condition in which the thyroid releases too little thyroxine. A person with a low BMR is usually overweight, tired, and sluggish. A high BMR may indicate hyperthyroidism, a condition in which the thyroid releases too much thyroxine. A person with a high BMR is usually underweight, nervous, and anxious.

Certain drugs have an effect on a person's metabolic rate. Amphetamines increase the rate of metabolism, while barbiturates decrease the rate of metabolism (see AMPHETAMINE; BARBITURATE).

Any disease that is due to abnormal body chemistry is called a metabolic disorder. Some metabolic disorders, such as diabetes, obesity, Addison's disease, and certain mental diseases, develop after birth. Other metabolic disorders, such as albinism and sickle cell anemia, are inherited and are established before birth.

See also ALBINO; DIABETES; KREBS CYCLE; PHOTOSYNTHESIS; RESPIRATION; SICKLE CELL ANEMIA.

Metal and Metallurgy

Most metals (mĕt′lz) are heavy, shiny solids that are good conductors of heat and electricity (see CONDUCTION OF ELECTRICITY; CONDUCTION, HEAT). Most of the chemical elements are metals (see ELEMENT). Almost all metals are solids at normal (room) temperatures. A few metals are very light. For example, lithium, sodium, and potassium are all less dense than water.

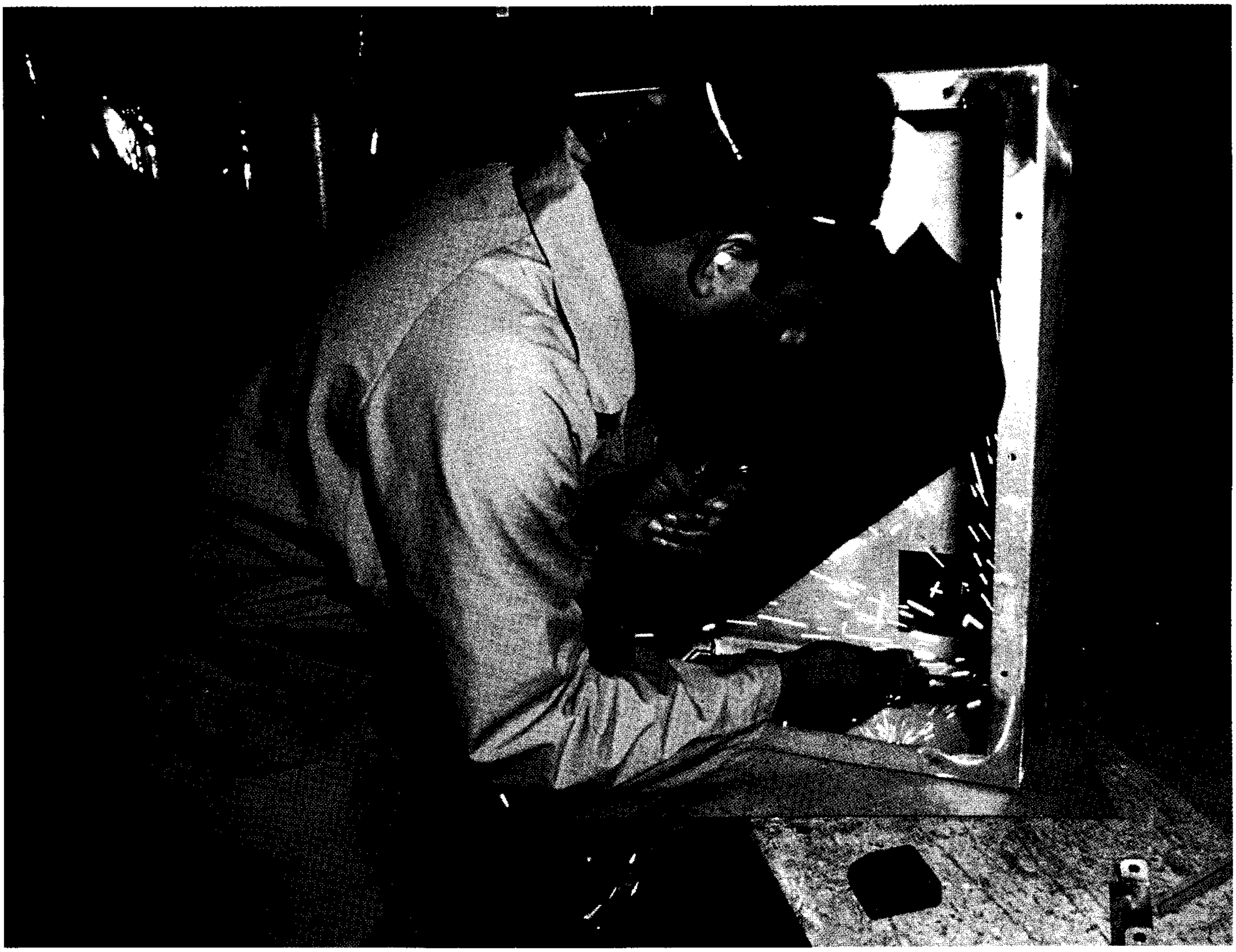
Properties of metals All materials, including metals, are made of atoms (see ATOM). Atoms have a central core called a nucleus with a number of electrons moving around it. Some of these electrons are closer to the nucleus than others. The outermost electrons are usually held only weakly to the atom. It is quite easy for them to be captured by other atoms. The giving up and capturing of electrons cause atoms to bind together to form molecules (see MOLECULE). In a metal, the outermost electrons of the atoms can move freely. For this reason, electric current, which is the flow of electrons, can flow easily through most metals.

The free electrons also make metals good conductors of heat. If one end of a metal bar is heated, the electrons there move faster. They collide with other electrons nearby. In this way, heat is quickly conducted along the metal bar.

The free electrons are also responsible for the shiny appearance of most metals. The free electrons prevent the light from entering very far into the metal. Thus, light is reflected from the surface of the metal, which is why the metal is shiny.

JOINING METALS

Many metal articles are made by joining several pieces. Here a worker is welding steel sheets together to make a metal box.

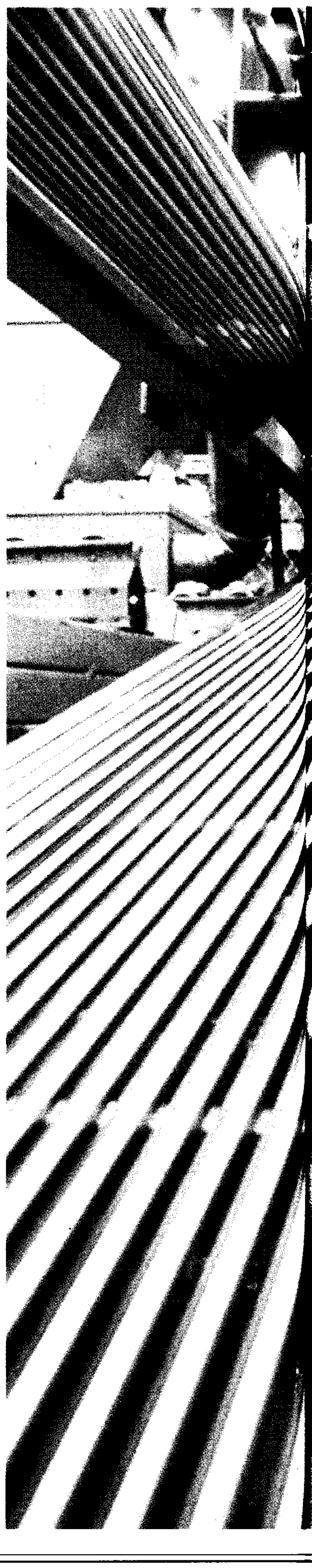


The atoms in most metals are packed tightly together in regular rows. This is why most metals have a high density. A piece of metal is made up of many tiny crystals. These crystals are arranged in a regular order (see CRYSTAL; DENSITY). Defects can occur in the arrangement of both the atoms and the crystals. When this happens, one layer of atoms or crystals can easily slide over the next layer. This means that the metal can easily change its shape. However, as it changes its shape, new defects are produced. In time, these defects weaken the metal, and it becomes brittle. The defects can be removed by heating the metal. This treatment causes the atoms and the crystals to move into alignment again.

Most pure metals are soft. Pure metals become harder and stronger when combined with other metals. These combinations of metals are called alloys (see ALLOY). Common alloys include brass, which contains copper and zinc, and bronze, which contains copper and tin. Steel is an alloy that contains iron with a small amount of a nonmetallic element—carbon. Usually, steel also contains

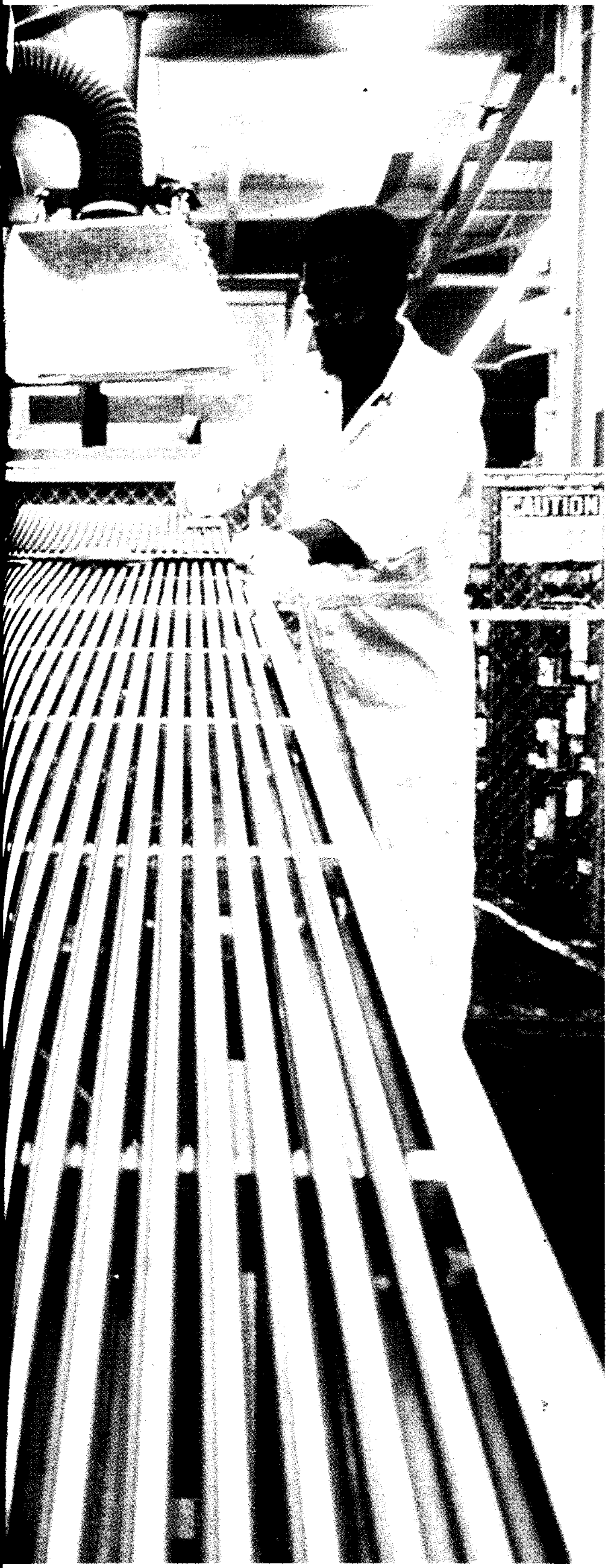
SPECIAL STEEL

Different metals have different properties. One kind of steel, shown at right, has been specially developed for use in nuclear reactors. This steel can withstand the high heat and the radiation produced in reactors.



ADAPTABLE METAL

Apart from the tablecloth, all the objects pictured below are made of stainless steel. Even the ribbon—which is so thin you can see through it—is woven from fine stainless steel wire.



small amounts of other metals as well.

Most metals readily form chemical compounds with other substances. The only exceptions are the noble metals, such as gold and platinum (see COMPOUND; NOBLE METAL). Except for the noble metals, all metals combine with the oxygen in the air. This reaction produces a coating of the metal oxide on the surface of the metal (see OXIDE). Some of these coatings are very useful. They protect the metal from corrosion (see CORROSION). For example, aluminum oxide forms a thin, hard coating that sticks firmly to an aluminum surface. The coating protects the aluminum from further attack by oxygen. Rust is an oxide coating formed on the surface of iron. However, rust is a loose substance and does not stop the oxygen from attacking the iron underneath it (see RUST). Therefore, iron and steel, which contains iron, must be protected from the air by other means. The iron or steel can be painted, or it can be covered with another metal. Iron covered with zinc is called galvanized iron (see GALVANIZING). Iron can be covered with chromium, which forms a protective layer of chromium oxide.

If metals are stretched a little and then released, they return to their original shape. This occurs because metals are elastic (see ELASTICITY). When metals are stretched beyond a certain point, they usually stay stretched. This point is called the yield point or the elastic limit. The yield point varies from metal to metal. It also depends on the number of defects in the metal. Lead, for example, has a very low yield point. A brittle metal, such as antimony, has no yield point. It breaks before becoming permanently stretched. Many metals can be deformed by a large amount before they break. These metals can be easily rolled into sheets or drawn out into wires.

In order to produce a metal object, the metal has to be shaped. There are a number of different ways of doing this. One common method is called casting (see CASTING). The metal is first heated until it melts. Then it is poured into a mold of the right shape. In another method, the metal is heated but not allowed to melt. The metal is then forced by pressure into molds. These molds are called dies.

Wire is made by pulling metal through a number of holes in turn. Each hole is smaller than the last. In this way, the diameter of the wire is slowly reduced until it is the right size. Metal sheets are made by squeezing the metal between heavy rollers.

A modern method of shaping metal is called sintering. In sintering, powdered metal is pressed into shape in a mold. The particles in the powder are then joined together by heating. Sometimes pressure is used as well (see SINTERING).

Metallurgy Metallurgy (mĕt′l ûr′jē) is the study of metals and alloys. The most important branch of metallurgy is the study of the methods of extracting metals from the earth. Most metals occur only as compounds in minerals. Only a few, such as gold, are found uncombined. Minerals that are mined for their metals are called ores (see ORE). Ores usually contain a mixture of different minerals. The amount of metal in an ore can vary greatly. Most iron is obtained from an ore that is almost pure iron oxide. Gold ore, on the other hand, may only contain one part of gold in a million (see MINERAL; MINING).

The first step in extracting metal from an ore is to crush the ore. Then the material containing the metal is separated from the rest of the ore. The unwanted material is called the gangue. The material containing the metal is called the concentrate. There are various methods of obtaining the metal from the concentrate. The method used depends on the metal.

One common method is to heat the concentrate in air. The oxygen in the air converts the metal into the metal oxide. Usually, the oxide is then heated with carbon and a flux in a furnace (see FLUX). The carbon removes the oxygen from the oxide and forms the gas carbon dioxide. This leaves behind the melted metal. The flux combines with other impurities in the concentrate. The impurities form a slag. Because the slag is lighter than the metal, the slag floats on top of the molten metal. The slag is then skimmed off. This method is used for metals such as iron and lead.

Some ores are treated with an acid or some other substance. The substance combines with the metal to form a compound. The compound can be extracted by dissolving it in water.

Another common method of extracting metals from ores is electrolysis (see ELECTROLYSIS). This method is used for very reactive metals, such as aluminum and sodium. In electrolysis, a compound of the metal is heated until it melts. Electrodes are placed in the liquid, and an electric current is switched on. As the current flows, pure metal is deposited onto one of the electrodes.

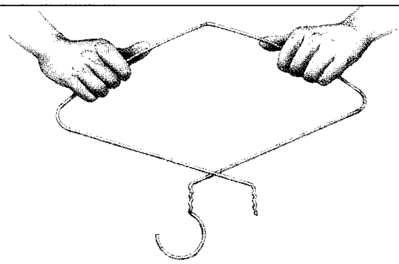
PRECIOUS METALS

Gold and silver have been valued since ancient times because of their beauty and rarity. They were originally used to make coins, ornaments, and (as here) jewelry, because they can be worked into ornate designs. Today, the metals have practical uses in the electronics and photographic industries.

METAL FATIGUE (mĕt′l fə tēg′) Metal fatigue is the gradual weakening of metal after it has been used for a long time. If too heavy a load is put on a piece of metal, it breaks. If a lighter load is put on the metal, it does not immediately break. However, a light load can weaken the metal. Eventually, the metal can become so weak that it breaks. This weakening is called metal fatigue.

In general, metal fatigue is caused by forces called stresses. A load is an example of a stress. Another example is a straight piece of metal that has been slightly bent. The bending causes a stress in the metal. If a metal is under stress, very small cracks start to appear on the surface of the metal. The cracks appear where there are tiny defects in the metal. These cracks become bigger and move inward. Then they start to join with one another. Eventually, the cracks weaken the metal so much that it breaks.

ACTIVITY *Showing metal fatigue*

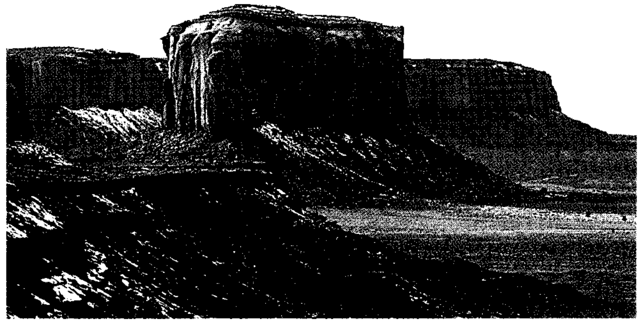


Take a piece of wire such as a metal coat hanger. Hold it firmly in both hands and bend it, first in one direction and then the other. Take care, the wire becomes very hot! How many times do you have to bend it before it breaks?

Metal fatigue is particularly dangerous in aircraft. It has caused a number of crashes. Today, certain metal parts in aircraft are regularly tested for cracks. If a part is cracked, it is replaced.

There are other methods of preventing metal fatigue. Metal parts can be redesigned to reduce the stress. Another method is to treat the surface of the metal to prevent cracks forming. New fatigue-resistant metals have also been developed to lessen the chances of metal fatigue (see METAL AND METALLURGY).

METAMORPHIC ROCK Metamorphic (mĕt′ ə môr′ fĭk) rock is rock that has changed in appearance or composition because of heat, chemical changes, or pressure beneath the earth's surface. Metamorphic rock is one of the three main classifications of rock. The other two are igneous rock and sedimentary rock (see EARTH; IGNEOUS ROCK; ROCK; SEDIMENTARY ROCK). Metamorphic rock can form from igneous, sedimentary, or other metamorphic rocks. The different changes that lead to the formation of metamorphic rock have different names. For example, contact metamorphism occurs when magma (melted rock beneath the earth's surface) heats the rocks surrounding it (see MAGMA). The heat causes the rocks to harden and causes a change in their crystalline structures (see CRYSTAL). A circle of metamorphic rocks called an aureole often forms around a pocket of magma.



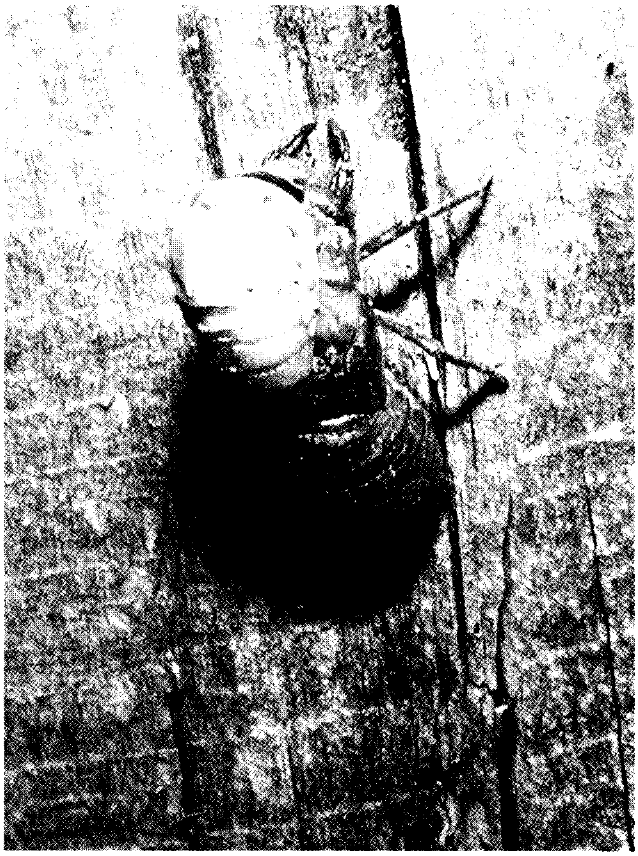
METAMORPHIC ROCK

This butte in Arizona is made of metamorphic rock. It was left standing when the softer sedimentary rock surrounding it was eroded away.

Hydrothermal metamorphism occurs in rocks near the earth's surface where there is an intense activity of hot water, such as near geysers (see SPRING AND GEYSER). The hot water changes the chemical composition of the rocks.

Dynamic metamorphism occurs when rocks are crushed and ground by tremendous pressure from the movements of the earth's crust. New minerals form from the rock's chemical composition (see MINERAL). Eclogite is an example of a rock that has been changed by dynamic metamorphism. Eclogite forms mainly from the minerals garnet and green pyroxene.

Dynamothermal metamorphism occurs when both heat and pressure change rocks. Through dynamothermal metamorphism, limestone becomes marble, sandstone becomes quartzite, and shale becomes slate.



METAMORPHOSIS (mĕt′ ə môr′ fə sĭs) is a series of striking changes in form that some organisms undergo as they mature. The word *metamorphosis* comes from a Greek word meaning "to transform." Hormones control the process of metamorphosis (see HORMONE).

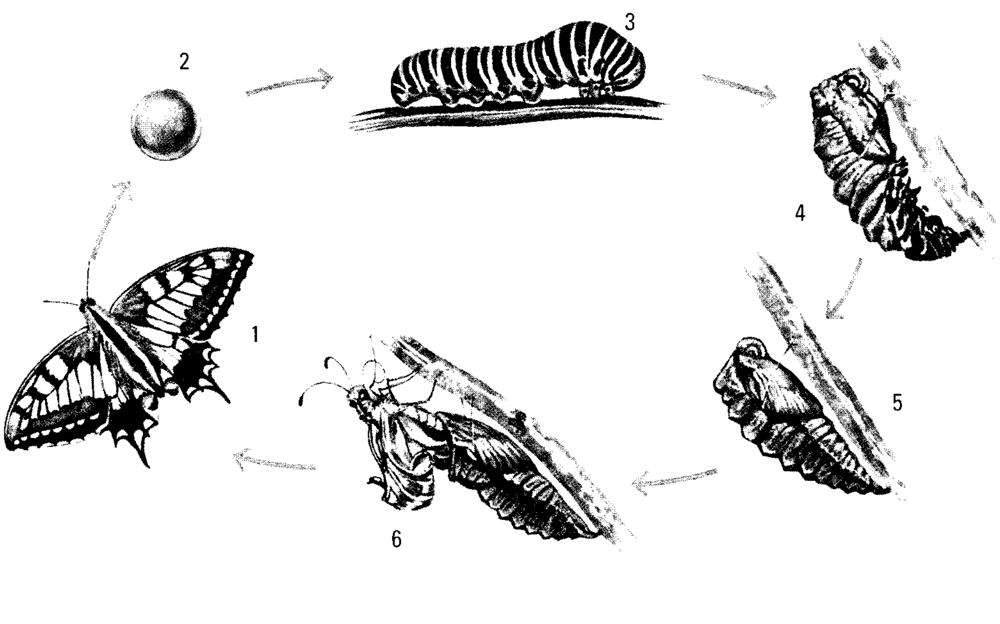
Most insects undergo metamorphosis. They may undergo complete metamorphosis or incomplete metamorphosis. In complete metamorphosis, the insect goes through four stages: egg, larva, pupa,

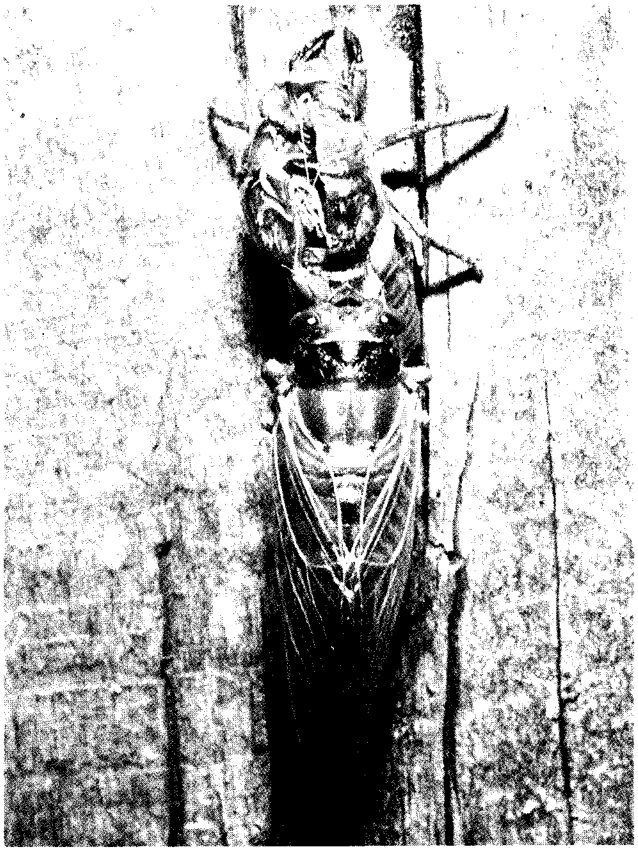
INCOMPLETE METAMORPHOSIS

The nymphal stage of the seventeen-year locust spends seventeen years underground. When it emerges (left) it sheds its skin (above and right) to become a winged adult (far right).

COMPLETE METAMORPHOSIS

(1) The female adult butterfly lays eggs soon after mating. The eggs are deposited on plants by the butterfly. An egg, shown greatly magnified here (2), is so small that it is almost invisible to the human eye. (3) The larva, or caterpillar, emerges from the egg. (4) The caterpillar feeds on plants until it reaches its full size. Then it is ready to become a pupa. (5) The pupa hangs from a twig. On the outside, it forms a hard shell called a chrysalis. (6) The newly formed butterfly leaves its shell. It will be able to fly in approximately one hour.





and adult. The larva is usually not at all like the adult in appearance or behavior and often has very different feeding habits (see LARVA). As it grows, it molts, or sheds its skin, several times before becoming a pupa (see MOLTING; PUPA). The pupa usually is more like the adult in appearance. Many of the adult structures, such as wings, have begun to develop. The most striking examples of complete metamorphosis occur in butterflies and moths (see BUTTERFLY AND MOTH).

Incomplete metamorphosis (or gradual metamorphosis) includes three stages of development: egg, nymph (or naiad), and adult. The nymph looks like a small adult but is wingless (see NYMPH). After the first molt, small wings appear as flaps of skin on the back. With each successive molt, the wings continue to develop until they are fully formed. Then, the insect is an adult. The grasshopper is a good example of an insect undergoing incomplete metamorphosis (see GRASSHOPPER). Grasshopper nymphs live in the same way as adults, but many nymphs live and behave very differently from the adults. Dragonfly nymphs, for example, live in water.

Many amphibians (such as frogs and toads) also undergo metamorphosis. Echinoderms, crustaceans, mollusks, sponges, cnidarians, sea squirts, and some fish also undergo this process. PROJECT 66

METCHNIKOFF, ELIE (mĕch′ nĭ kôf′, ā lē′) (1845–1916) Elie Metchnikoff was a Russian biologist who worked in France. He discovered how certain cells surround and engulf foreign particles. He named these cells phagocytes and this process phagocytosis.

Metchnikoff noticed that when foreign bodies, such as splinters, were introduced into the digestive system of starfish larvae, certain cells attacked the foreign bodies, preventing them from harming the animal. Metchnikoff reasoned that such cells also existed in other animals, including humans. He showed the importance of phagocytosis in the body's fight against infection (see IMMUNITY). For his discovery, Metchnikoff shared the Nobel Prize for medicine and physiology with Paul Ehrlich in 1908. Metchnikoff also suggested that phagocytes could sometimes attack a person's own body cells. This was later found to be true.

METEOR

A meteor (mē´ tē ər) is a piece of metallic or stony matter from outer space that gets caught in the earth's gravitational field. This causes the meteor to enter the earth's atmosphere (see ATMOSPHERE; GRAVITY). As the meteor enters the atmosphere, the heat caused by friction may raise the temperature of the meteor to 4,000°F [2,200°C] (see FRICTION). This heat causes the meteor to glow. Most meteors burn up completely at altitudes of 40 to 70 mi. [70 to 115 km] above the earth. Only the largest meteors reach the earth's surface.

No one is sure where meteors come from. Some may form from shattered asteroids or moons. Others may originate from comets (see ASTEROID; COMET; MOON). About 75 million visible meteors enter the earth's atmosphere every day.

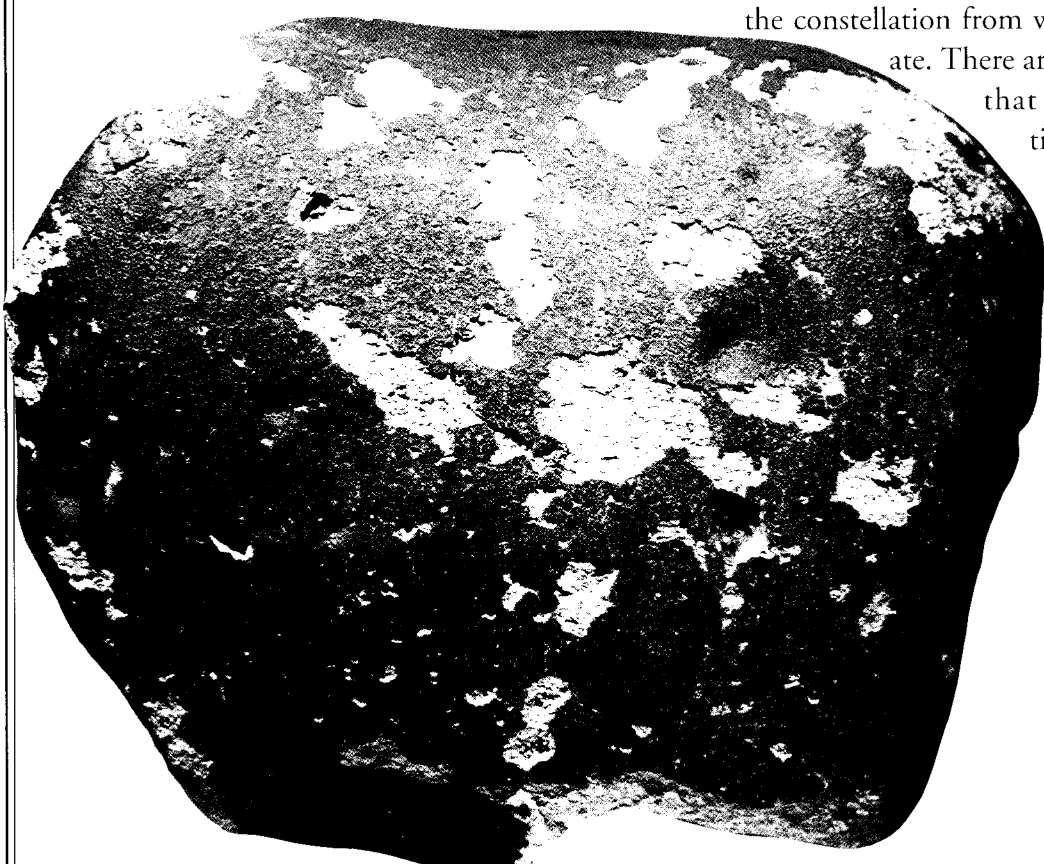
Before the meteor enters the earth's atmosphere, it is called a meteoroid. Meteoroids orbit the sun and are considered members of the solar system (see SOLAR SYSTEM). If the meteor reaches the earth's surface, it is called a meteorite.

Meteorites Meteorites are usually very large, since small meteors burn up before reaching the earth's surface. There are three main types of meteorites. Stony meteorites, called aerolites, contain stony minerals. Iron meteorites, called siderites, contain mostly iron and nickel. Meteorites that contain a mixture of stone and iron are called siderolites.

Meteorites are of great interest to scientists. Until the lunar landings, when astronauts collected moon rocks, meteorites were the only source of material from outer space. Astronomers have gained valuable knowledge about the formation of the universe by studying meteorites.

Meteor showers When the earth passes through a swarm of meteoroids, bright sparks and streaks in the sky form a meteor shower. No known meteorites have resulted from meteor showers. The meteoroids of a meteor shower are probably fragments of comets. Meteor showers are named for the constellation from which they seem to radiate. There are several meteor showers that occur about the same time each year. For example, the Leonid meteor shower, which seems to radiate from the constellation Leo, occurs about November 17 each year.

See also CONSTELLATION; COSMOLOGY.



STONY METEORITE
This meteorite was discovered in Antarctica. It is estimated to be 1,300 million years old.

Meteorology (mē′ tē ə rŏl′ ə jē) is the study of the atmosphere. Because all weather occurs in the troposphere (the lowest level of the atmosphere), meteorology is also the study of the weather.

Weather is the condition of the atmosphere at a given time in one place. Climate is the sum of all weather conditions in a place over a long period of time. Climate takes into account averages of temperature, precipitation, and wind (see PRECIPITATION; TEMPERATURE; WIND). Weather is constantly changing. Climate changes slowly over long periods of time. Weather and climate affect the way people dress, what kinds of work they do, the food they eat, and many other aspects of their lives.

Meteorologists (scientists who study meteorology) use chemistry, physics, and mathematics in their work. Chemistry is used when studying the gases that make up the atmosphere. Meteorologists analyze smog and other forms of air pollution using chemical principles (see POLLUTION; SMOG). Physics is closely related to meteorology. Through physics, meteorologists can explain precipitation (such as rain and snow), lightning, and other atmospheric phenomena (see LIGHTNING). Using mathematics, meteorologists can measure and forecast the movements of weather systems.

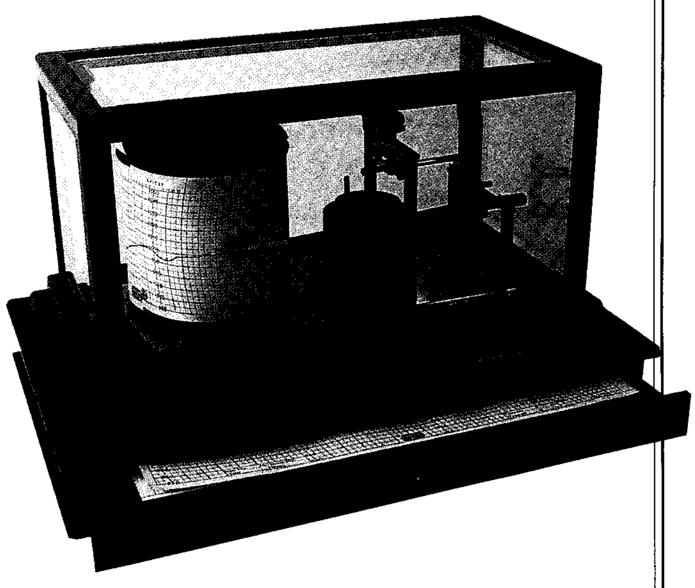
Meteorological instruments The meteorologist uses many instruments to study the weather. The most common instrument is the thermometer, which measures air temperature. A barometer is used to measure atmospheric (barometric) pressure. A drop in pressure often precedes the approach of stormy weather. A rise in pressure indicates a period of clear weather (see BAROMETER; THERMOMETER).

The wind is measured by an instrument called an anemometer. A hygrometer is used to measure the amount of water vapor in the air. A rain gauge is used to measure the amount of rainfall (see ANEMOMETER; HUMIDITY; HYGROMETER; RAIN GAUGE).

A radiosonde is a balloon that is sent up into the atmosphere. It takes measurements at different atmospheric levels. The information is then sent back to the earth. Wind speeds and other data (information) sent from a radiosonde can be used to forecast the development and movement of weather systems (see RADIOSONDE).

Weather satellites have been orbiting the earth since 1959. The satellites take photographs, which are sent back to Earth. A progression of photographs from satellites shows developing weather systems all over the world. Satellites have been especially useful in tracking hurricanes (see HURRICANE; SATELLITE).

Two kinds of weather satellites transmit weather information—polar satellites and geostationary satellites. The polar satellites circle the earth over both of the poles. Their orbits shift as the earth rotates. Because of the gradual shifting of their orbits, polar satellites take photos of the entire surface of the earth once every twelve hours. Geostationary satellites are stationary relative to the earth's rotation and thus are positioned in orbit over one area of the earth. Geostationary satellites pick up data constantly from the one area over which they fly. Advances in technology will soon



BAROGRAPH

A barograph is a barometer connected to a pen that traces a graph on a piece of paper. The paper is wrapped around a drum that is slowly rotated by a clockwork motor. The graph is a record of changes in air pressure over a period of time.

make it possible for satellites or space stations to monitor wind speeds, barometric pressures, and temperatures at very high altitudes, just as the radiosondes do at lower levels now.

A network of high-speed computers aids meteorologists in interpreting the data provided by radiosondes, satellites, and other sources. These computers are able to absorb millions of pieces of data and translate them into meaningful information with which meteorologists can forecast weather.

The history of meteorology For many centuries, people thought that the weather was under the control of various gods. If the weather was good, the gods were rewarding the people. Violent weather was considered the anger of the gods.

Modern meteorology began with the invention of the thermometer and the barometer in the 1600s. By the late 1700s, scientists realized that the weather was associated with moving air systems. With the development of the telegraph in 1844, weather information could be collected for the preparation of forecasts. In the early 1900s, radio made it possible for ships to transmit information about the weather.

About the time of World War I (1914–1918), a group of Norwegian meteorologists developed the polar front theory. This theory addressed how storms tend to form in the region where the cold polar air meets the warm subtropical air. This region is called the polar front (see POLAR FRONT).

In 1922, Lewis Fry Richardson, a British physicist, related temperature, humidity, and other factors to weather forecasting. He said that patterns could be observed based on changes in one or more of the factors and that similar patterns often lead to similar weather. Richardson also planned a grid system for covering the world in segments, with a weather observation station in the center of each segment. The observation stations would be used to accumulate information about current weather conditions from all over the world. Then forecasting could be done with greater accuracy. However, Richardson's plan was never put into effect. Today, only about 15 percent of the surface of the earth is

monitored regularly for weather data. Most of that monitoring takes place in the Northern Hemisphere. Since World War II (1939–1945), meteorologists have benefited from rapid technological advances. Radar is used to monitor storm systems. In some parts of the world, regularly spaced radar stations monitor large areas (see RADAR). Satellites have also been a great help to meteorology, giving meteorologists increased amounts of information and making forecasts more accurate.

The National Weather Service In the United States, weather forecasts are made by the National Weather Service. Forecasts are based on over forty thousand observations made on the earth each day, plus the information coming from satellites, ships, radiosondes, and aircraft. All this information is

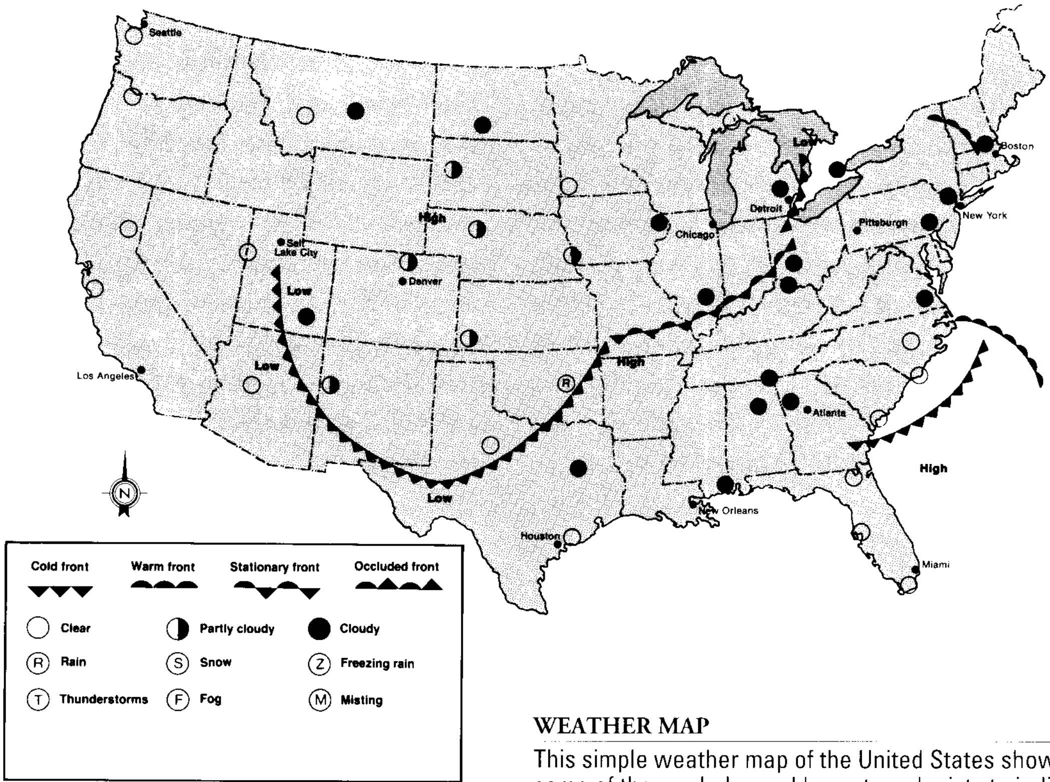
WEATHER SATELLITE
Photographs taken from orbiting satellites (left) provide meteorologists with information to produce weather forecasts. This view of North America shows storms in the Gulf of Mexico.

gathered together in a large computer facility at the National Meteorological Center in Maryland, near Washington, D.C. Twice daily, national forecasts are sent to regional weather service offices. Local meteorologists use the available data on nearby conditions to make local forecasts. Then the local forecasts are printed in newspapers and are broadcast on radio and television.

In addition to regular forecasts, the National Weather Service also provides agricultural forecasts regarding farming, ranching, and related industries; aviation forecasts for private and commercial aircraft; and marine forecasts about conditions on oceans and lakes. Many private forecasting services also operate to give specialized data to business and industry.

See also ATMOSPHERE; CLIMATE; WEATHER.

PROJECT 22, 24, 25



WEATHER MAP
This simple weather map of the United States shows some of the symbols used by meteorologists to indicate the weather. A stationary front is one that is not moving; an occluded front is one formed when a cold air mass overtakes a warm air mass and displaces it upward.

METHANE (mĕth′ ān′) Methane (CH_4) is a colorless, odorless gas. It is flammable (easily set on fire) and gives off a large amount of heat when it burns. Natural gas is mostly methane. Natural gas is used as a fuel. Methane is also found in marsh gas and coal gas (see COAL GAS; NATURAL GAS). It also occurs in firedamp. Firedamp is a mixture of gases found in coal mines. This mixture is dangerous because it explodes very easily.

Besides being used as a fuel, methane is also used to make other chemicals. Methane combines with chlorine to form chloroform, which is used as a solvent (substance that dissolves other substances) or an anesthetic (substance that causes loss of feeling). Methane can be oxidized to form formaldehyde, a preservative (see OXIDATION AND REDUCTION). Methane causes 40 percent of global warming through the greenhouse effect.

See also GREENHOUSE EFFECT.

METRIC SYSTEM The metric system is a group of units used to measure various properties, such as length, mass, temperature, and time (see UNIT). The metric system is also called the Système Internationale, or International System of Units, abbreviated as SI.

In the 1790s, a group of French scientists created the metric system. At various times, this system has undergone changes. Today, the metric system has replaced the customary system, which uses feet and pounds as basic units of measure, in most parts of the world. Units in the metric system increase or decrease in size by 10. For example, a meter has 10 parts called decimeters. A decimeter has 10 parts called centimeters.

The meter is the base unit for length or distance in the metric system. A meter is a little longer than a yard. Shorter lengths are commonly measured in centimeters or millimeters. A centimeter equals about 0.4 inches. A pencil may be measured in centimeters. A millimeter is equal to about 0.04 inches. Tiny mechanical parts are often measured in millimeters. Long distances, such as those between cities, are measured in kilometers. A kilometer is equal to about 0.621 miles. A shorter length, such as the height of a flagpole, is usually measured in meters.

A surface measurement tells how much of an area something covers. Many areas, such as that of a floor, are measured in square meters. A square meter is equal to the surface covered by a square one meter long on each side. A square meter is slightly larger than a square yard. Square centimeters or square millimeters may be used to measure smaller areas. Land may be measured in units called hectares. A hectare equals 10,000 square meters, or roughly 2.5 acres. Some large land areas are measured in square kilometers.

Volume and capacity measurements tell how much space something occupies. Volume and capacity are both measured in cubic units, such as cubic meters or cubic centimeters. A cubic meter is equal to the volume covered by a cube one meter on each side. Most capacity measurements for liquids are made in units called liters. A liter, equal to a cubic decimeter, is a little larger than a liquid quart. Smaller units include the milliliter, which equals a cubic centimeter.

The kilogram is the base unit of mass in the metric system (see MASS). It equals about 2.2 pounds in the customary system. The gram is used for smaller measurements. A gram equals 0.001 kilogram. Bulk goods are weighed in metric tons. A metric ton equals 1,000 kilograms. A metric ton equals about 1.1 short tons in the customary system. In the metric system, weight, which differs from mass because it is related to the force of gravity, often is measured in newtons but may be measured in kilograms (see NEWTON).

In the metric system, the second is the basic unit of time. The metric system measures time exactly as the customary system does (see TIME).

The Kelvin scale is used to measure temperature in the metric system. The Kelvin scale begins at absolute zero. Therefore, for most measurements, people use the Celsius scale rather than the Kelvin scale. One degree on the Kelvin scale is equivalent to one degree on the Celsius scale (see CELSIUS SCALE; KELVIN SCALE). Water freezes at 0°C or 273.15 K and boils at 100°C or 373.15 K.

In the metric system, the ampere is the base unit for electrical measurements. The mole is the base unit for measuring the amount of any substance involved in a chemical reaction. The candela is the base unit for measuring light (see AMPERE; CANDELA; MOLE).

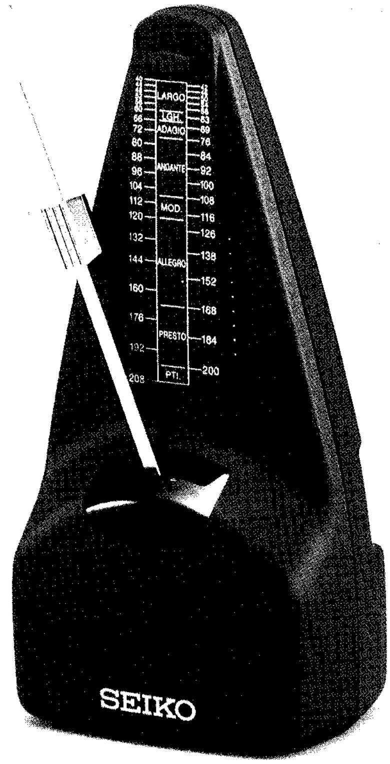
The United States is the only major country that does not use the metric system as its standard measurement system. In 1975, the U.S. Congress passed a bill that asked for voluntary conversion from the customary system of measurement to the metric system. The U.S. Metric Board was formed to help a gradual conversion take place. In 1982, Congress ended funding for the board and created the Office of Metric Programs. This office promotes the use of the metric system in business and industry. The public does not yet generally use the metric system. Business and industry often use both the metric and customary systems of measurement. For example, sewing patterns include instructions given in centimeters and inches. Automobile speedometers have kilometers-per-hour markings along with miles-per-hour markings. Because many U.S. products are traded around the world, the use of metric measurements in business and industry is increasing. The metric system will probably some day replace the customary system of measurement in the United States.

For tables showing conversions between the base units in the metric and customary systems, see METRIC CONVERSION TABLE, VOL. 23.

METRONOME (mĕt′ rə nōm′) A metronome is a device that beats time for musicians. The most common version consists of a triangular wooden box about 8 in. [20 cm] high containing an upside-down pendulum. A spring mechanism that winds up with a key makes the pendulum swing back and forth. A movable weight on the pendulum can be adjusted to make the pendulum swing faster or slower. A scale behind the pendulum shows where to place the weight for the desired number of beats per minute. Each time the pendulum swings, it makes a loud clicking sound for the musician to hear. Some metronomes are operated by electricity rather than by a spring wind-up.

The metronome was invented by the German inventor Johann Maelzel. He first began to manufacture the device in 1816.

See also PENDULUM.



METRONOME

This modern metronome is an electronic device that beats time very accurately.

MICA (mī′ kə) Mica is a type of silicate mineral that breaks easily into separable sheets. Micas contain aluminum, oxygen, and potassium, as well as silicon (see MINERAL; SILICA; SILICON). There are several types of mica. The most important are muscovite, phlogopite, lepidolite, and biotite. Their crystals form thin, flaky sheets.

Muscovite is a kind of mica that contains mostly aluminum and potassium. It is called muscovite because it was once used for windowpanes in Moscow, Russia. It is transparent in thin sheets and translucent in thicker blocks. (Transparent substances allow almost all light through; translucent substances allow light through, but you cannot see through them.) Other names for muscovite are white mica and common mica. It is colored in light shades of yellow, brown, green, or red. Today, muscovite is used as an insulation material in electrical appliances (see INSULATION).

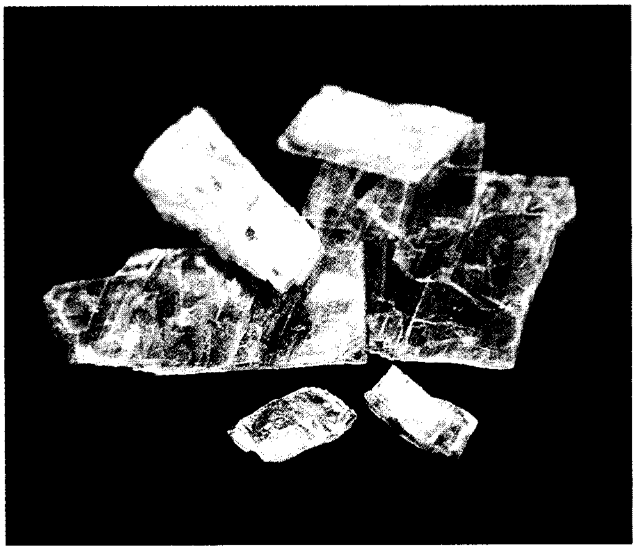
Phlogopite, which contains potassium, magnesium, and aluminum, is transparent in thin sheets and pearly or glassy in thick blocks. It is yellowish brown, green, or white in color. Like muscovite, phlogopite is used as an insulating material in the manufacture of electrical appliances and components.

Lepidolite, or lithia mica, contains potassium, lithium, and aluminum. It is usually lilac or pink in color. Lepidolite is an important source of the element lithium.

Biotite is usually found in igneous rock (see IGNEOUS ROCK). It contains potassium, magnesium, iron, and aluminum and has a very glossy appearance. Biotite is usually dark green, brown, or black in color.

Scrap mica, obtained as waste material in the manufacture of sheet mica, is used as a lubricant when mixed with oils. It is also used as a fireproofing material.

The main producers of mica are the United States, Brazil, and India. In the United States, most mica is found in North Carolina, New Hampshire, and South Dakota.



MICA

Crystals of the muscovite type of mica form thin, flaky sheets. It is used as an electrical insulator.

MICHELSON, ALBERT ABRAHAM

(1852–1931) Albert Abraham Michelson was a German-born American physicist. He came to the United States with his parents when he was two years old. Michelson was graduated from the U.S. Naval Academy at Annapolis, Maryland, in 1873 and later taught chemistry and physics there. In 1878, Michelson began his research on measuring the speed of light. In 1880, he invented an instrument called the interferometer (see INTERFEROMETER).

In 1887, Michelson worked with American chemist Edward Morley to determine the velocity (speed) of the earth through the "ether." Scientists at that time thought that "ether" was the material through which light and heat were transmitted in space. It was believed that this substance was both invisible and odorless and that it filled all the unoccupied space around us.

The Michelson-Morley experiment demonstrated that the motion of the earth is not measurable relative to the "ether." In other words, the "ether" does not exist. As a result of their experiment, Michelson and Morley discovered that the speed of light remains the same and does not change relative to other moving bodies. To understand this concept, picture throwing a ball forward on a moving train. A person standing on the ground would see the ball moving at the speed it was thrown plus the speed that the train was moving. Before Michelson and Morley did their experiment, people thought that light behaved in the same way—that it would travel faster from a moving body. Michelson and Morley showed that this was not true. Their research helped Albert Einstein develop his theory of relativity (see EINSTEIN, ALBERT; RELATIVITY).

In 1893, Michelson used the interferometer to measure the meter, calibrating it in terms of light. This is how the meter is measured as part of the International System of Units (see CALIBRATION; METRIC SYSTEM). In 1927, Michelson refined earlier measurements of the speed of light.

Michelson was awarded the Nobel Prize for physics in 1907. He was the first American to receive a Nobel Prize in science. His other achievements include the measurement of the diameter of the star Betelgeuse as 240 million mi. [386 million km] in 1920.

MICROBIOLOGY

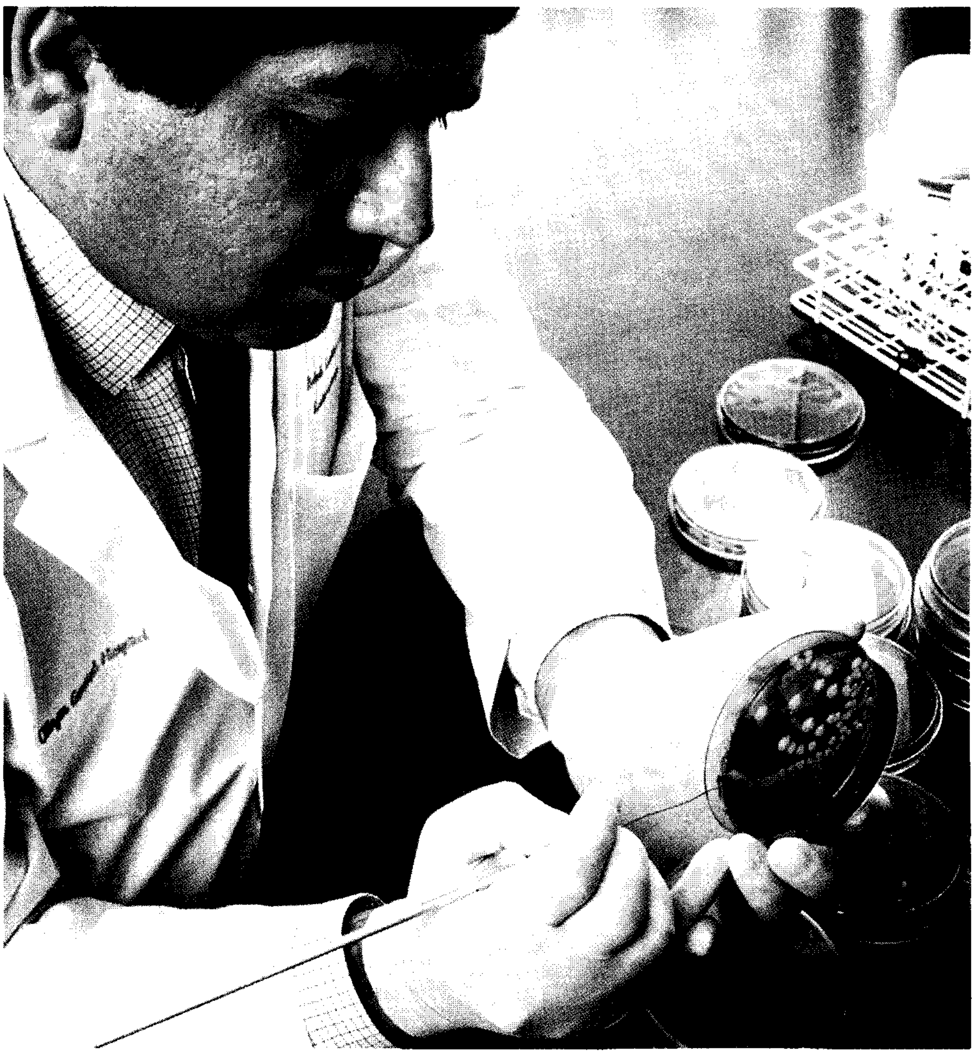
Microbiology is the study of forms of life too small to be seen without the use of a microscope. Microbiologists study such organisms as bacteria, microscopic algae and fungi, protozoans, and viruses. Such organisms are called microorganisms or microbes. Nearly all microorganisms measure less than 0.004 in. [0.1 mm] across. To see many microorganisms, microbiologists may use microscopes that can magnify up to two thousand times. To see viruses, much greater magnification is needed. This is provided by the electron microscope, which can magnify objects many thousands of times. The electron microscope can also show microorganisms in great detail (see ALGAE; BACTERIA; ELECTRON MICROSCOPE; FUNGUS; MICROORGANISM; MICROSCOPE; PROTOZOA; VIRUS).

Many microbiologists specialize in the study of certain types of microorganisms. For example, bacteriologists study bacteria, mycologists study fungi, and virologists study viruses.

Viruses do not have true cell structure. They

POISONOUS MICROBES

This photograph (above), taken with an electron microscope, shows a colony of the bacteria known as *Salmonella*. These bacteria can cause a dangerous form of food poisoning.



STUDYING BACTERIA

Microbiologists study bacteria by growing them in glass dishes containing the jellylike material agar. Here a scientist uses a piece of platinum wire to "streak" bacteria onto the agar.

become active organisms only when they enter the living cells of another organism. All other microorganisms are cellular, having cytoplasm, membranes, and nuclear material (see CELL). Bacteria are the smallest single-celled organisms. The smallest bacteria may only measure 0.000015 in. [0.0004 mm or 0.4 microns]. (A micron equals 0.001 mm or 0.000039 in.) Viruses are much smaller than the smallest bacteria. For example, about ten thousand small viruses could fit into a cell the size of one of these bacteria. Even smaller than viruses are the recently discovered viroids and prions. Only one-tenth of the size of the smallest virus, a viroid consists simply of a few molecules of the nucleic acid RNA without the protein coat typical of viruses. Viroids cause various diseases in plants. Prions are particles of protein less than one-hundredth the size of a virus.

General microbiologists study the basic features of microorganisms, including structure, genetics, and metabolism (see GENETICS; METABOLISM). Much of our knowledge about the functions of cells of plants and animals has come from such basic studies of microorganisms.

Microorganisms are essential in producing products such as alcoholic beverages, cheeses, pickles, and antibiotics (see ANTIBIOTIC). Industrial microbiologists study the microorganisms involved in these processes and ways to help them grow. Bacteria and algae have also been grown in large quantities as a means for providing protein for domestic animals. The microorganisms can be fed on many sorts of waste materials. Thus, the protein of their cells is produced quite inexpensively. Further development of these microbiological processes may eventually help solve worldwide food shortage problems.

Microorganisms also play an important part in sewage treatment and pollution control—for example, cleaning up oil spills in the oceans. Some microbiologists study the microorganisms involved in treating sewage and in controlling pollution (see SEWAGE TREATMENT).

Although most microorganisms carry out activities that are beneficial to other organisms, a few of them cause infectious diseases (see DISEASE; INFECTION; PATHOGEN). Microbiologists work to develop new drugs to treat infectious diseases. All large hospitals need microbiologists to carry out tests for the identification of microorganisms that cause disease. Bacteria are identified by their size, shape, and reaction to dyes, and by end products of their biochemical reactions (see BIOCHEMISTRY). Disease-causing fungi and protozoans are sometimes identified by biochemical tests. More often, their shapes when viewed through a microscope are enough to identify them. Viruses are usually identified by the effects they have on living cells and by their shapes as shown by the electron microscope.

See also BIOLOGY.

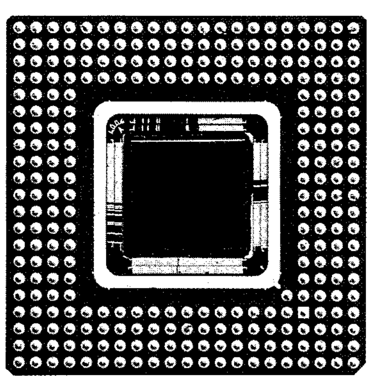
USEFUL MICROBES

Microbiology plays an important role in the production of cheese. There are hundreds of kinds of cheeses, each produced by the action of microbes on whey (a solid separated from curdled milk).

MICROCHIP A microchip, also known as a semiconductor chip or an integrated circuit, is a tiny wafer of a semiconductor material, such as silicon. Ordinarily silicon is a poor conductor of electricity. But in a microchip, silicon is mixed with tiny amounts of other materials to make it a good conductor of electricity. By varying the placement of the mixed-in materials, a large number of many different types of electrical components can be built into the surface of the wafer. One microchip can do the work of thousands of individual electronic devices. Microchips are also much more reliable than other types of circuits.

Techniques have also been developed to make it possible to produce low-cost microchips. As a result, microchips are now commonly used in a wide range of items, including calculators, washing machines, video games, and some types of credit cards. By adding memory and logic circuits, a microchip can be made into a microprocessor, which is the chip that carries out the instructions for computer programs

See also CHIP; COMPUTER; INTEGRATED CIRCUIT.

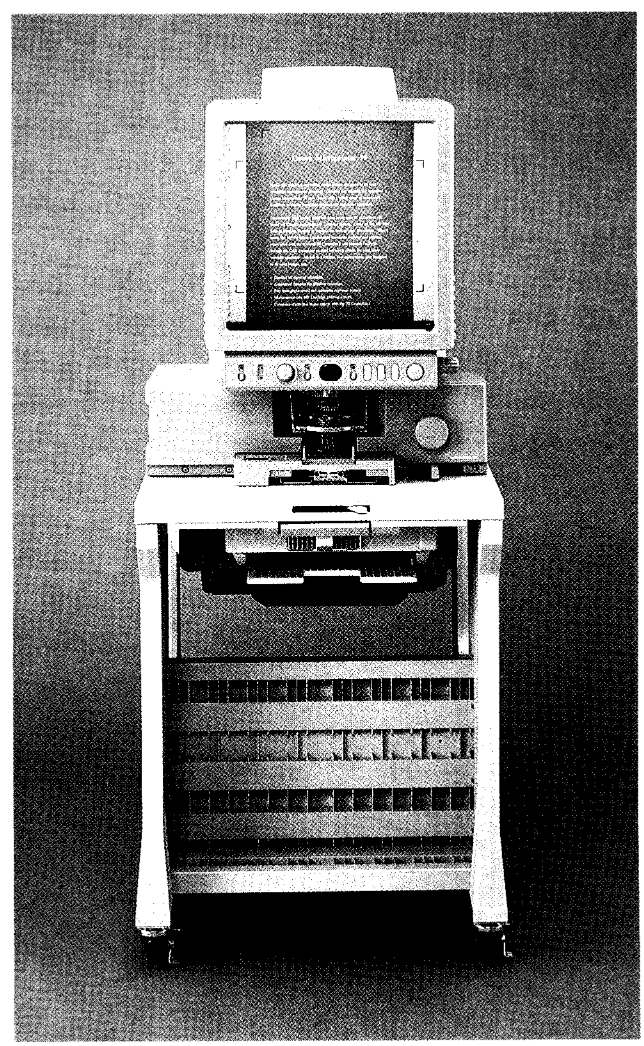


MICROCHIP
The Intel Pentium chip is a microprocessor. It carries out the programmed instructions in a high-speed personal computer.

MICROELECTRONICS Microelectronics is the branch of electronics that concentrates on making smaller individual electronic components and electronic circuits. The development of integrated circuits and microchips greatly helped the microelectronics industry (see CHIP; INTEGRATED CIRCUIT; MICROCHIP).

The growth of the microelectronics industry has affected our lives in many ways because it has made a huge range of small and inexpensive electrical goods widely available. As the costs of producing microchips and integrated circuits have come down, these components have become very widely used in products such as personal computers, watches, calculators, remote control devices, televisions, and video recorders. New uses for microchips and integrated circuits are being found very quickly.

MICROFILM Microfilm is a small piece of photographic film on which reduced images of printed matter and other material are recorded. Microfilm stores a large amount of information in a small space. For example, the contents of an entire book can be recorded, page by page, on a



MICROFILM
A microfilm reader is a type of film projector. It has a screen that displays an enlarged image of words or pictures stored on microfilm.

short strip of microfilm 1.37 in. [35 mm] wide. The film strip can then be wound on a small spool and stored in a fraction of the space occupied by a book.

The microfilm copy of the book can be read by putting it in a projection machine, called a microfilm reader, that enlarges the image. Some projection machines can make a paper copy of the enlarged image. Most microfilm is black and white.

A microfilm strip that has been cut into short pieces and placed in a plastic card is called a microfiche. A microfiche measures about 4 by 6 in. [10 by 15 cm].

Microfilm has many uses. A small library can be contained in a few small boxes of microfiches. Businesses, newspaper publishers, libraries, and government offices use microfilm extensively. Architects and engineers can store large, detailed drawings on microfilm.

The process of making microfilm copies is called microphotography. It became a large industry in the United States after the Library of Congress began to microfilm books in 1928.

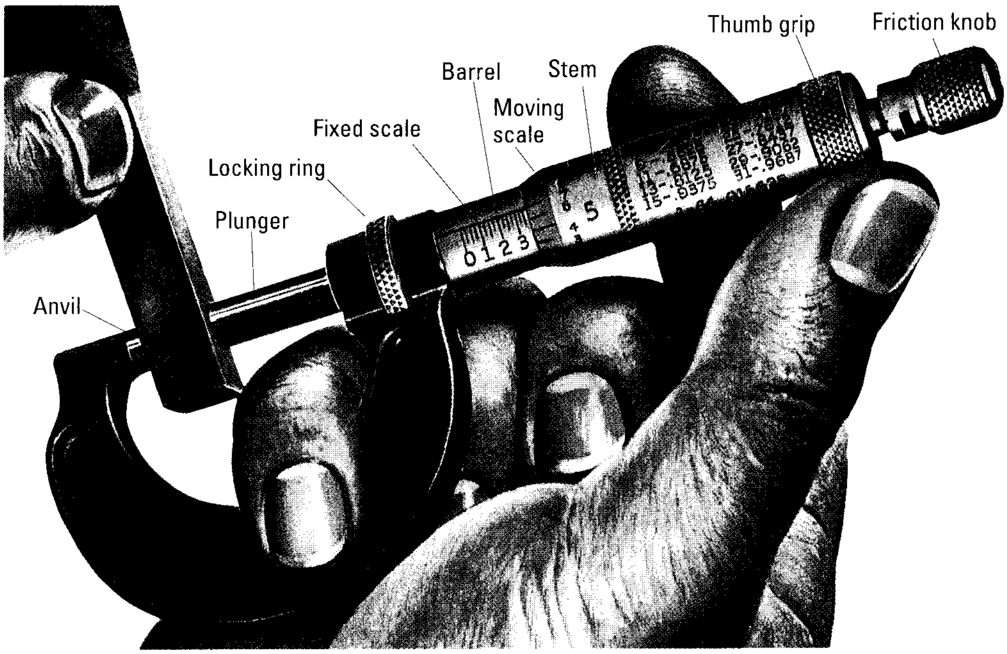
MICROMETER A micrometer is an instrument for measuring small dimensions. One of the most common types of micrometers is the micrometer caliper. A micrometer caliper can measure accurately to 0.0001 in. [0.0025 mm]. Micrometer calipers are used by machinists and auto mechanics.

Surveyors' instruments have micrometers. Microscopes often have micrometers attached. Astronomers use a type of micrometer to measure the distance between stars on photographic plates.
See also CALIPER, MEASURING.

MICRON *Micron* is a name formerly used for the unit of length in the metric system now known as the micrometer (symbol *μm*). This unit is one-millionth of a meter.
See also METRIC SYSTEM.

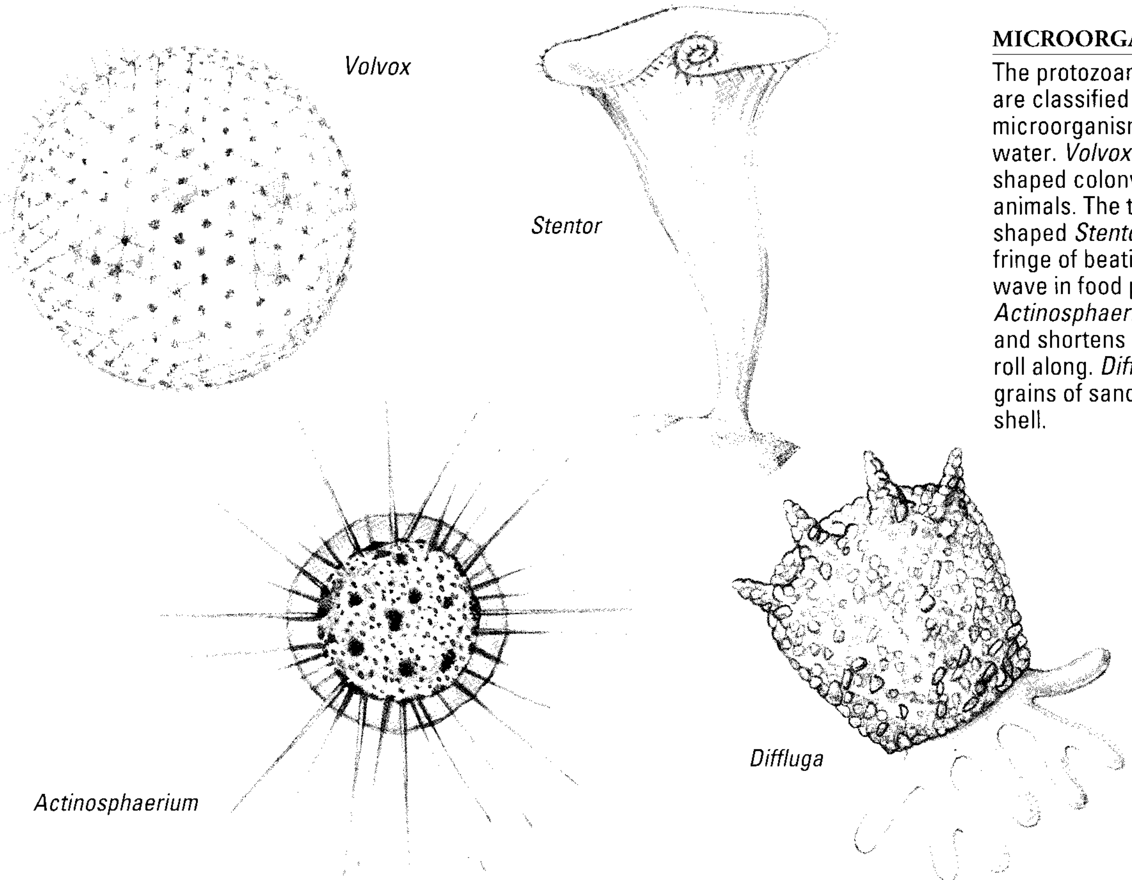
MICROORGANISM (mī′ krō ôr′ gə nĭz′ əm) A microorganism is any of a number of types of microscopic organisms. Most microorganisms are single-celled or have only a few cells. Microorganisms include bacteria, microscopic kinds of algae and fungi, and protozoans. Viruses are often included in the list, though they are unlike other living organisms in certain ways (see ALGAE; BACTERIA; FUNGUS; PROTOZOA; VIRUS).

A few kinds of microorganisms can cause disease. Such microorganisms are called pathogens (see PATHOGEN). However, the majority of microorganisms are harmless. In fact, they are important for carrying on life processes in other organisms. For example, microorganisms live in the digestive systems of most animals and aid in



MICROMETER

The illustration shows the way to hold a micrometer caliper. This instrument can measure accurately to the nearest ten-thousandth of an inch [0.0025 mm].



MICROORGANISM

The protozoans shown here are classified as types of microorganisms that live in water. *Volvox* is a ball-shaped colony of many animals. The trumpet-shaped *Stentor* uses a fringe of beating hairs to wave in food particles. *Actinosphaerium* lengthens and shortens its "spines" to roll along. *Diffluga* uses grains of sand to build a shell.

the breaking down of certain foods (see SYMBIOSIS).

Some microorganisms are used by people to make vinegar, cheese, bread, antibiotics, and other useful substances (see ANTIBIOTIC). Vast numbers of bacteria are also involved in purifying sewage (see SEWAGE TREATMENT). Many microorganisms, including bacteria, protozoans, and fungi, live in countless billions in soil and water. These microorganisms make possible the nitrogen cycle and also provide most of the carbon dioxide in the air.

See also CARBON CYCLE; MICROBIOLOGY; NITROGEN CYCLE.

MICROPHONE A microphone is a device for changing sound into electrical signals. These signals can then be broadcast through the air or sent over wires to distant points where they can be changed back into sound again. Radio and television stations use microphones to pick up the sounds they want to broadcast. Microphones serve a similar purpose in public address systems and in making sound recordings and the sound portion of motion pictures. Telephones also use microphones for transmission.

The main types of microphones are: carbon, crystal or piezoelectric, moving coil or dynamic, condenser or capacitor, and ribbon. Condenser, moving coil, crystal, and carbon microphones contain a thin metal piece called a diaphragm, which is stretched like a drumhead inside a rigid frame. The diaphragm is part of an electrical circuit. When sound waves strike the diaphragm, they make it vibrate. These vibrations produce corresponding electrical signals by varying the strength of the electric current that flows through the circuit (see CIRCUIT, ELECTRIC; CURRENT, ELECTRIC).

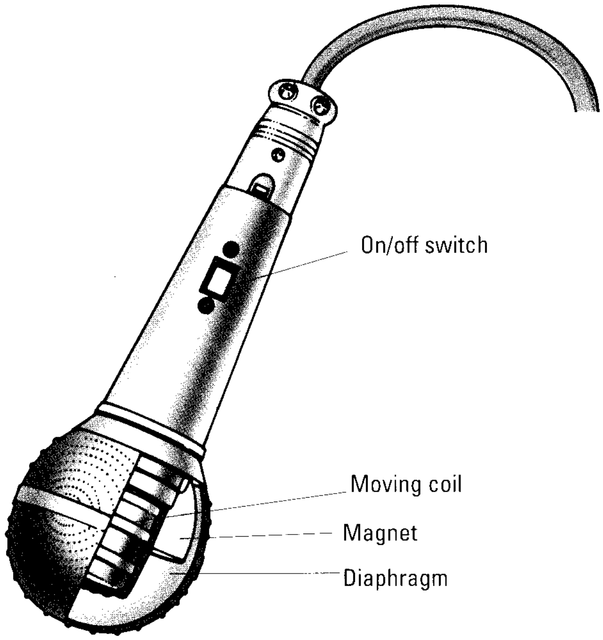
In the condenser microphone, the vibrating diaphragm changes the capacitance of a condenser (see CAPACITOR AND CAPACITANCE; CONDENSER). The moving coil microphone works opposite of the way a loudspeaker works (see LOUDSPEAKER). In the crystal microphone, the vibrating diaphragm twists a piezoelectric crystal, producing an electric current (see PIEZOELECTRIC EFFECT). A carbon microphone works like a telephone transmitter (see TELEPHONE).

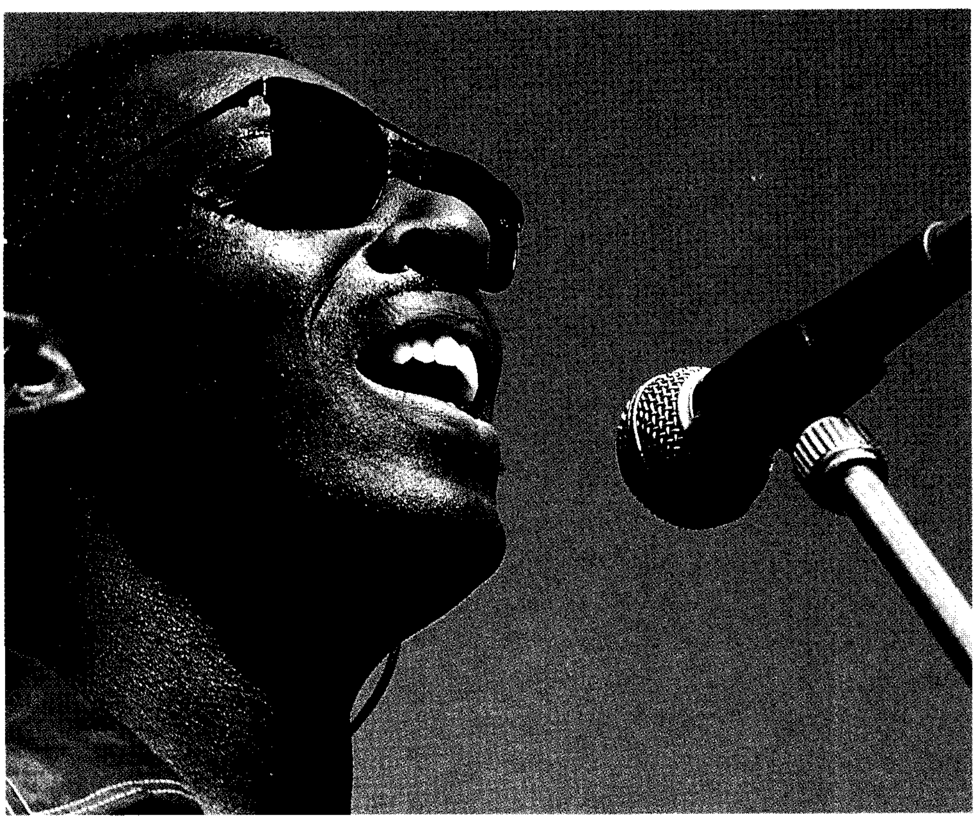
In contrast, ribbon microphones have a light ribbon of aluminum foil loosely held in a strong magnetic field. Sound waves make the ribbon vibrate. The movement of the ribbon in the magnetic field generates varying amounts of current in the ribbon. This produces an electric signal (see ELECTROMAGNETISM; MAGNETIC FIELD).

Microphones have been developed for many uses. Small pencil or studio microphones are used when they will be seen by audiences. Broadcasters and entertainers often wear personal microphones called lavalier or lapel microphones. Wireless microphones have been developed so that entertainers can be free to move about the stage without worrying about tripping over wires.

Nondirectional, or omnidirectional, microphones detect sounds from any direction. Unidirectional microphones are sensitive to sounds from only one direction. A metal arm called a boom may be used to hold one or more microphones over the heads of actors appearing before television or motion-picture cameras. The boom can be raised, lowered, or tilted to follow the actors. However, the microphones remain out of camera range.

Several people have been credited with the invention of the microphone, including the American inventor Thomas Alva Edison (see EDISON, THOMAS ALVA). The first practical microphone, however, was invented in 1878 by David Edward Hughes of the United States. Other inventors who contributed to the invention of the microphone include Emile Berliner, Philip Reis, Francis Blake, and Henry Hunnings.





MICROPHONE

The moving coil microphone (above and left) is commonly used by singers in recording studios or on stage.

A microscope is an instrument used to examine objects that are too small to be seen with the unaided eye. The object being examined is usually called the specimen.

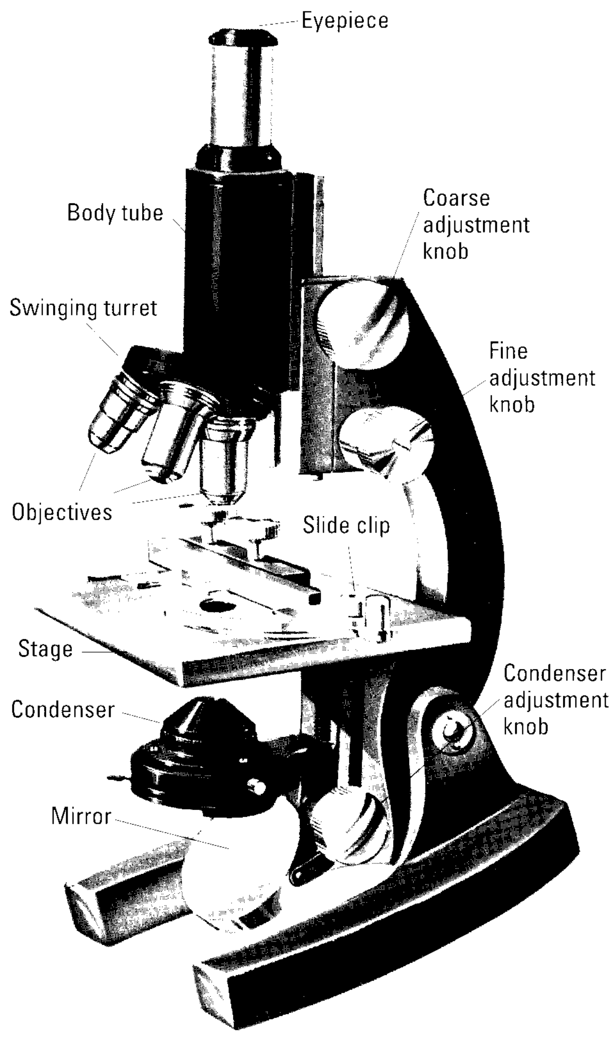
Parts of a microscope A microscope has one or more lenses. These lenses produce a magnified, or enlarged, image of the specimen (see LENS; MAGNIFICATION). If the microscope has one lens, it is called a simple microscope. A hand lens, or "magnifying glass," is a simple microscope. A microscope that has more than one lens is called a compound microscope. A compound microscope can produce a much greater magnification than can a simple microscope. It can produce an image hundreds or thousands of times larger than the specimen.

The simplest type of compound microscope has two kinds of lenses. They are called the objective lens and the ocular, or eyepiece, lens. Light passes from the specimen to the objective lens. In some microscopes, the light is reflected off the specimen. The objective lens produces a magnified image. Usually, a microscope has several different objective lenses. Each one gives a different magnification. They are attached to a turret on the microscope. The turret can be turned to bring a different lens into position. The image produced by the objective lens is then magnified by the eyepiece lens. The eyepiece lens can be single or double. If it is double, the eyepiece is called binocular. With a binocular eyepiece, both eyes are used to view the image. The eyepiece produces an inverted image. This means that the image of the specimen is upside down and right to left.

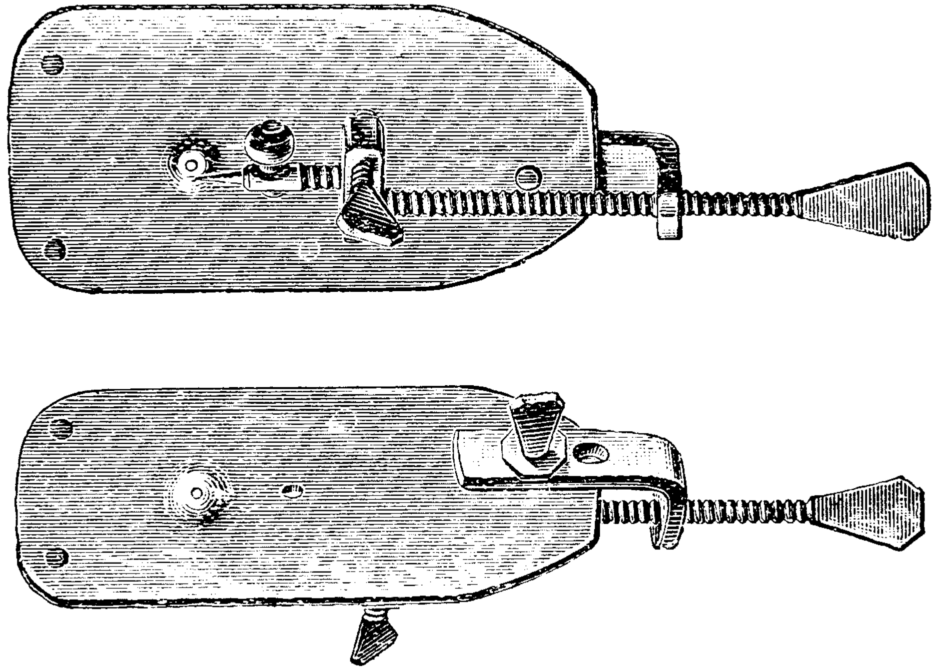
In order to examine a specimen, it is first mounted on a glass slide. The slide is then held by clips on the microscope stage. The slide can be moved about on the stage. This allows different parts of the specimen to be examined. The specimen often needs to be moved by only a very small amount. This is done by using two knobs that are attached to the stage. One knob moves the specimen from side to side. The other moves it forward and backward.

The distance of the objective lens from the specimen can be varied. The required distance depends on the magnification produced by the objective. A powerful objective has to be brought very close to the specimen to be in focus. This is done by two knobs. One knob is used for large movements. It is called the coarse adjustment knob. The other knob is used for small movements. It is called the fine adjustment knob. The fine adjustment knob brings the specimen sharply into focus.

Most stages have a hole in the center. The specimen is placed over this hole and light is passed up through it. The light used is often ordinary



MODERN MICROSCOPE
A modern student's microscope has a condenser to concentrate light (reflected from the mirror) onto the specimen on the stage. A turret has three objective lenses of different magnifications—from low- to high-power.



FIRST MICROSCOPES

The first microscopes are termed simple microscopes (left) because they had a single lens. They were constructed in the late 1600s by the Dutch lensmaker and naturalist Anton van Leeuwenhoek.

daylight. Sometimes an electric lamp is used. The light is reflected off a mirror and through a lens called a condenser. The condenser focuses the light onto the specimen. Without the condenser, the image of the specimen would be very dim.

Microscopes can be used to measure specimens. This is done by using a scale engraved on a glass disk. The disk is placed inside the eyepiece. The eyepiece magnifies the scale, and it can be used to measure an object.

Preparing the specimen Different kinds of specimens have to be prepared in different ways before they are examined. For example, samples of pond water containing small organisms can be placed directly on the slide. The sample is then covered with another, thinner glass slide called a cover slip. Samples of very small particles to be viewed are first immersed in oil. The oil is called the mounting medium. The oil with the particles in it is then placed on a glass slide.

Only very thin specimens can be examined under a microscope. For larger specimens, thin slices have to be cut for viewing. For animal and plant tissue, slicing is done with an instrument called a microtome (see MICROTOME). These slices are then mounted on a slide. Sometimes they are stained with chemicals. Depending on the stain used, various details of the specimen will be clearly seen. For hard substances, such as rocks, slices are cut with a

MICROSCOPE IMAGE

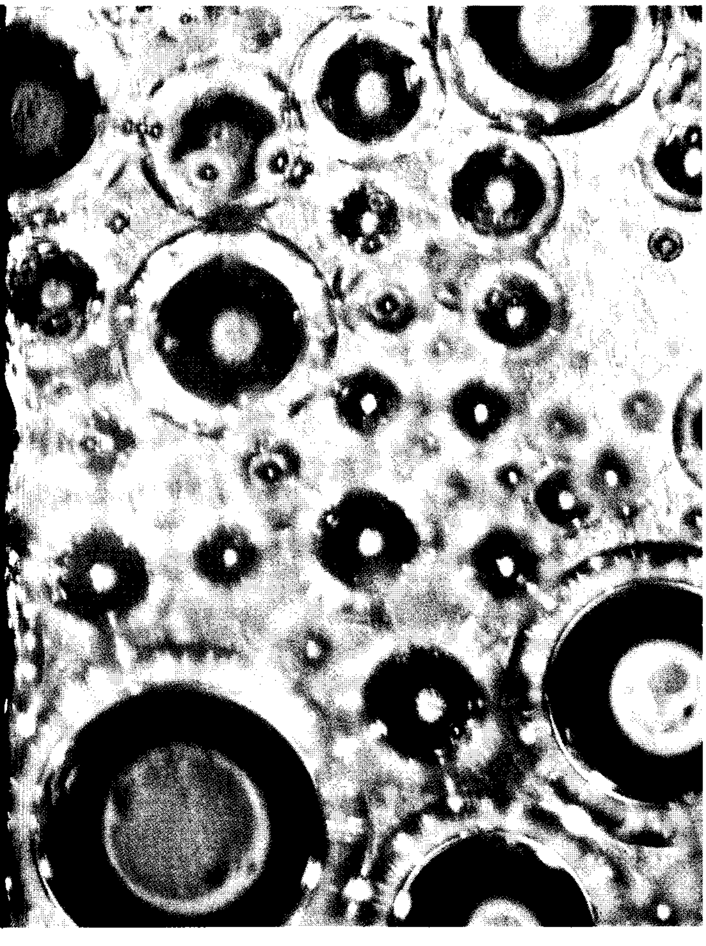
Like most branches of science, biology and medicine make frequent use of microscopes. This picture (right) shows a sample of saliva taken through a low-power microscope.

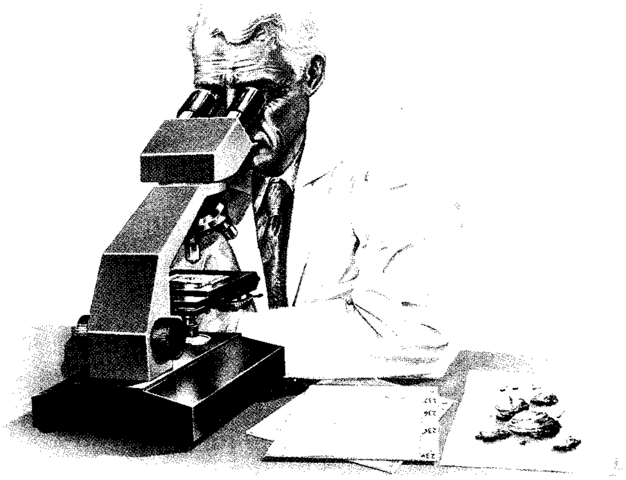
diamond saw. Only a diamond is hard enough to cut through most rocks. The rock slices are mounted in a plastic or in a hard resinous substance called Canada balsam.

A different method of preparation is used for metals. The metal surface is smoothed and polished. The surface is sometimes stained with chemicals to show its structure.

Magnification The amount of magnification a microscope produces can be increased in a number of different ways. Lenses of shorter focal length can be used. Another method is to immerse the specimen and the lower surface of the objective lens in oil. This increases the amount of detail that can be seen.

Another method is to increase the frequency of the light used. The frequency of light is the number of times that it vibrates in a second (see FREQUENCY). Blue light has a higher frequency than red light. For every frequency of light, there is a maximum magnification that can be reached. At





BINOCULAR MICROSCOPE

A binocular microscope has two eyepieces, one for each eye. It produces 3-D images that reveal the structures of specimens. Here a geologist (a scientist who studies rocks) is using a binocular microscope to examine samples of rock.

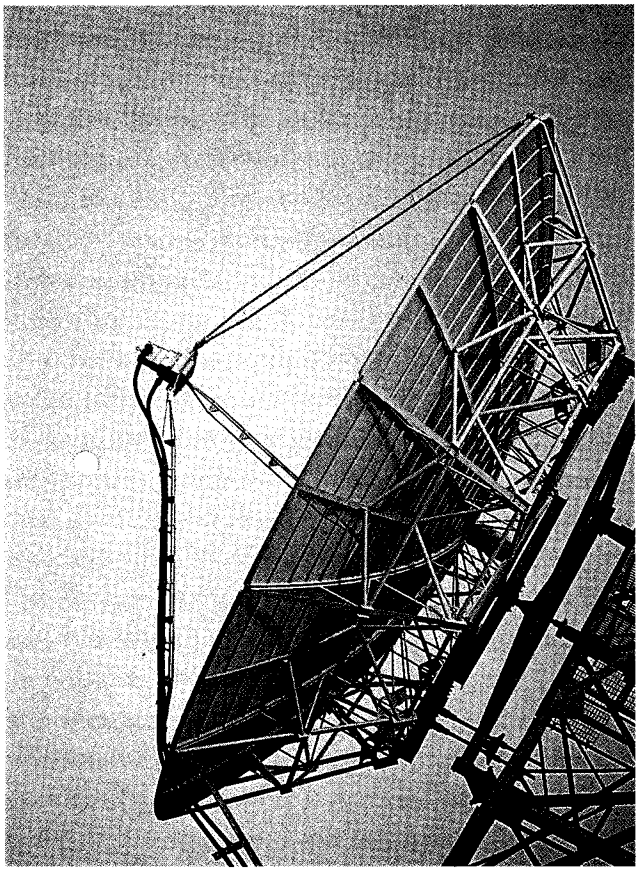
higher magnifications, the image becomes fuzzy. The higher the frequency of the light, the greater is the magnification that can be reached. Microscopes sometimes use blue or ultraviolet light. They have a higher frequency, and thus allow a higher magnification, than ordinary white light (see LIGHT; ULTRAVIOLET RAY).

For even higher magnifications, light is not used at all. Instead, beams of very small particles called electrons are used. These beams can have a very high frequency. Microscopes that use beams of electrons are called electron microscopes (see ELECTRON MICROSCOPE). An electron microscope can examine an object as small as a millionth of a centimeter in size.

Objects as small as individual atoms can be observed using scanning tunneling and atomic force microscopes. In these types of microscopes, a probe is held close to the surface of the sample. Electrons travel, or tunnel, between the sample and the probe and produce an electrical signal. In order to "see" the specimen, the probe is moved across its surface and raised and lowered so that the signal remains constant. By recording the movements of the probe, it is possible to use a computer to make a map of the surface of the specimen.

MICROWAVE A microwave is a very short electromagnetic wave. It varies in length from 0.04 to 12 in. [1 mm to 30 cm]. Microwaves, like light waves, may be reflected (turned back) and focused (concentrated). However, microwaves can pass more easily through rain, smoke, and fog than light waves. Microwaves have many varied uses.

A common use of microwaves is in cooking. Microwaves penetrate and heat the interior of food by agitating (shaking) the molecules in the food. This method cooks food much faster than if heat is applied to the food's exterior, as in a regular oven. Most microwave ovens have sides made of metal and a glass door with a metal screen. The metal prevents the microwaves from escaping. Because microwaves may destroy body tissue with which they come in contact or interfere with artificial heart pacemakers, microwave ovens must meet specific safety requirements. For example, microwave doors have seals to prevent microwaves from leaking. In addition, a safety switch stops the microwaves as soon as the door is opened.



MICROWAVE
Satellite communications make use of microwaves. Pictured here is a microwave antenna on a South Pacific island.

An important feature of microwaves is that they can carry signals of high quality, even over long distances. For this reason, microwaves are preferred over radio waves for a variety of applications. For example, microwaves are used in radar, which is a method used to detect faraway objects (see RADAR). In television systems, electronic signals are converted into microwaves to be sent long distances (see TELEVISION). Radio and telephone systems, which also require sending signals over long distances, use microwaves (see RADIO; TELEPHONE).

Other uses for microwaves include being part of the electromagnetic fields created by certain particle accelerators and being used in spectroscopes to study the structure of molecules and crystals (see ACCELERATORS, PARTICLE; SPECTROSCOPE). In the future, scientists hope to develop satellites that use microwaves to beam concentrated amounts of solar energy to Earth (see SATELLITE). Large photoelectric cells on such a satellite would collect light from the sun and convert the light to electricity. The satellite would then convert the electricity to microwaves. Such a system may someday help replace fossil fuels as a major power source.

See also FOSSIL FUEL; PHOTOELECTRIC EFFECT; RADIO; SOLAR ENERGY.

MIDNIGHT SUN The midnight sun occurs in polar regions when the sun appears for twenty-four hours a day. Because of the earth's tilt, each hemisphere is inclined toward the sun during its summer and away from the sun during its winter (see SEASON). At the North Pole, there is a six-month period of daylight between about March 20 and September 23. At the South Pole, the period of daylight lasts from about September 23 to March 20. The other six months are spent in continuous darkness.

At the Arctic Circle, the midnight sun occurs for a few days around June 21. The number of days of the midnight sun increases north of the Arctic Circle. Places at extreme northern latitudes are sometimes called the "lands of the midnight sun." At the Antarctic Circle, the midnight sun lasts for a day or two around December 21.

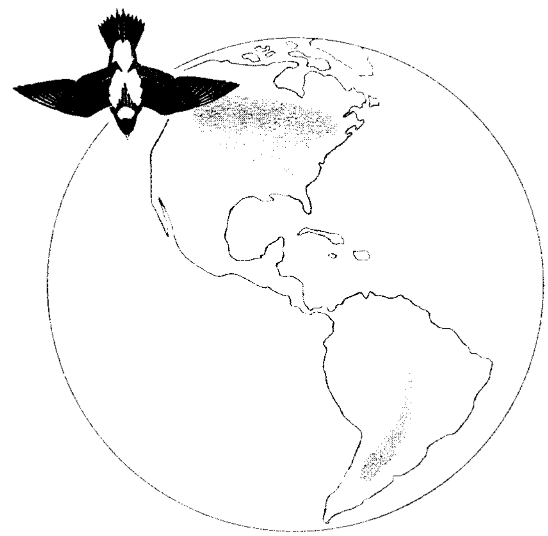
MIGRATION

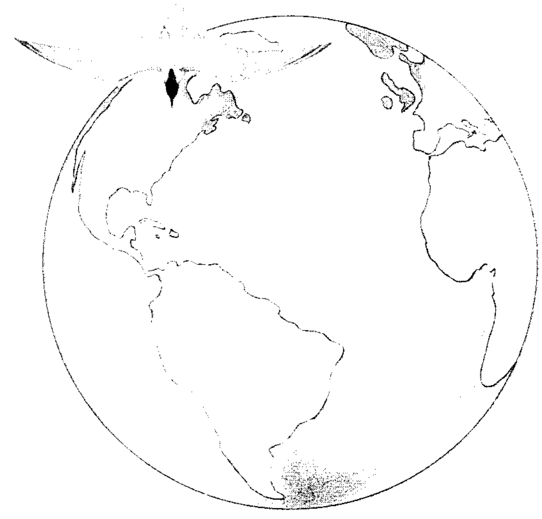
A migration is a regular movement of animals that occurs at the same time and place each year. It is a two-way process. The animals leave an area and return to the same area some time later. Migrations often start before winter. Animals may leave an area that is soon to become cold. They go to an area that is warm. More food is available in the warm areas. Some animals that do not migrate must hibernate during the winter because there is not enough food to eat (see HIBERNATION). Many birds that live in North America from April to September fly to South America for the months of October to March. In this way, they are always living in summer. (Summer occurs in South America during the winter of North America.)

Birds Birds are perhaps the best known of the migratory animals. Most of the songbirds in North America fly south for the winter. For example, most robins in the northern parts of the United States fly south during the autumn. According to tradition, when the first robin returns north, spring is soon to arrive. Swallows also migrate long distances. There is a town in California named Capistrano. The swallows come back to this town nearly the same day every spring. Waterfowl, such as geese and ducks, do not always fly all the way to South America. Many of these birds spend the winters in the southern United States and Mexico. In many places, the hunting season occurs during the fall migration of ducks. Hawks, eagles, and other birds of prey also migrate south for the winter (see BIRD).

Fish Fish also make long migrations. Many saltwater fish travel thousands of miles during the year in order to stay in warm waters where there is plenty of food. Tuna swim hundreds of miles south for the winter. They swim back north in the spring. Other fish make shorter migrations. Sharks, flounder, and bluefish swim to the deep offshore waters for the winter and return to the shallow coastal waters in the summer.

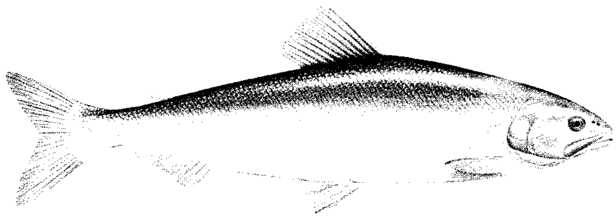
Some fish migrations are made in order for the fish to spawn, or reproduce (see SPAWNING). Although most fish spawn in the same type of water in which they usually live, some species migrate to or from the ocean in order to spawn. Species that migrate from the ocean to freshwater rivers to spawn are called anadromous fish. Salmon are the best known of the anadromous fish. Every spring, these fish swim up the rivers and spawn in fresh water. Most species of salmon die after they spawn.





LONG-DISTANCE TRAVELERS

The bobolink (top) and Arctic tern (bottom) make long migration flights. The Arctic tern flies halfway around the world on its yearly journey from the Arctic to the Antarctic.



MIGRATORY FISH

The adult ayu (above) lives in the fresh waters of Asian rivers. When it is ready to breed, it migrates to the sea, where the eggs are released and the young are born.

After the young fish hatch, they live in the river for several years before they go to the sea. The salmon live in the sea for two or three years before they swim back to the same river in which they were hatched to spawn.

Species that migrate from fresh water to salt water to spawn are called catadromous fish. The best-known catadromous species is the American eel. During the late spring, adult eels swim down the rivers in which they have lived for many years. Once in the sea, the eels swim to an area in the Atlantic Ocean called the Sargasso Sea. Here they spawn and die. The young eels drift in the sea and, after several springs, swim to rivers where their parents lived. The male eels stay near the mouth of the rivers, but the females go far upstream—sometimes traveling thousands of miles (see FISH).

Other animals Birds and fish are not the only animals that migrate. Many mammals that live in cold regions, such as caribou, also migrate. They migrate to low-lying lands that are warmer and have more food than the high-elevation, open, snowy regions (see MAMMAL). Some flying insects also migrate. For example, the monarch butterfly spends the winter in Mexico and the southern United States. It flies to northern areas every spring (see INSECT).

Finding the way When they migrate, some birds may learn their way from their parents. They make the first migration with the older birds that have made the trip before. These younger birds teach their young the migration route the next year. Some birds may guide themselves by landmarks, such as mountains, lakes, and coastlines. Others may use the sun and stars for guidance. New research shows that birds may be sensitive to the earth's magnetic field. Traces of iron in their brain tissue may somehow act as a natural compass to guide birds to their destination. Salmon and other anadromous fishes may memorize the taste of the water in the river in which they were spawned. When it is time for them to return and spawn, they follow the taste in the water back to its source.

MIGRATORY HERD

Wildebeest are large antelopes that live in Africa. Every year vast herds of wildebeest migrate across the savannas in search of fresh grass to eat.

MILDEW The word *mildew* is sometimes used to mean the same as mold and refers to any fluffy or powdery growth of fungus. The true mildews, however, are all parasites that grow on living plants (see FUNGUS; MOLD; PARASITE). There are two main groups of mildews: powdery mildews and downy mildews.

Powdery mildews usually look like white blotches on the surface of the host plant. They put out hyphae (threadlike structures) that penetrate the surface layers of the host and absorb food from it. Although they can reproduce sexually, reproduction is normally asexual (see ASEXUAL REPRODUCTION). The hyphae produce thousands of tiny capsules, called conidia, that look like white powder. They break away from the hyphae and blow away in the wind. When they land on suitable plants, they grow directly into new hyphae (see REPRODUCTION). Powdery mildews often disfigure plants, but they do not often cause serious damage. Unlike most fungi, the powdery mildews flourish best in hot, dry weather. Roses and gooseberries often suffer from powdery mildews.

The hyphae of downy mildews penetrate further into the tissues of their host plants and generally cause more damage than powdery mildews do. Reproduction is largely asexual and occurs mainly in damp conditions. The hyphae break through the plant surface and branch rapidly to form a fluffy or downy mat on the plant surface. This is usually grayish or white, but the surrounding area of the plant may be yellowish. The hyphae produce capsules full of spores. When the spores are ripe, the capsules break open and the spores float away in the film of water covering the plant. In drier conditions the complete capsules may break away from the hyphae and release their spores later (see SPORE). Lettuces are sometimes destroyed by a downy mildew, and another species of downy mildew causes serious damage to grapevines.

MILDEW

The leaves on this oak tree are infested with mildew. Called powdery mildew, it is a type of fungus.

MILK Milk is a highly nutritious liquid that female mammals produce to feed their young (see MAMMAL). It contains most of the nutrients needed for growth and is the main food most young mammals take in for several months after birth.

Milk is 80 to 90 percent water. It also contains proteins, carbohydrates, fats, vitamins, and minerals. The proteins (mostly casein and albumin) supply all of the essential amino acids (see AMINO ACID; PROTEIN). The carbohydrates (mostly lactose, or milk sugar) are a good energy source and help the body absorb calcium and phosphorus (see CARBOHYDRATE). The fats are in tiny droplets called globules. The fat globules give milk its white color and carry many vitamins. Milk supplies vitamins A, B, C, D, E, K, and niacin. Commercial milk supplies often have vitamin D added to supplement its natural content (see FAT; VITAMIN). Milk is rich in calcium and phosphorus and also supplies many other important minerals (see MINERAL).

Milk is produced in specialized glands called mammary glands. In mammals called monotremes, these glands open as pores on the abdomen (see MONOTREME). These pores "sweat" milk. The young monotremes lick the milk from the mother's fur. Most female mammals, however, have structures called teats or nipples, from which the young can suck milk.

Most of the milk sold in the United States is cows' milk. In some other countries, buffalo, goats, or reindeer supply most of the milk for human use. The content of milk varies from mammal to mammal, but cows' milk is usually about 3.5 percent fat,

MILK

The Holstein (left) is a common type of dairy cow in the United States and Europe (where it is known as Fresian). Its milk is high in fat, so it is good for making cream, butter, and cheese.

5 percent lactose, 3.5 percent protein, 0.7 percent minerals, and more than 87 percent water.

Milk sold in the United States is usually pasteurized and homogenized. Pasteurized milk has been heated to a temperature that kills most bacteria and other microorganisms (see PASTEURIZATION). Homogenized milk has been treated under pressure to dissolve fat droplets in the liquid, giving milk a uniform consistency and flavor. If not homogenized, the fat droplets rise to the surface of the milk, forming cream.

Skim milk is popular with people who want to lower their fat intake, because most of the fat is skimmed off before the milk is homogenized. Acidophilus milk is skim milk with a special bacteria, *Lactobacillus acidophilus.* This milk is sometimes used by people with intestinal disorders.

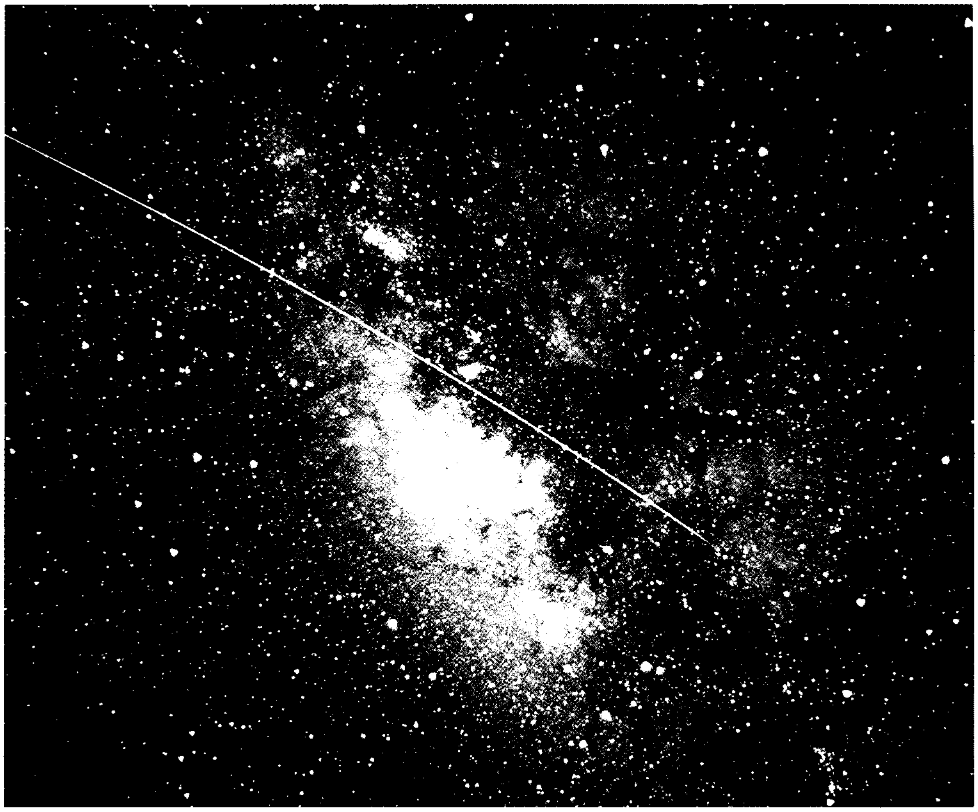
Some people are allergic to milk and are unable to drink it without becoming sick (see ALLERGY). Other people do not have enough of the enzyme lactase to digest the milk sugar (see ENZYME). These people must avoid milk or drink specially prepared milk that has the lactose in predigested form. For most people, however, milk and milk products (for example, cheese and yogurt) can play an important part in a balanced diet.

See also DIET; NUTRITION.

MILKY WAY The Milky Way is the galaxy, or star system, that includes the sun, the earth, the rest of our solar system, and about 100 billion stars (see GALAXY; SOLAR SYSTEM). The stars of the Milky Way spread out from the center of the galaxy in a spirallike fashion. Thus, astronomers refer to the Milky Way as a spiral galaxy. It is shaped like a flat disk, with a bulge in the center. Surrounding the disk is a sphere-shaped halo of faint, older stars and star clusters.

The Milky Way galaxy is so huge that it takes light, moving at 186,282 mi. [299,792 km] per second, 100,000 years to get from one side of the galaxy to the other. The sun is located about 25,000 light-years from the center of the galaxy (see LIGHT-YEAR).

In addition to its many stars, the Milky Way also contains great clouds of gas and dust (see NEBULA). However, the total amount of stars, gas, and dust is less than the total mass that astronomers have calculated it should be. This has led them to believe that the galaxy also contains matter in some invisible



MILKY WAY
This photograph shows that the Milky Way is made up of thousands of stars. The bright streak across the picture is the track of the *Echo* communications satellite.

form, such as black holes (see BLACK HOLE).

All the members of the galaxy revolve around the galaxy's center in much the same way that the earth revolves around the sun. It takes the sun about 225 million years to make one complete trip around the center of the galaxy.

Observers can see a side view of the rest of the galaxy from the earth. It appears as a hazy, glowing band in the night sky. This band, also called the Milky Way, is part of the Milky Way galaxy.
See also STAR.

MILLET (mĭl′ ĭt) Millet is an important cereal crop that grows in most parts of the world, even where the climate is dry and the soil is poor. About one-third of the people in the world rely on millet as their major source of food. Millet is high in carbohydrates, proteins, and fats (see NUTRITION). It grows to a height of about 4 ft. [1.2 m] and has clusters of flowers in a spike or raceme (see INFLORESCENCE).

Millet seed is round and is usually white, though it may also be yellow, gray, brown, or black. In the United States, millet and millet seed are commonly used as feed for chickens and other livestock. In most other countries, however, millet is ground into a flour that is used for cooking. There are several genera (plural of *genus*) of millet. These include *Panicum* (common and little millet), *Setaria* (Italian millet), and *Pennisetum* (pearl millet).
See also CEREAL CROP; GRASS.

MILLET
Millet is a useful food crop in many parts of the world. The main countries that produce millet are China, India, and Russia.

MILLIBAR The millibar is a unit used in meteorology, the study of the weather (see METEOROLOGY). The millibar is used to measure atmospheric pressure. One millibar is the pressure exerted by a force of 100 newtons over an area of one square meter [10.76 sq. ft.]. It is equivalent to a pressure of 1/32nd of an inch of mercury. Atmospheric pressure is about a thousand millibars. The millibar is often shortened to mb.

See also ATMOSPHERE; BAROMETER.

MILLIKAN, ROBERT ANDREWS (1868–1953) Robert Millikan was an American physicist who was the first to successfully measure the charge on the electron (see ELECTRON). Millikan was born in Illinois and taught at the University of Chicago from 1896 to 1921. Then he became a professor at the California Institute of Technology in Pasadena, California.

In 1910, Millikan designed an experiment to measure the charge on the electron. Until that time, scientists realized that the electron has an electric charge, but they did not know the size of the charge. Millikan's experiment was successful, and he won the Nobel Prize for physics in 1923.

MILLIPEDE A millipede is a tube-shaped arthropod with many legs (see ARTHROPODA). The millipede usually lives in dark, damp places, such as in leaf litter or under stones or rotting logs. The millipede has a segmented body. Nearly every segment of the body has two pairs of legs. The first three or four segments and the last one or two segments may be without legs. *Millipede* means "a thousand feet." Although some millipedes have 115 pairs of legs, no millipedes have one thousand feet.

Millipedes vary from 0.13 in. to 9 in. [0.3 to 23 cm] in length. The millipede has a round head bearing a pair of short antennae (see ANTENNAE).

Millipedes usually feed on plant material, eating dead and decaying matter most of the time. However, millipedes sometimes damage potatoes and other root crops growing in damp soil.

MIMICRY (mĭm′ ĭ krē) Mimicry is the close imitation of plants and animals by other plants or animals. For example, a member of a harmless species can protect itself by mimicking a member of a harmful species. Predatory animals think the animal is dangerous, so they leave it alone.

Many dangerous or undesirable plants and animals have bright colors and patterns. This is called warning coloration (see WARNING COLORATION). After an animal has tried several bad-tasting animals with such coloration, it learns to avoid them. Any other animal that looks like the bad-tasting species is also avoided. The bad-tasting species is called the model. A good-tasting species that resembles the model is called a mimic. In order to

MILLIPEDE

This millipede, found in the Great Smoky Mountains in Tennessee, has orange and black warning colors to frighten off predators such as birds and lizards.

MIMICRY
The female orchid bee (top) is preyed on by the South American robberfly (bottom). The robberfly is an excellent mimic of the bee, though a close look shows that the bee has four wings whereas the fly has two.

escape predation, the mimic must live in the same area as the model. Mimicry is very common in insects. Many snakes also mimic. For example, some species of king snakes have the same colors as the poisonous coral snakes.

Mimicry is not always used for defense. Some predators mimic harmless animals so that prey will not be afraid of them. For example, the zone-tailed hawk flies as the vulture does. A vulture does not eat living animals, so small animals will come out in the open when a vulture flies overhead. By imitating a vulture, the zone-tailed hawk can catch these small animals. A praying mantis can look like a plant. Other insects mistake it for a plant and land on it—and are then eaten by it (see MANTIS).

Some flowers use mimicry to reproduce. The blossoms of certain orchids resemble female insects. This attracts male insects. When the males land on the flower, they brush against the pollen and pollinate the flower.

See also CAMOUFLAGE; POLLINATION; PROTECTIVE COLORATION.

MIMOSA (mĭ mō′ sə) Mimosa is a genus of about 450 species of herbaceous plants, shrubs, and trees belonging to the pea family (see HERBACEOUS PLANT; PEA FAMILY). Most are native to tropical Central and South America, though some varieties grow in the temperate regions of North America and Europe. The mimosa has small flowers that grow in clusters as heads or spikes in the axils (see AXIL; INFLORESCENCE). The flowers have four or five partially fused petals and may be white, pink, or light purple. They produce seeds in flat pods called legumes (see LEGUME).

The leaves of the mimosa are small and featherlike. The leaves of some species, such as *Mimosa pudica,* often called the sensitive plant, are thigmonastic. This means they respond to touch by drooping. If one leaf is touched, all of the leaves droop (see MOVEMENT OF PLANTS). This reaction is due to a change in the pressure within the cells of the plant. The yellow-flowered florist's mimosa is actually a species of *Acacia.*

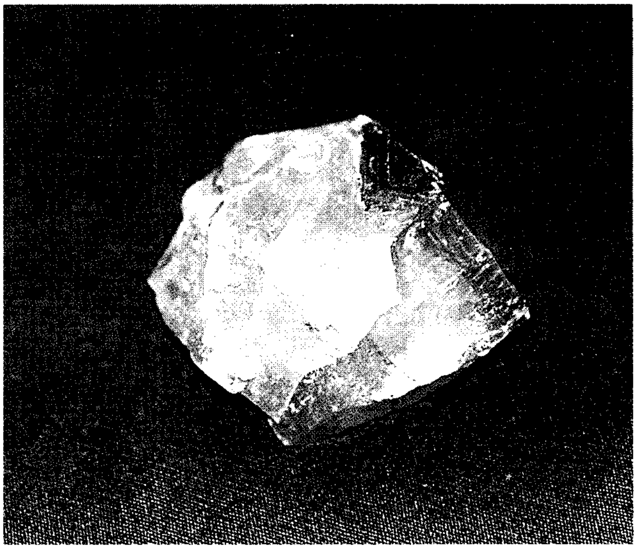
MIMOSA
The mimosa has featherlike leaves. In some species, the leaves droop if they are touched. For this reason, such species are known as sensitive plants.

MINERAL

Minerals are crystalline elements or compounds of elements that occur naturally in the earth (see COMPOUND; CRYSTAL; ELEMENT). Rocks are made up of minerals. Most rocks are a mixture of minerals, but some rocks contain only one mineral (see ROCK).

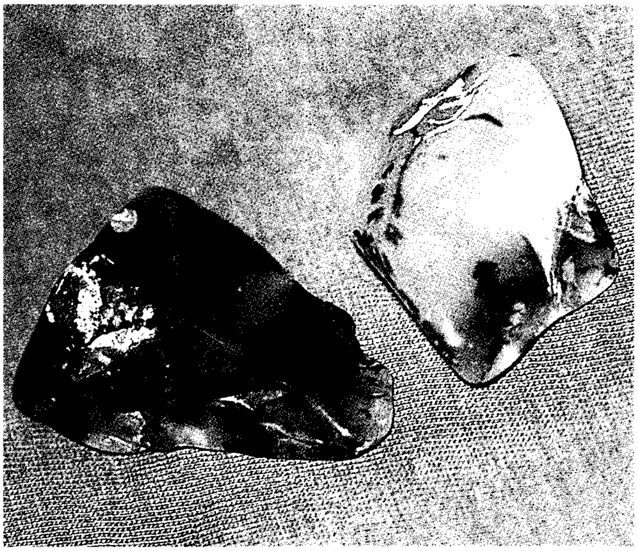
Some minerals consist of just one element. These elements are called native elements. They include gold, silver, copper, carbon, and sulfur. However, most minerals are compounds of several elements. The most common elements found in minerals are, in order from most to least common, oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and magnesium. Geologists (scientists who study the earth) have discovered about two thousand minerals. Of these, only about one hundred are common.

Formation of minerals Minerals are formed in many different ways. Magma is molten rock that lies beneath the earth's surface (see MAGMA). Magma tends to move up to the surface, and as it does, it cools and solidifies. Many common oxide and silicate minerals are formed from cooling magma, including quartz, feldspar, and magnetite. Minerals are also formed by the gases given off by magma, especially in volcanoes. These gases cool and condense to form minerals. Sulfur is formed by this method. Many minerals are formed from material dissolved in water. Water in seas and lakes always contains dissolved substances. When the water evaporates, it leaves behind minerals such as gypsum and halite (the source of common table salt).



QUARTZ

Quartz, consisting of silica, is one of the most common minerals. The variety pictured above is called rose quartz for its pinkish color.



OPALS

These opals (above) have been lightly polished to highlight their milky appearance. The feathery black spots are inclusions (impurities locked into the mineral's structure).

Identification of minerals The best place to identify a mineral is in the laboratory. However, geologists sometimes need to identify a mineral where they find it. There are a number of simple tests to identify minerals in the field.

Color is sometimes an important clue. For example, the mineral azurite is always blue. The color of most minerals, however, can vary greatly.

Streak is the powder produced when a mineral is scratched. It may be a different color from the mineral and so can be a useful way to identify the mineral. Luster is the way that a mineral reflects light. There are different kinds of luster. A brilliant luster is called an adamantine luster. Diamond has this luster. Quartz has a vitreous luster, meaning that it reflects about as much light as glass. Some minerals, such as pyrite and galena, have a metallic luster.

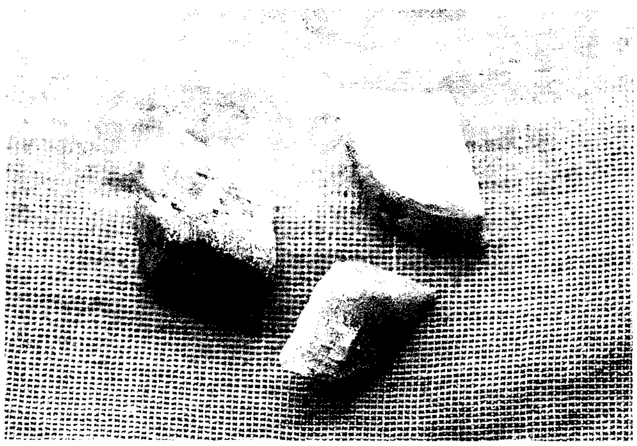
Hardness is a very important guide for identifying minerals. The Mohs scale is commonly used for measuring the hardness of minerals. The Mohs scale is based on ten values of hardness, from talc (1) up to diamond (10). To find the hardness of a mineral, the mineral is scratched against other minerals. Suppose that a given mineral scratches gypsum but not calcite. This means that the mineral is harder than gypsum but softer than calcite. Gypsum has hardness 2 and calcite has hardness 3. Therefore the hardness of the mineral is between 2 and 3 (see HARDNESS).

Relative density, also called specific gravity, is often used to identify minerals. Relative density is the density of a substance compared with the density of water (see RELATIVE DENSITY). Borax is a mineral with a low relative density. Diamonds have a medium relative density. Gold and uranium have very high relative densities.

Cleavage is another property of some minerals. When a mineral is struck, it sometimes breaks in certain directions, forming flat shiny surfaces. This is called cleavage. For example, mica splits easily into thin sheets. Minerals are usually identified by using a combination of the properties discussed above.

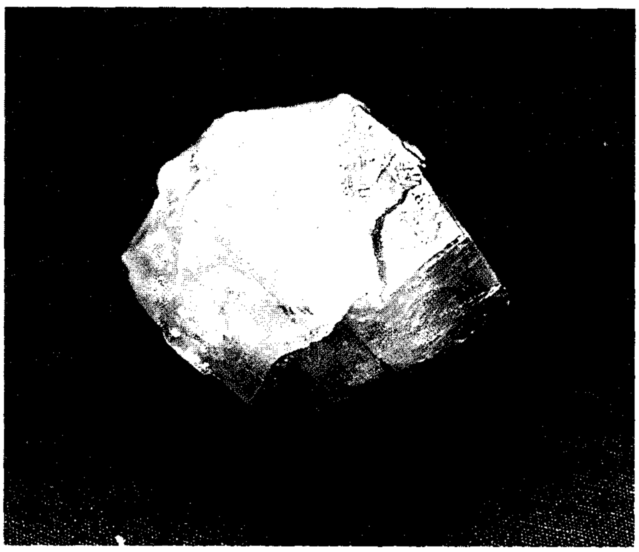
The term *mineral* also refers to certain substances in food and water that plants and animals need. Minerals represent one of the six categories of nutrients in the diet of humans. Minerals are classified as either major minerals or trace elements, depending on the amount needed each day. If humans require 100 milligrams or more per day of a mineral, it is considered a major mineral. Otherwise the mineral is considered a trace element. The major minerals include calcium, phosphorus, potassium, sulfur, sodium, chloride, and magnesium. Major minerals play important roles in the body in maintaining the skeleton, balancing fluids, and transmitting nerve signals.

See also DIET; GEOLOGY; MINERALOGY; NUTRITION.



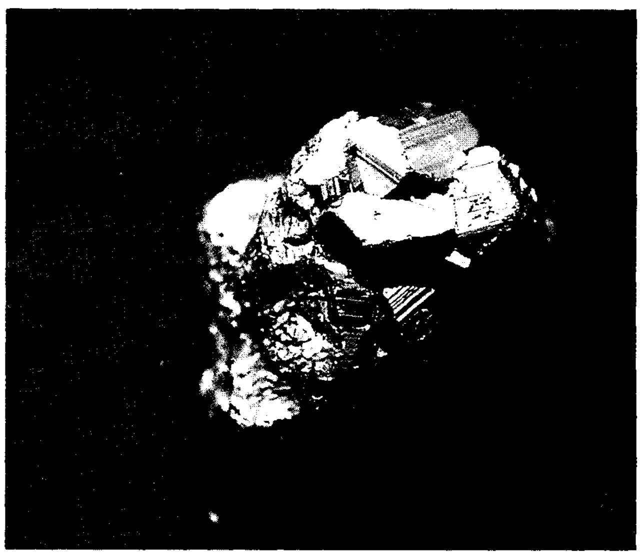
AMAZONITE

Amazonite (above), also known as Amazon stone, is a silicate of potassium and aluminum. It can be polished and used as a semiprecious gemstone.



CALCITE

Calcite (above) is a mineral form of calcium carbonate. It comes in many colors, including white, pink, orange, and green.



PYRITE

Pyrite (above) consists mainly of iron sulfide, and it is a principal ore of iron. It is also known as "fool's gold" because of its resemblance to the precious metal.

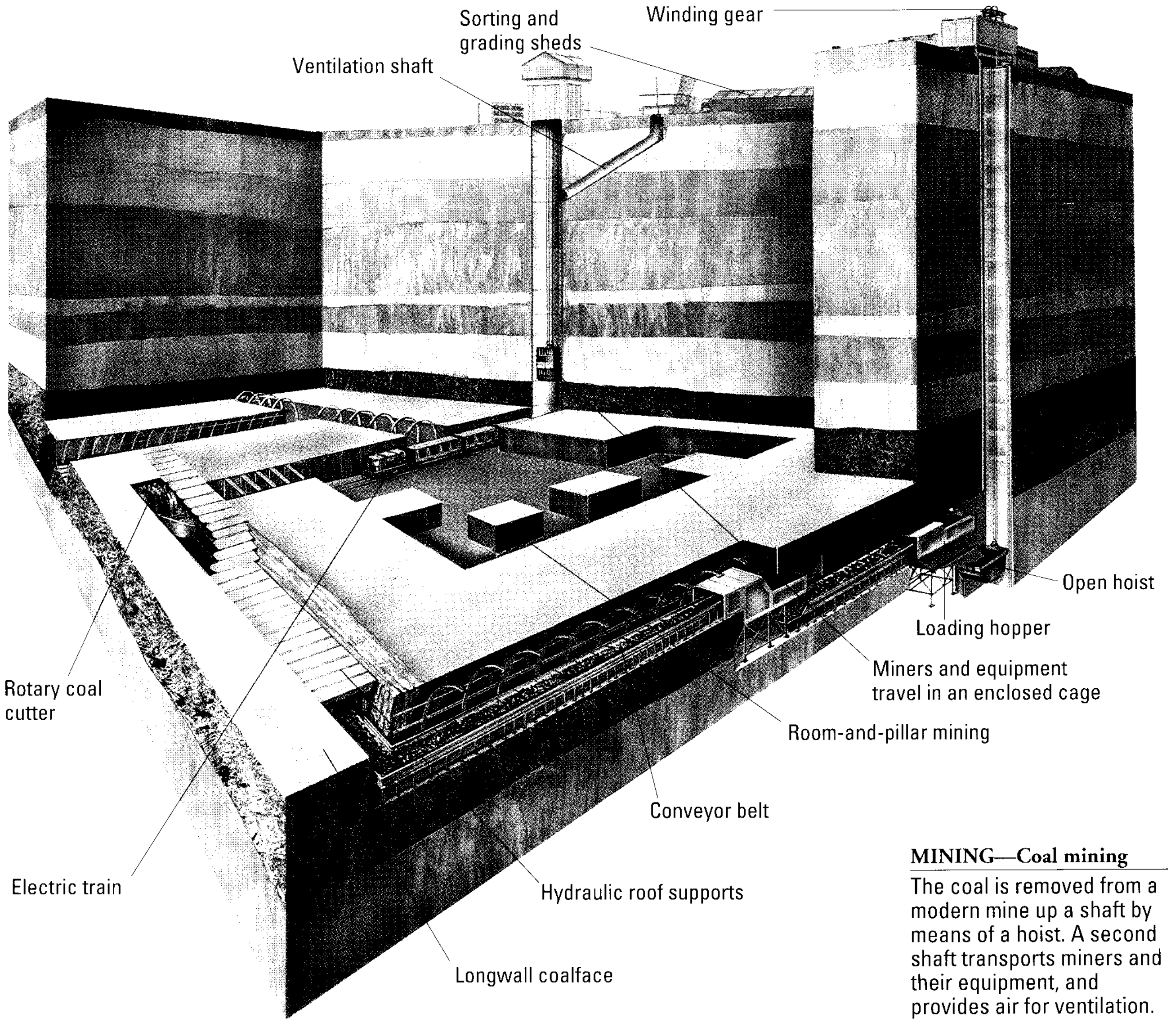
MINERALOGY (mĭn′ ə rŏl′ ə jē) Mineralogy is the study of minerals. People who study mineralogy are called mineralogists. They study the physical properties of minerals, such as their hardness. They study the chemical composition of minerals, finding out what elements a mineral contains and how much of each element. They also study the structure of minerals, or how the atoms of each element are arranged in a mineral. In addition, they may study where minerals occur and how they are formed.

Mineralogists try to make minerals in the laboratory by repeating the conditions in nature that created them. These conditions may include very high temperatures and pressures.

A very important branch of mineralogy is called optical mineralogy. This is the study of how minerals affect light. If the mineral is transparent, and most are if sliced thinly enough, it is possible to measure how it refracts, or bends, light as light passes through the mineral (see RERACTION OF LIGHT). The refraction of light by a mineral is examined by a special microscope called a petrographic microscope. Minerals may be identified by the different ways in which they refract light. Many minerals are not transparent. These minerals can be identified by seeing how they appear when they reflect light.

See also MINERAL; REFLECTION OF LIGHT.

MINING Mining is the process of taking minerals out of the earth for human use (see MINERAL). Copper, iron, precious stones, and many other minerals are mined. Coal, petroleum (oil), and



MINING—Coal mining
The coal is removed from a modern mine up a shaft by means of a hoist. A second shaft transports miners and their equipment, and provides air for ventilation.

natural gas are also mined and are often called minerals, though scientists who study minerals do not consider them true minerals. Almost every manufactured product is made using one or more minerals. Even food is planted, harvested, processed, and packaged using machines made of steel, a metal alloy made from iron (see ALLOY).

Minerals found at the surface of the earth can usually be mined quite easily. However, some minerals are buried far beneath the surface. They can be taken out only by digging deep underground. Other minerals are found in bodies of water.

Human beings have mined the earth for thousands of years. As early as five thousand years ago, the Egyptians opened copper mines on the Arabian Peninsula. The ancient Romans were among the first people to realize that mining could make their empire rich and powerful. The Romans had iron mines on the island of Elba in the Mediterranean Sea. They also sent thousands of slaves to work in Spanish copper mines.

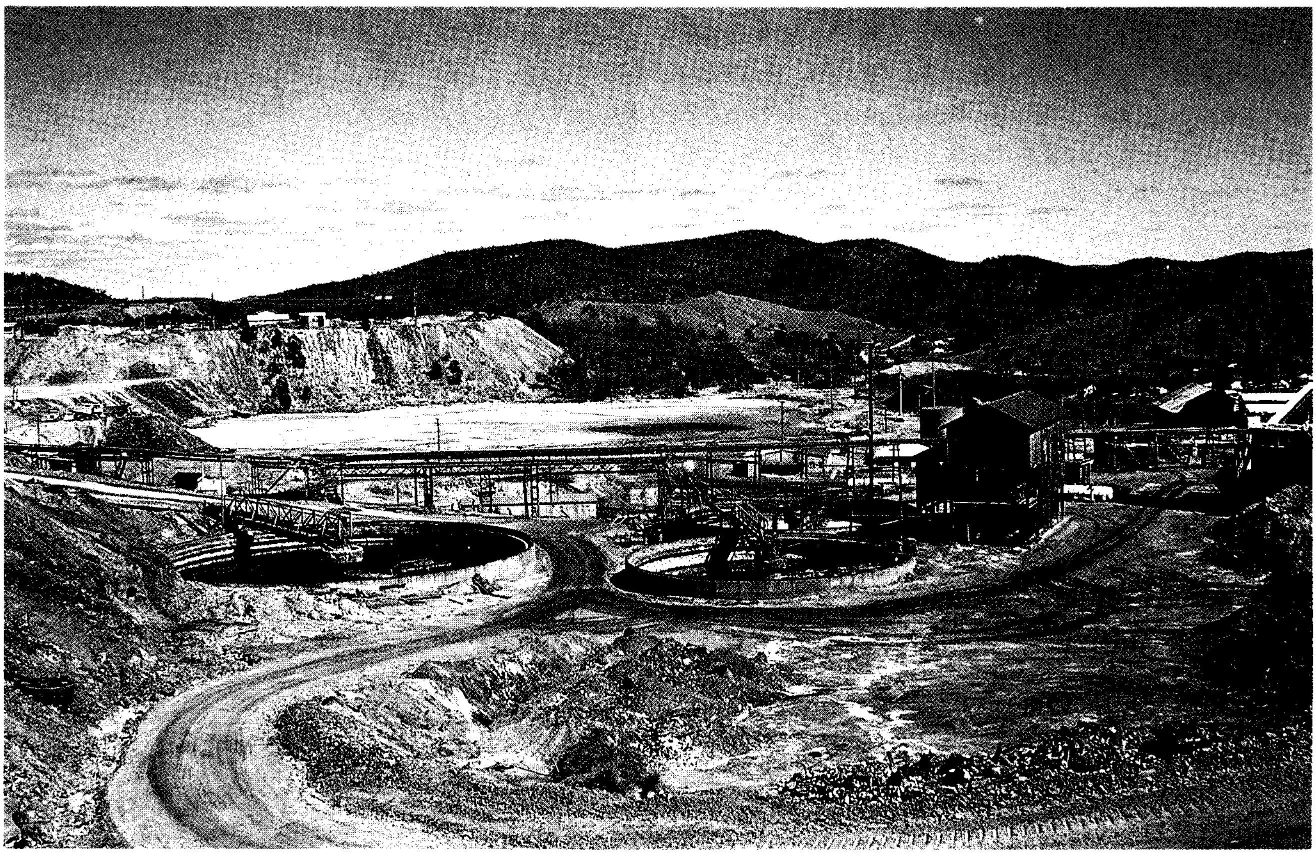
In the early 1700s, mining began in what is now the United States. French explorers mined lead and zinc in the valley of the Mississippi River. In the middle 1800s, large amounts of coal were dug up in Pennsylvania. During this time, thousands of people moved to California, hoping to find gold. The gold rush led to the discovery of many useful minerals throughout the western United States.

When any mineral substance is found in an amount large enough to make it worthwhile to be taken out of the earth, it is called ore (see ORE). A deposit is an accumulation of ore. Some kinds of deposits have special names. A long, branching deposit, surrounded by rock, is called a vein of ore. Gold and silver are sometimes found in veins. A wide, flat deposit is called a bed. Coal is found in beds. Oil and gas deposits occur in deposits called reservoirs.

Locating minerals The first step in mining is to find the minerals. Searching for ore is called prospecting (see PROSPECTING). Prospecting was

MINING—Open pit mining

This copper mine at Mount Morgan in Queensland, Australia, is an example of an open pit mine. The ore is removed by large machinery and then washed before being transported to the smelter.



first done by people who simply wandered around looking for signs of ore. About 150 years ago, geologists (scientists who study the earth) learned how to make maps of the rocks in an area. Miners had observed that certain kinds of ores were usually in or near certain kinds of rock. With maps to guide them to the proper kinds of rocks, prospectors knew the best places to search for ore.

By about 1945, mining experts turned to prospecting with scientific instruments. One such instrument is the seismograph. The seismograph records the intensity of shock waves traveling through the earth. If prospectors explode dynamite in holes drilled in the ground, they can use a seismograph to record shock waves from the blast. If ore is in the area of the explosion, the speed of waves passing through the deposit may be different from their speed in the nearby earth.

Prospectors may fly instruments over an area that they think contains ore. One of these instruments is a magnetometer. A magnetometer measures changes in the earth's magnetic field (see MAGNETISM). The magnetic field is slightly different around a deposit of iron, nickel, or cobalt ore. A similar instrument is a gravity meter. This instrument records changes in the strength of the earth's gravity (see GRAVITY). Changes may indicate the presence of ore deposits. A scintillatometer (a device for measuring radiation) is used to locate radioactive ores, such as uranium (see RADIOACTIVITY). Whatever system modern prospectors use, they must have a good knowledge of geology, mineralogy, and metallurgy (see GEOLOGY; METAL AND METALLURGY; MINERALOGY).

Methods of mining After the ore has been located, the next step is to dig the ore out of the earth. There are many methods of mining. The method used depends on where and how a mineral deposit occurs in the earth and the nature of the minerals in the deposit.

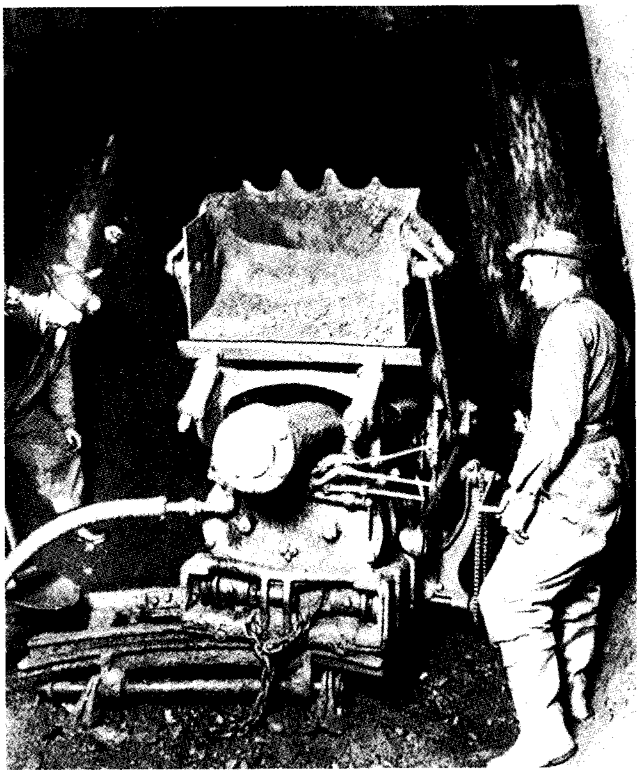
Surface mining methods are used when deposits occur at or near the surface of the earth. Such methods include placer mining, dredging, open pit mining, strip mining, and quarrying.

Placer mining and dredging use water to get gold and other minerals from sand and gravel deposits. Placer miners wash gravel into long, sloping troughs called sluices. The gold separates from the gravel by gravity. Dredges are used where there are large deposits and a good supply of water (see DREDGING).

Open pit mining is used to dig valuable minerals from large deposits in hard rock. In this kind of mining, the soil and other kinds of earth (called the overburden) are dug away from the top of the ore deposit. Then large amounts of ore are dug up by large power shovels. Many iron, copper, diamond, phosphate, and gypsum mines are operated as open pits.

Strip mining is used to obtain coal and other minerals that lie flat near the earth's surface. It is similar to open pit mining.

Quarrying is a way in which large blocks of rock are wedged loose or sawed out of a deposit that lies near the surface. Chains and pulleys are used to lift the blocks from the pit. Miners quarry rock materials such as marble, sandstone, limestone, granite, and slate. Gravel and sand are also said to be



MINING—Early machinery
This photograph was taken in Michigan in about 1918. It shows miners with a machine for digging out iron ore.

MINING—Waste
One of the problems with mining is the amount of waste (or slag) produced. This hill is an asbestos slag heap at a mine in Swaziland, Africa.

quarried, even though the process is more like open pit mining (see QUARRYING).

Underground mining methods are used when the mineral deposit lies deep beneath the surface of the earth. Miners make a wide hole called a shaft. The shaft is driven (dug) straight down beside the ore deposit. Then a horizontal tunnel, often called a crosscut, is dug from the shaft to the ore. Miners dig the ore from a cleared area of the shaft called a stope. The ore is sent in small cars to the shaft, where it is dumped into a container called a skip hoist. The skip hoist, which is somewhat like an elevator car, is lifted to the surface and dumped. The miners keep digging the stope, making it longer, as they follow the deposit of the ore. When the stope has passed through the ore, or when the stope becomes too long to work in conveniently, a new stope is begun. In underground mining, the miners try to remove only the ore and leave most of the rock that surrounds it. Minerals mined by this method include copper, gold, silver, lead, and zinc.

The waters of the oceans and some large lakes contain huge amounts of mineral elements. These substances are often obtained by pumping the water into plants, where it is treated. Pumps move large amounts of seawater through precipitators (separators) so that the minerals in the water can be removed. Magnesium is often obtained by this pumping method. Sulfur, salts, petroleum, and natural gas are also extracted from the earth by various pumping methods.

Today, fewer and fewer mineral deposits are found near the surface of the earth. Miners must dig deep underground to find ore. Great care must be taken for the miners' safety. People are trained in colleges and technical schools to become experts in mining processes.

Mining has various effects on the environment. Mining and processing of minerals often produce noise and water pollution. Large areas of water have been polluted by oil spills resulting from leaks or explosions in offshore mines. Strip mining also ruins the surface of the land. However, strip-mined land can be restored. Topsoil can be replaced. Trees can be planted on sloped areas. Level areas can be turned into parks or farms.

See also CONSERVATION; POLLUTION.

MINK The mink is a small mammal belonging to the weasel family (see MAMMAL). Mink are found in North America and in the northern parts of Europe and Asia. The animals live in wooded areas near streams, lakes, and marshes. On land or in water, mink are swift, agile animals.

The male North American mink ranges from 14 to 25 in. [36 to 64 cm] in length, including its bushy tail. The female is smaller, weighing about half as much as the male. The European mink is slightly smaller than its American relative.

MINK
This mink was photographed in Flathead Valley, Montana. A mink's fur helps it stay warm and dry in water.

Mink eat frogs, fish, and crayfish. They also eat smaller mammals, such as mice. A litter of four to ten young mink, called kits, is born in the spring. The family stays together until late summer or fall. Then the young go to find hunting places of their own.

The mink has a strong, musky odor. Usually, the mink gives off this smell only when it is angered or frightened. The mink's main enemies include the lynx, the bobcat, some types of owls, and people. Trappers kill more mink than do all other animals combined.

Wild mink fur ranges from light to dark brown. The mink usually has a white patch on the chin and several white spots on the throat and chest. Mink furs are highly valued and often made into costly coats, capes, stoles, and jackets. Mink are raised commercially for their fur. They have been bred to produce fur from white and pale silver to black. Such furs are called mutation mink.

See also BREEDING; MUTATION.

MINNOW A minnow is a freshwater fish that belongs to the carp and minnow family, Cyprinidae. This is the largest family of fish in the world, with more than 1,500 species.

Some minnows are quite large. The Colorado squawfish, a species of minnow in the western United States, grows to lengths of about 3 ft. [1 m]. However, most minnows are small, measuring an inch long or less. Many of the smaller minnows are used by fishers for bait and are often reared for this purpose.

MINT FAMILY

Apple-scented mint is an unusual variety of mint used as an herb.

MINT FAMILY The mint family, Labiatae, includes about 3,500 species of herbaceous plants and shrubs that grow throughout the world (see HERBACEOUS PLANT). They have square stems and opposite leaves. The flowers are usually small and grow in whorls at the bases of the leaves or in spikes rising above the leaves (see INFLORESCENCE; LEAF).

Many herbs used in cooking are members of the mint family (see HERB). These include sage, thyme, basil, and marjoram. Spearmint and peppermint

MINNOW

Small minnows (left) swim in large schools for safety.

are among the 40 species of fragrant mints in the genus *Mentha*. The leaves and oil from these plants are used in cooking, perfumes, and medicines. Members of the genus *Coleus* are popular as houseplants because of their brilliantly colored leaves.

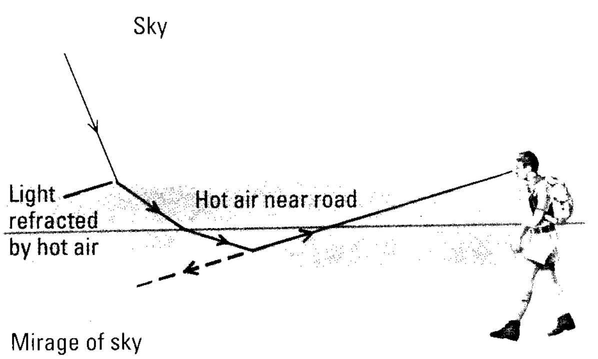
MIOCENE EPOCH (mī′ ə sēn′ ĕp′ ək) The Miocene epoch is a period in Earth history that began about 23.5 million years ago and ended 5.2 million years ago. It is a subdivision of the Tertiary period.

The Miocene epoch saw the formation of the Alps and the Himalayas, two major mountain ranges. By the time of the Miocene, more than half the modern mammal families existed on Earth. These included bats, monkeys, dogs, bears, whales, and elephants. Birds such as ducks, eagles, owls, and pheasants were also common.

The evolution of apes underwent important stages during the Miocene epoch. In Europe, fossils of humanlike apes have been found in rocks dating to the Miocene.

See also EVOLUTION; FOSSIL; GEOLOGICAL TIME SCALE; TERTIARY PERIOD.

MIRAGE (mĭ räzh′) When light passes from air into glass, it changes direction. This is called refraction (see REFRACTION OF LIGHT). Light can also be refracted as it passes through air. This happens when light passes through air layers of different densities. For example, if the weather is very hot, the air nearest the ground is much warmer than the air above. Warm air has a lower density than cool air. Therefore, on a hot day, the air nearest the ground is much less dense than the air above it. This causes the light to bend as it passes through the air. Because the light is bent, objects seem to be in different places than they actually are. This false image of an object is called a mirage.



MIRAGE

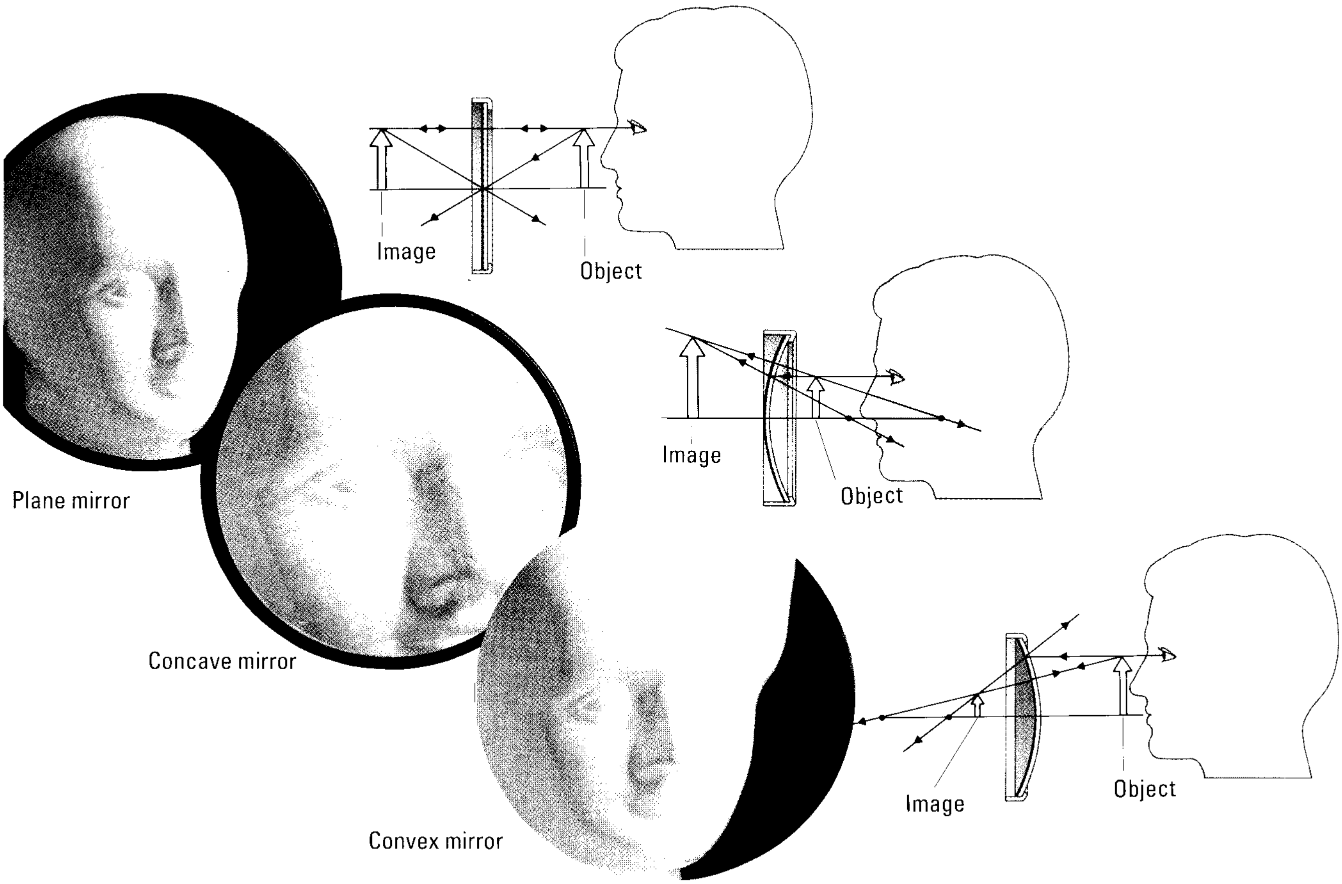
On a hot day, light from the sky is progressively refracted (bent) by the hot air until it is directed upward. Because of this refraction, the hiker sees a mirage.

A mirage familiar to most people is the shimmer on a hot, dry road. The mirage looks like a pool of water. It is, in fact, an image of the sky. Light from the sky is bent by the hot air and appears to come from the road. Sometimes, the opposite effect takes place. Over water, a layer of cold air may lie under a layer of warm air. This causes the light to bend downward. For example, a ship beyond the horizon may appear to be lifted into the sky. In some mirages, distorted images of distant objects are seen. PROJECT 41

MIRROR Mirrors are used to reflect light. They are usually made by placing a smooth coating of metal onto a glass surface. The metal coating reflects the light. The metal is often aluminum. Better-quality mirrors use silver, because silver reflects more light than aluminum. Mirrors in the home have the metal placed on the back of the glass. This protects the metal coating, but the image may not be as sharp. High-quality mirrors have the metal coating on the outer surface of the glass. These mirrors are used in some telescopes. Sometimes, highly polished metal by itself is used as a mirror.

Mirrors obey the law of reflection (see LIGHT; REFLECTION OF LIGHT). A ray of light strikes the mirror and is reflected into our eyes. The ray of light striking the mirror is called the incident ray. The ray that leaves the mirror is called the reflected ray. According to the law of reflection, these two rays make the same angle with the mirror's surface.

Mirrors can have flat or curved surfaces. A flat mirror is called a plane mirror. The image seen in a plane mirror is called a virtual image. A virtual image cannot be projected onto a screen, because the image appears to be formed behind the mirror. The image in a plane mirror is right side up. However, the right-hand side of an object becomes



the left-hand side in the image, and vice versa. The image is always the same size as the object.

There are two different types of curved mirrors—concave mirrors and convex mirrors (see CONCAVE; CONVEX). The image in a concave mirror depends on how far the object is from the mirror. For example, if the object is close to the mirror, its image is virtual and magnified. A magnified image is larger than the object (see MAGNIFICATION). Because they can magnify, concave mirrors are used as shaving mirrors. If the object is beyond a certain distance from the mirror, the image changes. It becomes smaller than the object, and it is upside down. The image now lies in front of the mirror. It is said to be real. A real image can be projected onto a screen.

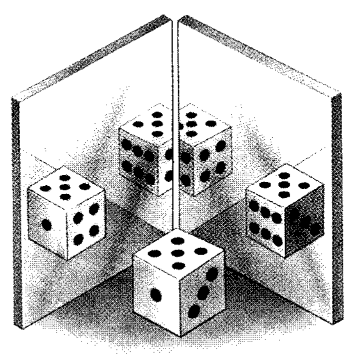
Convex mirrors curve outward, and concave mirrors curve inward. The image in a convex mirror is always smaller than the object. The image is also upright and virtual, like the image in a plane mirror. Convex mirrors are used as rearview mirrors in automobiles, because they allow drivers to see a large area of the road behind them.

PROJECT 43

MIRROR

The type of image formed by a mirror depends on the mirror's shape. A plane (flat) mirror (top) gives a same-size image the right side up. An object close to a concave mirror (center) has a magnified image. With a convex mirror (bottom), the size of the image is reduced.

ACTIVITY *Making many reflections*



Place two mirrors together as shown in the diagram. Put a die between the mirrors and count the number of images formed. See if you can increase the number of images by changing the angle between the mirrors.

MISSILE

Generally, a missile is an object that is projected to hit a distant object. However, *missile* usually refers to a kind of weapon that was developed during World War II (1939–1945). The rest of the article will discuss this kind of missile.

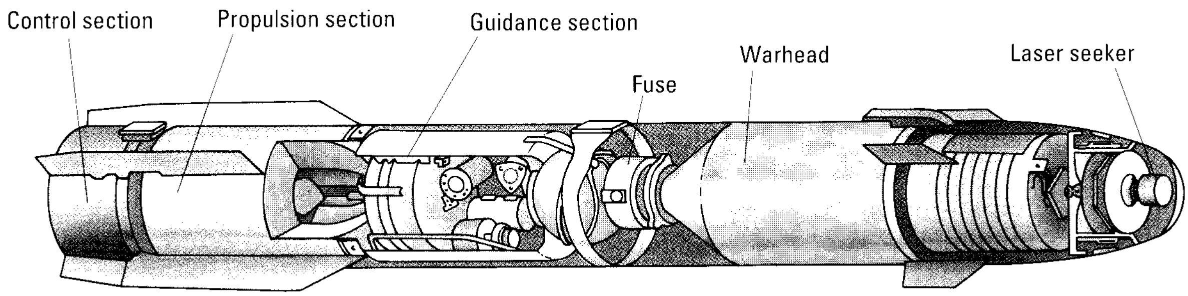
A missile has several parts. The nose (front) of the missile usually contains a section called a warhead. A warhead may carry explosives, such as high explosives or nuclear explosives; disease-causing microorganisms, such as bacteria or viruses; or poisonous gases (see CHEMICAL AND BIOLOGICAL WARFARE; EXPLOSIVE). A missile may have several warheads that can be released miles apart from each other.

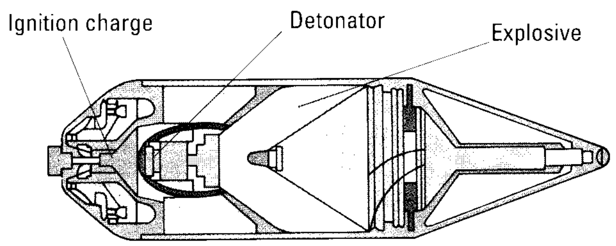
Rockets are found at the rear of most missiles. They supply the power for the missile (see ROCKET). Missiles may have one or more rockets, depending on the size of the missile. An antiaircraft missile, which is a large missile that is fired toward an aircraft, sometimes has rockets called boosters attached to the outside of the missile, in addition to the main rocket. A few missiles do not have rockets. They are powered by jet engines. Unlike rockets, which carry a substance that supplies oxygen for burning, jet engines obtain oxygen from the atmosphere. Therefore, missiles with jet engines can only fly inside the atmosphere and not into outer space. However, certain missiles do not need to fly into outer space and work better with the lightweight jet engines (see COMBUSTION).

There are various methods of launching missiles. Some large missiles are launched from underground buildings called silos. Other missiles are launched from aircraft, ships, submarines, or tanks. Some very small missiles can be carried and launched by one person.

Most of today's missiles have some kind of system to guide them to their targets. One kind of missile, called a guided missile, is guided throughout its entire flight. This makes guided missiles especially useful in hitting moving targets.

Guided missiles use several kinds of guidance systems. Many small missiles that attack slow-moving targets, such as tanks, are guided by wire. As the missile travels through the air, it remains attached to a length of wire. The soldier operating the missile sends instructions in the form of electrical signals along the wire to the missile. In this way, the soldier can guide the missile to the target. Wires can only be used for short-range missiles, however. Many long-range missiles have a homing guidance system. Such a system enables a missile that has been launched to detect a moving object, such as an airplane or another missile. The missile can then chase the object and destroy it. The missile is said to home in on the object. One method of homing in on objects is to have a device called a heat sensor in the nose of the missile. The heat sensor detects heat from the exhaust of the targeted object.





MISSILE CONSTRUCTION

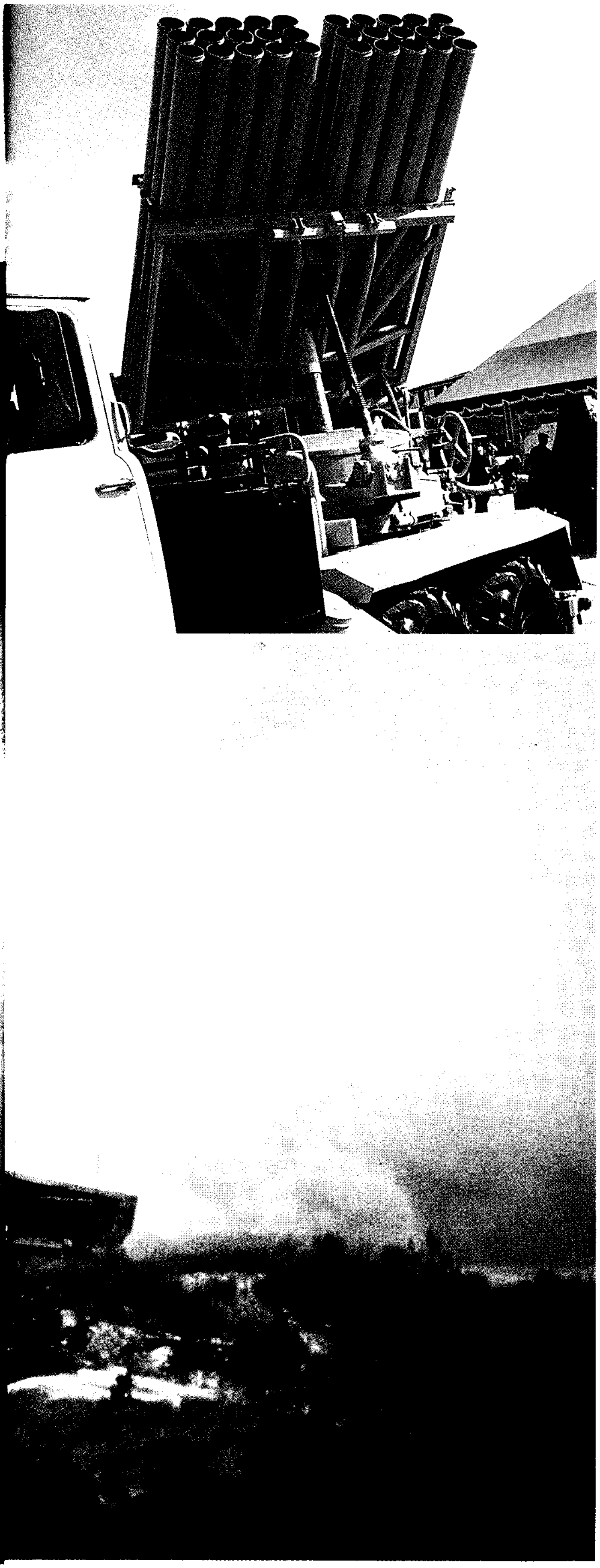
The Hellfire missile (above) has control, propulsion, and guidance sections. It has a laser light detector in the nose, in front of the warhead. The warhead uses a shaped charge (left), which makes a hole in armor before the main charge penetrates the target.

GUIDED MISSILE

Ground-to-ground guided missiles, such as the one pictured at launch (below), are aimed at enemy armor such as tanks.

MOBILE LAUNCHER

This rocket launcher mounted on a truck (right) can fire thirty rocket-powered missiles in rapid succession.



PORTABLE MISSILE

Some missiles used by infantry (above) are small enough to be carried and fired by only two soldiers. They are used against targets such as vehicles and helicopters.

Another homing guidance system that is useful for moving objects that are farther away involves radar (see RADAR). The nose of the missile contains instruments that transmit radio waves and detect the waves that bounce back off an object. If the missile detects any such waves, it follows the object and homes in on it. Other missiles only detect, rather than transmit, radio waves. The waves are transmitted either from the ground or from an airplane, usually the one from which the missile has been launched. If waves are bounced back by an object, the missile detects the waves. It then homes in on the object.

A more complicated radar system is called a radio command system. In this system, two radar sets are used. The radar sets may be on the ground, on a ship, or in the launching airplane. One radar set tracks the missile, and the other tracks the object that the missile is chasing. A computer determines the direction for the missile based on the location of the object. Instructions are then sent by radio waves to the missile.

Some missiles, called ballistic missiles, are not guided throughout their entire flight. *Ballistic* refers to the arching path this kind of missile follows. Ballistic missiles have been preprogrammed with initial instructions for speed, height, and direction. These directions are given only while the rockets are burning. The rockets have enough fuel to continue burning until the ballistic missile leaves the atmosphere (see ATMOSPHERE). The ballistic missile then travels for a short time in space. The ballistic missile is not guided when it travels through space. It reenters the atmosphere, and the guidance system of the warhead then takes over. The warhead may be preprogrammed or it may have another guidance system, such as a heat sensor. An intercontinental ballistic missile (ICBM) is an example of a ballistic missile. An ICBM may strike a target up to 8,100 mi. [13,000 km] away after reaching heights of up to 680 mi. [1,100 km]. ICBMs often carry several warheads, which are called multiple independently targeted reentry vehicles (MIRVs). MIRVs are usually nuclear explosives. ICBMs are the largest missiles and travel the longest distances. They are often the first missile used because their preprogrammed guidance system allows them to be launched quickly.

Another missile that is generally considered to be in a separate category from guided and ballistic missiles is the cruise missile. The cruise missile flies at very low altitudes to escape radar detection. These jet-powered missiles use a guidance system called "terrain contour matching." The phrase *terrain contour* refers to the shape of land. As part of the terrain contour guidance system, a cruise missile has a computer with a detailed "map." The map contains information about the terrain of the missile's path and the surrounding terrain. As the cruise missile travels along its programmed path, its radar system bounces radio waves off the ground. The computer analyzes the waves to determine the terrain the missile is flying over. For example, radio waves bouncing off a mountain would reach the missile quicker than radio waves bouncing off flat ground. The computer then checks this information against its map of the missile's path to see if they match. If the terrains do match, the missile is on course. If the terrains do not match, the missile has gotten off course. This may have been caused by a strong wind or the force of a nearby explosion. The computer searches its map to determine how far the missile is off course. The computer then corrects the flight of the missile to get it back on course.

OLD AND NEW MISSILES

The iron balls hurled by the old cannon in the foreground—technically missiles—contrast with the modern rocket-powered missile behind. Both are at a museum in Perm, Russia.

MISSISSIPPIAN PERIOD The Mississippian period is a stage in Earth history that began about 363 million years ago and ended about 323 million years ago. It is the earlier part of the Carboniferous period. In Europe, the Lower Carboniferous period is equivalent to the Mississippian period (see CARBONIFEROUS PERIOD).

During the Mississippian period, most of what is now the United States was covered by a shallow sea. Amphibians thrived, and algae, fish, and shelled animals were abundant. Several kinds of shelled animals made reefs similar to modern coral reefs at this time. Deposits of coal, oil, natural gas, lead, and zinc also began to form. The Mississippian period saw the formation of most of the Appalachian Mountains.
See also GEOLOGICAL TIME SCALE.

MIST Mist is very thin fog. When the air temperature drops to the dew point, water vapor condenses into small water droplets that stay suspended in the air (see CONDENSATION). If the visibility is less than 0.6 mi. [1 km], the water droplets are called fog. If the visibility is more than 0.6 mi. [1 km] but less than 1.2 mi. [2 km], the water droplets are called mist.

Some people incorrectly refer to a very light rain as mist. Very light rain should instead be called drizzle.
See also DEW POINT; FOG.

MISTLETOE Mistletoe is a parasitic or semiparasitic plant that grows on the trunks and branches of certain trees (see PARASITE). The various species of mistletoe belong to the family Loranthaceae.

Mistletoe produces specialized roots called haustoria. The haustoria grow into the host tree and take water and nutrients from it. The mistletoe does, however, have green leaves on its forked branches and can make its own food by photosynthesis (see PHOTOSYNTHESIS). Because it can make some of its own food and does not rely on its host for everything, the mistletoe is known as a semiparasite.

Mistletoe is dioecious, with male flowers growing on some plants and female flowers growing on others (see DIOECIOUS). The tiny yellow flowers produce small, fleshy, white berries. These berries are a favorite food of birds but can be poisonous to humans and other animals. When a bird eats mistletoe berries, some of the seeds stick to its beak. They are dislodged later when the bird scrapes its beak on the bark of a tree. The seeds often stick to the bark, where they begin to germinate (see DISPERSION OF PLANTS; GERMINATION). As the seed grows, it puts out haustoria, which lodge firmly in the bark.

American mistletoe belongs to the genus *Phoradendron.* European mistletoe belongs to the genus *Viscum.* Dwarf mistletoe belongs to the genus *Arceuthobium.* Mistletoe has been considered a sacred or ceremonial plant in some cultures for centuries.

MISTLETOE
Mistletoe is a parasitic plant. Here it can be seen growing on the trunk and branches of an old apple tree. Its fleshy white berries, produced in winter, are poisonous to humans.

MITCHELL, MARIA (1818–1889) Maria Mitchell was an American astronomer who was the first woman to discover a comet (see COMET). She is also known for her studies of sunspots and of planets' satellites (see SATELLITE; SUNSPOT). Maria Mitchell was born in Nantucket, Massachusetts. She learned astronomy from her father, who was the headmaster (principal) of a school and an amateur astronomer.

In 1847, Mitchell discovered a comet before any of the famous astronomers of Europe spotted it. She was awarded a gold medal by the king of Denmark for her discovery. In 1848, Mitchell became the first woman ever elected to the American Academy of Arts and Sciences. Mitchell became professor at Vassar College for women in 1865, the year the college opened. She remained at Vassar for twenty-three years and retired just a year before her death at age seventy-one. An observatory in Nantucket, Massachusetts, is named after Mitchell.

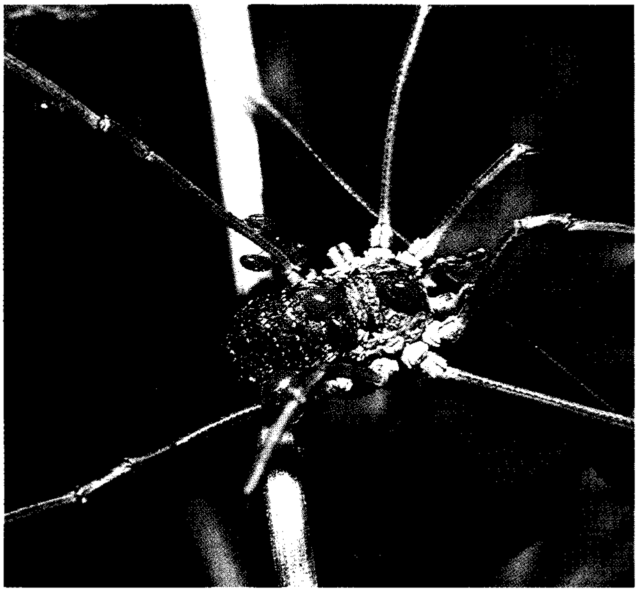
See also ASTRONOMY; OBSERVATORY.

MITE Mites are small arachnids, closely related to ticks, spiders, and scorpions. Although they look like insects, they are not closely related to those animals (see ARACHNID).

Some mites live in water. Others live on land. Some are too small to be seen by the unaided eye and must be studied under a microscope. Mites have saclike bodies with a slight dividing line between the abdomen and the combined head and thorax. They have four pairs of legs (see ABDOMEN; THORAX).

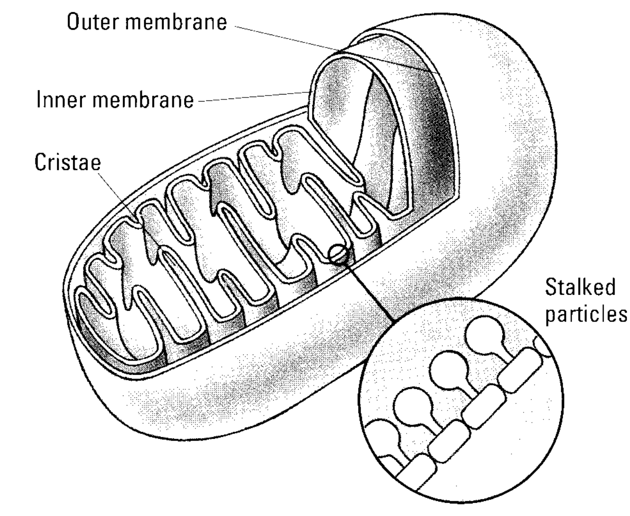
Most species hatch from eggs as six-legged larvae. Later, they shed their skins and change into nymphs with eight legs. After one or more further molts, the nymphs change into adults (see METAMORPHOSIS; MOLTING).

Most mites live freely in the soil, feeding on fungi, small animals, or decaying plants. But some are parasites. They suck the blood of animals or the juice from plants (see PARASITE). The mite's mouth has piercing and grasping organs. Its digestive system begins with its sucking beak. Several kinds of mites burrow into the skin of people and other mammals, such as horses, cattle, and sheep. They cause the skin to break out and itch. The troublesome chiggers, or red bugs, that torment people who have been in the woods or fields, are mites. The so-called red spiders on house plants also are mites.

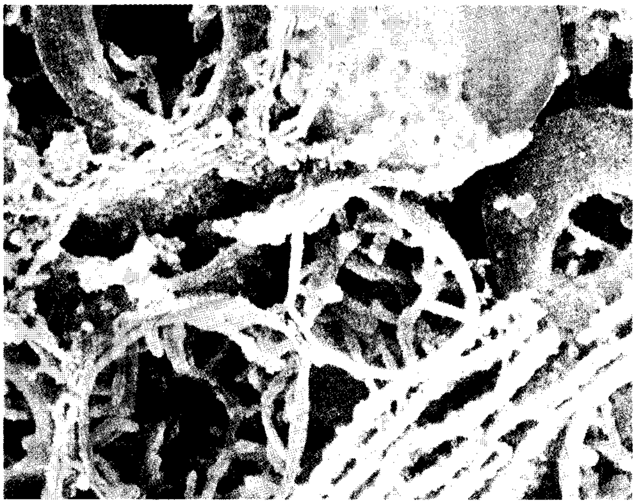


MITE
This harvestman, or daddy longlegs, has several parasitic red mites attached to its body and legs.

MITOCHONDRIA (mī′ tə kŏn′ drē ə) Mitochondria are organelles, or tiny structures, found inside many living cells. Mitochondria are



MITOCHONDRIA—Structure
A mitrochondrion has a pair of membranes. The inner membrane is looped into many folds, called cristae. The cristae are folded to maximize their surface area. Stalked particles on the cristae hold chemicals (enzymes) that control energy production.



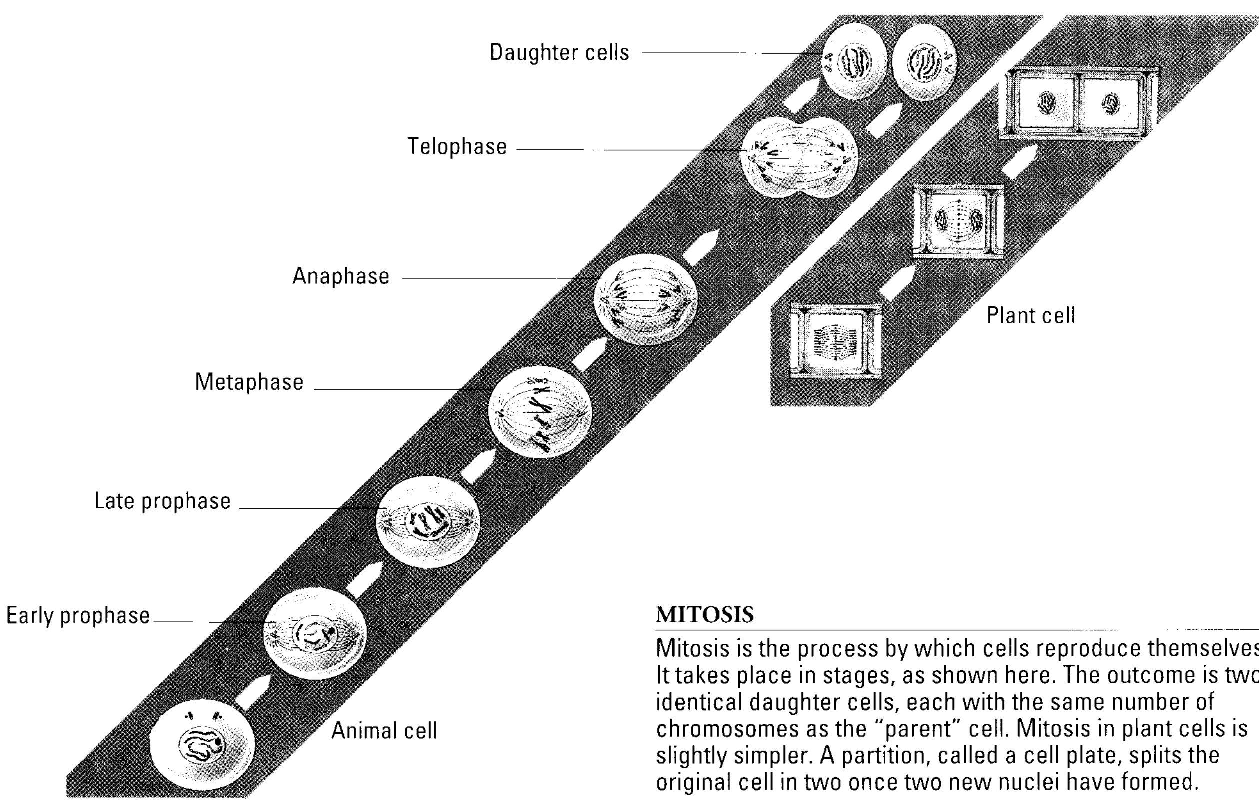
MITOCHONDRIA—Liver cell
This electron microscope photograph of tiny structures inside a liver cell shows cut-through mitochondria (green) and endoplasmic reticulum (yellow brown). Mitochondria convert food into energy, and the endoplasmic reticulum is the site where proteins are made.

responsible for converting food into energy for the cell. Mitochondria are found in both plant and animal cells. A cell can contain as few as one or as many as several thousand mitochondria (see CELL; ORGANELLE).

Mitochondria are quite varied in size and shape. Each mitochondrion (singular of *mitochondria*) is enclosed by a membrane and has another membrane folded inside it (see MEMBRANE). Chemicals derived from food are broken down on the surfaces of this inner membrane by a series of chemical reactions known as the Krebs cycle (see KREBS CYCLE). The Krebs cycle releases water and carbon dioxide as wastes and enables the mitochondria to form adenosine triphosphate (ATP) (see ATP). This molecule is broken down to release energy to fuel cell processes.

MITOSIS (mī tō′ sĭs) Mitosis is the process of cell division in which one parent cell produces two "daughter" cells. Each of these daughter cells is genetically identical to the parent cell. Mitosis goes on continuously in the bodies of multicellular organisms. It is the means of growth and of replacing worn-out cells (see GROWTH). It is also the basis of all asexual reproduction, including reproduction in one-celled organisms (see ASEXUAL REPRODUCTION).

There are four main stages in mitosis: prophase, metaphase, anaphase, and telophase. These are followed by interphase, a resting and reproductively inactive stage. In early prophase (or late interphase), the chromosomes split lengthwise to form two "sister" chromatids, which are joined by a



MITOSIS
Mitosis is the process by which cells reproduce themselves. It takes place in stages, as shown here. The outcome is two identical daughter cells, each with the same number of chromosomes as the "parent" cell. Mitosis in plant cells is slightly simpler. A partition, called a cell plate, splits the original cell in two once two new nuclei have formed.

centromere (see CHROMOSOME). The centriole, just outside the nucleus, also splits into two at this time. As prophase continues, the nuclear membrane begins to dissolve. The centrioles move to opposite ends (poles) of the cell. Fibers form between the poles, in a structure called a spindle.

In metaphase, the chromatid pairs move to the middle of the spindle, called the equator. The centromeres attach to the fibers at the equator, with one chromatid resting on each side of the equator. In late metaphase (or early anaphase), the centromeres begin to split.

In anaphase, the centromeres have split, and each chromatid becomes a separate chromosome. The chromosome pairs are pulled apart as the spindle fibers begin pulling them toward the poles.

In telophase, the new chromosomes are enclosed by new nuclear membranes. The cell itself divides at the equator, forming two new cells, each of which has a full set of chromosomes. Near the end of telophase, the chromosomes elongate and once again become almost invisible. This final stage of mitosis is followed by another interphase.

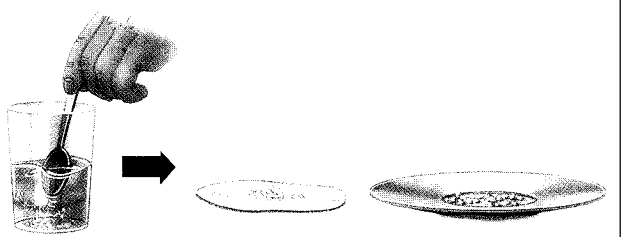
The entire process of mitosis may take only a few minutes or may last several hours, depending on the cell and the conditions. Although mitosis is basically the same in plants and animals, plant cells do not have centrioles.

See also CELL; DIFFERENTIATION, CELLULAR; MEIOSIS.

MIXTURE A mixture contains two or more different substances that are not bonded together chemically. In contrast, in a compound two or more substances called elements are held together by chemical bonds (see COMPOUND; ELEMENT). For example, salt is a compound of sodium and chlorine atoms bonded together. Salt has properties that are quite different from those of either sodium or chlorine. To show how a mixture differs from a compound, put some salt crystals in a cup and then add some sugar crystals. Shake the two together and you will have a mixture. The salt and the sugar do not bond. The mixture is both salty and sweet. It has no new properties of its own.

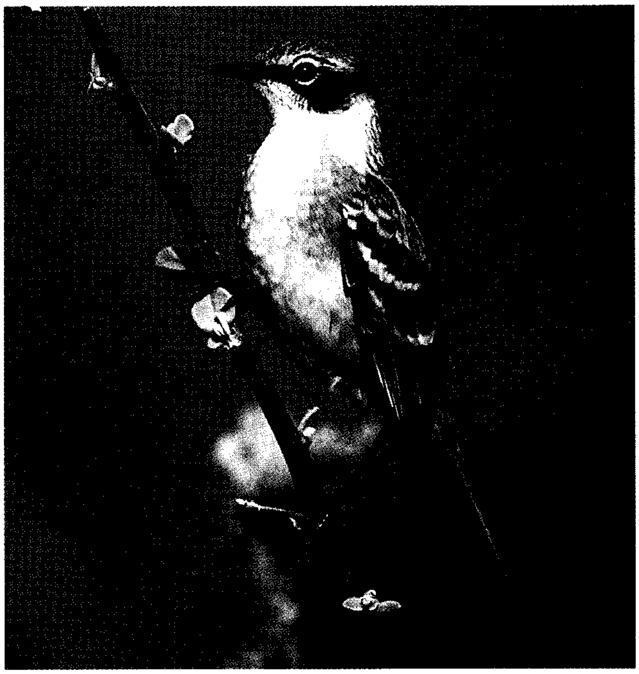
Gases and liquids as well as solids can form mixtures. For example, air is mostly a mixture of oxygen and nitrogen. Oil and water will also form a mixture if they are shaken together.

ACTIVITY *Separating a mixture*



Make a mixture by placing a little sand and a tablespoon of salt in a drinking glass. Separate the mixture by adding warm water and stirring. Filter the sand out of the salt solution with a coffee filter. Put the salt solution on a plate. When the water evaporates, salt crystals form.

MOCKINGBIRD Mockingbirds are songbirds that belong to the family Mimidae. The best known of them are common in the United States and Mexico. The mockingbird is about 9 in. [22.5 cm] long. It has a long tail; long, slender bill; white



MOCKINGBIRD
The mockingbird gets its name from its habit of mimicking, or copying, the voices of other birds and sounds that it hears.

belly; and gray back. It is called a mockingbird because it mimics, or "mocks," the voices of other birds and other sounds. The mockingbird commonly sings at night.

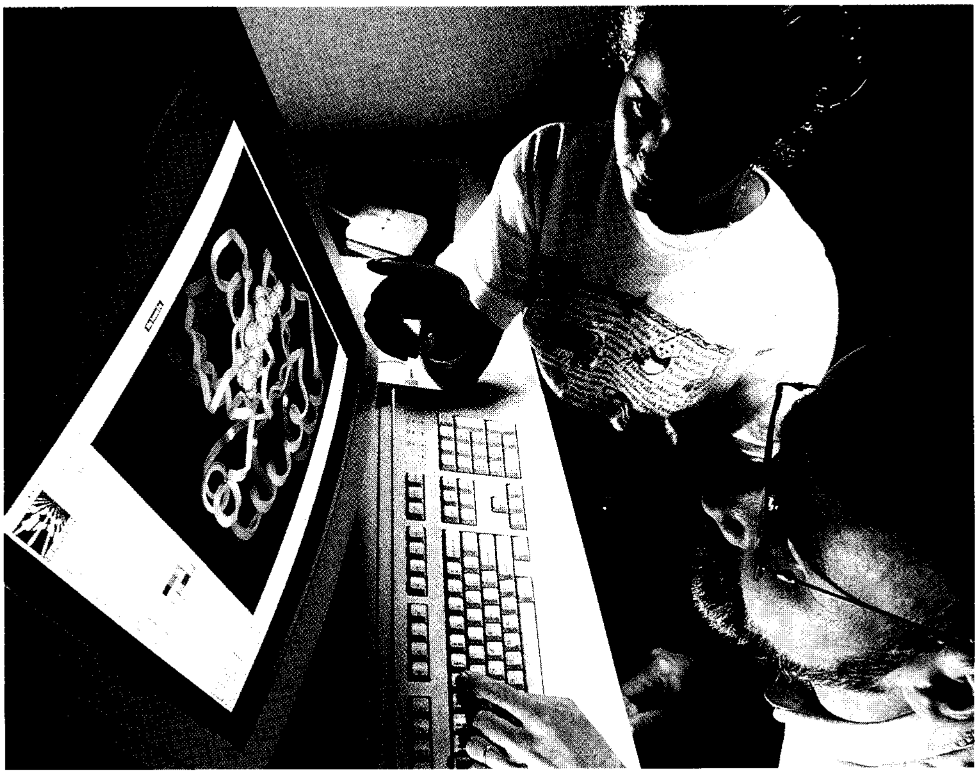
MOCK ORANGE Mock orange is the name given to several shrubs belonging to genus *Philadelphus* of the saxifrage family (see SAXIFRAGE FAMILY). Mock oranges grow as tall as 20 ft. [6 m] and have simple leaves with toothed edges (see LEAF). The white flowers may grow alone or in clusters on short stems. The flowers of some species are sweetly scented, while those of other species are odorless. Members of this genus grow wild in northern temperate areas, and several are cultivated in gardens for their scent.

MOCK ORANGE
Mock orange gets its name because its flowers look and smell like orange blossoms.

Another plant also called mock orange is the calabazilla, a member of the gourd family (see GOURD FAMILY). It is native to the southwestern United States and is also called Missouri gourd or wild pumpkin. This plant produces a green and yellow fruit that is shaped like an orange but is inedible.

MODELING In math, modeling is used to describe two forms of representation. Physical modeling uses real objects to represent mathematical ideas. Examples include cones, curves, and simple shapes such as cubes and spheres, which can be used as mathematical models. This kind of modeling allows people to visualize abstract mathematical concepts more easily.

For scientists and engineers, the more important kind of modeling refers to analytical or theoretical



MODELING
Researchers at a drug company use a computer to display a model of a protein molecule. Molecular modeling is a powerful tool in the production of new medicinal drugs.

models of the real world or processes occurring in it. Any natural process can be described by a model if it can be described in terms of mathematical equations. Changing the values in the equations changes the way the model behaves. This allows for describing the real-world process under varying conditions and predicting how it would behave in those conditions. Computers are almost universally used to construct, change, and test models in this way, with very wide applications, from predicting traffic patterns to forecasting weather.

MODEM A modem is an electronic device that converts one form of communication signal into another. It allows computers to send and receive messsages, usually by using telephone lines. The device can be located inside the computer or can be a special computer attachment. Modems are widely used in business and government, because they allow computer users who may be far apart to communicate quickly. A group of computers that communicate by using modems is called a network.

Modems can be used with portable computers, called personal computers. This allows people who work away from their offices, such as reporters and salespeople, to communicate with those people working at the office. People can also use modems to communicate with information services. These services provide general news or specific information, such as stock-market information.

Modems must be used in pairs. The modem at the originating computer converts the digital information that is being sent into analog electronic signals that start traveling over telephone lines. The telephone lines are plugged directly into each computer or computer attachment. At the receiving computer, another modem receives the analog electronic signals and converts them into digital signals the computer can understand. The process of transmitting information by a modem takes about the same amount of time as completing a telephone call.

See also COMPUTER.

MODERATOR Moderators are rods in a nuclear power plant that slow the speed of neutrons emitted by the radioactive fuel (see NUCLEAR ENERGY; RADIOACTIVITY). This helps control the nuclear reactions in the power plant. Moderator rods are usually made of graphite (a form of carbon), beryllium, or heavy water (water in which deuterium has replaced hydrogen).

MOHO The Moho is the boundary between the earth's crust and mantle (see EARTH; MANTLE). Moho is short for *Mohorovicić discontinuity.* The depth of the Moho ranges from about 5 mi. [8 km] below the ocean floor to about 20 mi. [32 km] beneath the continents.

The Moho was discovered by Andrija Mohorovicić in 1909. He determined that the speed of seismic (earthquake) waves changes when the waves pass from the mantle to the crust (see SEISMOLOGY). This indicated that the mantle rocks are different from the rocks in the earth's crust.

A project to drill a hole to the earth's mantle was proposed in the 1950s. This project was called the Mohole. By studying rocks brought up from this hole, scientists hoped to gain valuable information about the composition and properties of the Moho and the mantle. The project was suspended in 1964 because of its expense.

MOLD A mold is a type of fungus that sometimes grows on plants, animals, or decaying organic material (see FUNGUS). Some molds also grow on leather, fabric, and bookbindings. A mold cannot make its own food and must rely on its host for nutrition (see PARASITE; SAPROPHYTE).

Molds develop from one-celled structures called spores (see SPORE). When a spore that is floating in the air lands on an appropriate damp surface, it swells, produces threadlike parts called hyphae, and grows into a new mold.

Molds are classified by the color of their spores. Blue and green molds belong to the genera *Aspergillus* and *Penicillium.* Black molds belong to the genus *Rhizopus.* White molds belong to the genus *Mucor.*

Molds are often associated with food spoilage. If

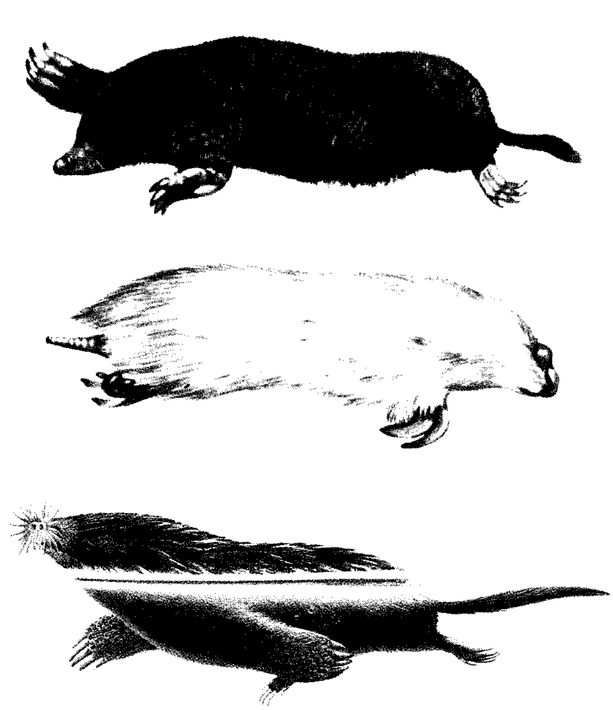
MOLD
This fluffy mold (above), which is a type of fungus, is seen growing on decaying mushrooms—another kind of fungus.

a mold develops on food, the food should probably be discarded. Some molds, however, are used to give certain cheeses, such as Roquefort, their sharp flavor.

Some molds help break down decaying organic matter and are an important link in the food chain (see FOOD CHAIN). One type of mold (genus *Penicillium*) is used to produce penicillin.
See also ANTIBIOTIC; PENICILLIN.

MOLE The mole is a thick-bodied mammal belonging to the order Insectivora. Moles live underground and feed mainly on worms and insect grubs. They are fast, almost tireless diggers, spending most of their lives tunneling through the soil. The mole's body is well suited for such activity. The animal has a long, pointed nose and a wedge-shaped head. The forelegs, which turn outward, work like shovels, scooping through the earth. The mole is nearly blind, but it does not need keen vision in its underground tunnels. The mole's gray or black fur lies in the direction it is brushed, so the animal can easily move backward or forward along its tunnels. A mole's home can be identified by a mound of earth above it.

The common mole is found in the eastern, midwestern, and southwestern United States. The star-nosed mole is found in southeastern Canada and the eastern United States. This species is named for the fringe of fleshy feelers, shaped like a star, around its nose. The Russian desman is the largest mole. It is about 14 in. [36 cm] in length, including the tail. The shrew moles are the smallest



MOLE
There are several species of moles, most of which spend most of their lives tunneling through the soil. Pictured here are the common mole (photograph and top drawing) and the star-nosed mole (bottom), which is a good swimmer. The marsupial mole (center) is not a true mole but a similar pouched animal that lives in Australia.

species. They are about 5 in. [13 cm] in length, including the tail.

MOLE (UNIT) The mole is a unit used in chemistry to measure the amount of a substance. It is one of the units in the metric system (see METRIC SYSTEM).

A mole is the amount of a substance that contains as many elementary units (atoms, molecules, ions, or electrons) as there are carbon atoms in 12 grams of carbon 12 isotope (see ISOTOPE). To work out how many moles of a particular compound are needed in a chemical reaction, its relative atomic or molecular mass is calculated (see RELATIVE MOLECULAR MASS; RELATIVE ATOMIC MASS). One mole of an element is present when its relative atomic mass is expressed in grams. For example, 1 mole of sodium is 23 grams.

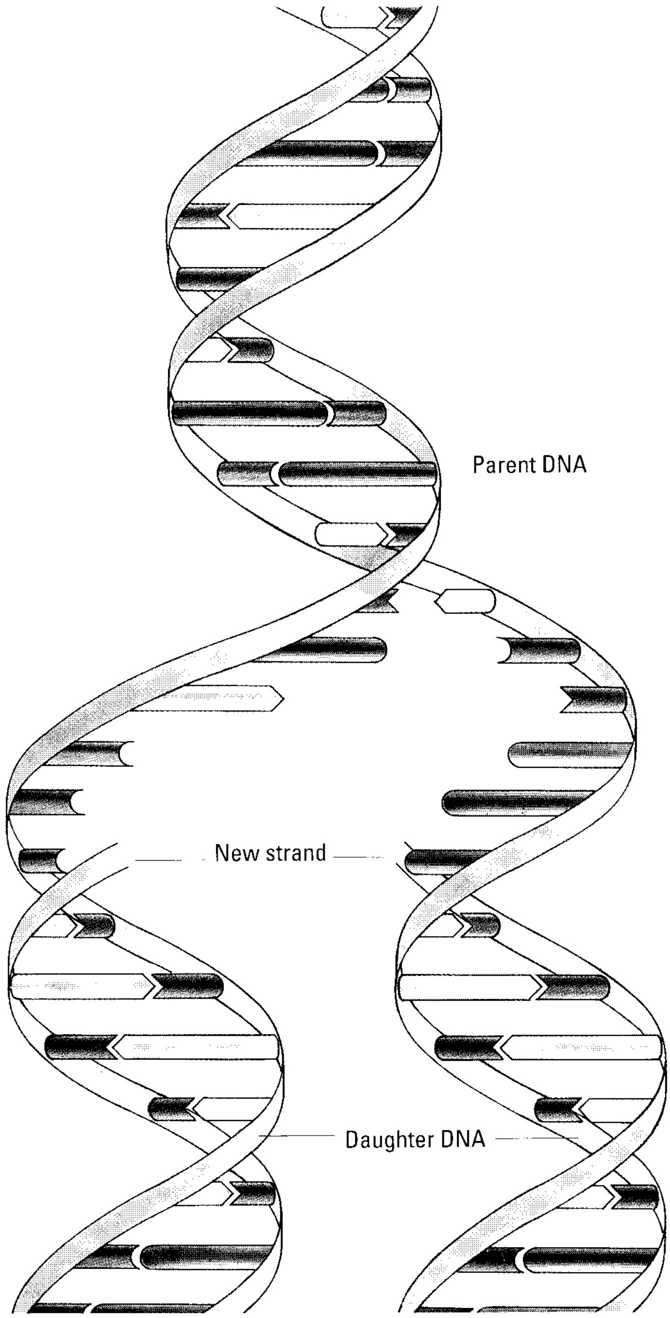
One mole of any substance always contains the same number of molecules. This number is 6.023×10^{23} (10^{23} is 10 followed by 23 zeroes). It is known as Avogadro's number (see AVOGADRO, AMEDEO).

MOLECULAR BIOLOGY (mə lĕk′ yə lər bī ŏl′ ə jē) Molecular biology is the study of the molecules in cells. A molecule is the smallest unit into which a substance can be divided but still keep the characteristics of the substance. Molecular biologists study the structure of the molecules in living systems and try to understand how they cause reactions in the cell (see CELL; MOLECULE).

In the twentieth century, the most important research in biology has been done in the area of molecular biology. This has been largely made possible through new instruments and techniques, such as the electron microscope, the ultracentrifuge, X-ray diffraction, and chemical methods of breaking down molecules. These instruments and techniques enable molecular biologists to explore levels of the cell that are not visible with conventional microscopes (see CENTRIFUGE; ELECTRON MICROSCOPE; MICROSCOPE).

Much of the growth of molecular biology has been due to the discovery of deoxyribonucleic acid (DNA). DNA carries the genetic code in every cell. All the information necessary for an organism's complex life functions is encoded in the DNA molecules (see DNA).

It has been known for thousands of years that certain characteristics are passed from parents to offspring. In the early 1900s, scientists found that it was the genes in cells that transmit the characteristics. Then, in the 1940s and 1950s, it was discovered that genes are composed of DNA. It is now



MOLECULAR BIOLOGY
Much of the work of molecular biology concerns deoxyribonucleic acid (DNA), the substance of which chromosomes are made. This diagram shows how DNA reproduces, or replicates, by "unzipping" along the center and adding two new strands.

known that the total genetic process of a living cell is determined by DNA (see GENE; HEREDITY).

Genetic engineers have used knowledge from molecular biology to help them change certain organisms to meet human needs. Bacteria, for instance, can be changed so that they produce human hormones (see HORMONE). Also, through genetic engineering, plants can be made more resistant to disease. Research in molecular biology has also been valuable to the fields of embryology, physiology, biochemistry, and clinical medicine, as well as to industry.

See also BIOCHEMISTRY; BIOLOGY; BIOPHYSICS; CELL; GENETICS.

MOLECULAR WEIGHT *See* RELATIVE MOLECULAR MASS.

MOLECULE (mŏl′ ĭ kyo͞ol′) A molecule is the smallest unit into which a substance can be divided but still keep the characteristics of the substance. Molecules are made up of atoms (see ATOM). Inside the molecule, the atoms are held together by forces called chemical bonds. These bonds hold the atoms in a particular position in the molecule.

Molecules can vary greatly in size. A molecule of hydrogen (H_2), for example, has just two atoms of hydrogen bonded together. On the other hand, a molecule of DNA, which is the genetic material in cells, contains thousands of atoms. Some common molecules include water (H_2O), carbon dioxide (CO_2), and glucose ($C_6H_2O_6$).

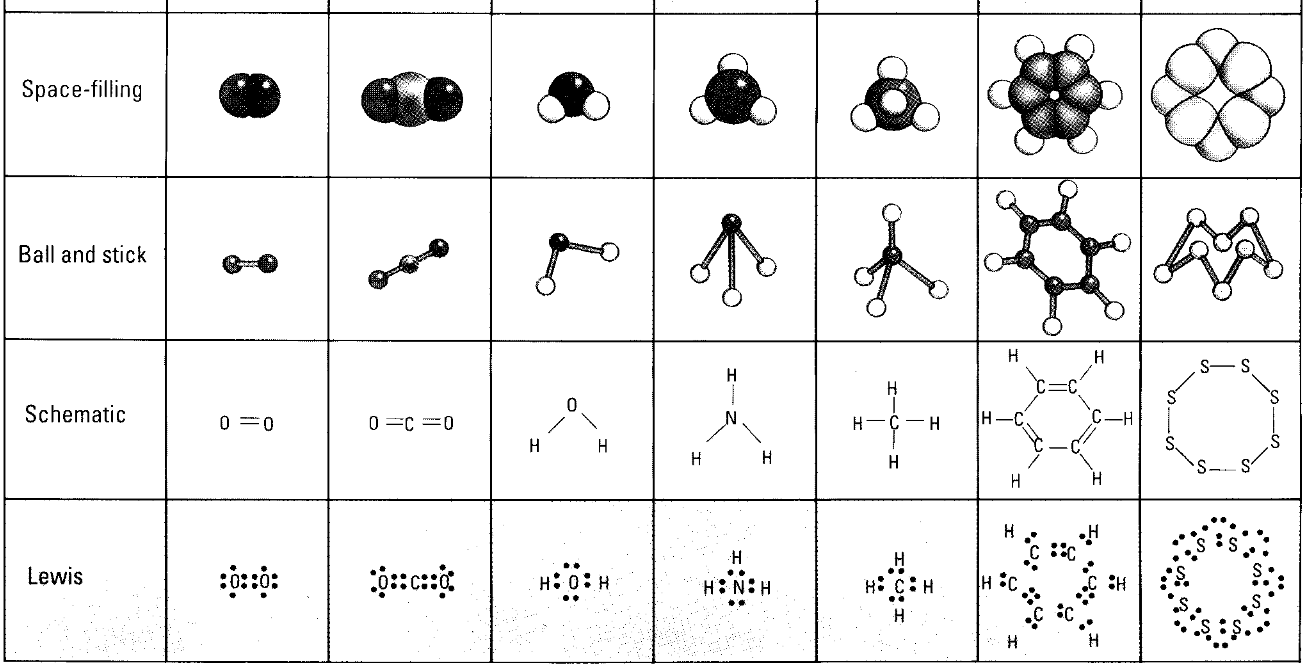
In chemical reactions, atoms can recombine to form different molecules. For example, molecules of hydrogen and molecules of oxygen can combine to form molecules of water. Water is a very different substance from hydrogen or oxygen (see CHEMICAL REACTION; COMPOUND).

Some substances consist of ions arranged in a regular arrangement called a lattice. Many crystals have this structure (see IONS AND IONIZATION).

MOLECULE

Chemists use different ways of representing molecules, depending on whether they are concerned with composition, structure, or shape. Shown here are five kinds of representation that are used.

	Oxygen	Carbon dioxide	Water	Ammonia	Methane	Benzene	Sulfur
Formula	O_2	CO_2	H_2O	NH_3	CH_4	C_6H_6	S_8



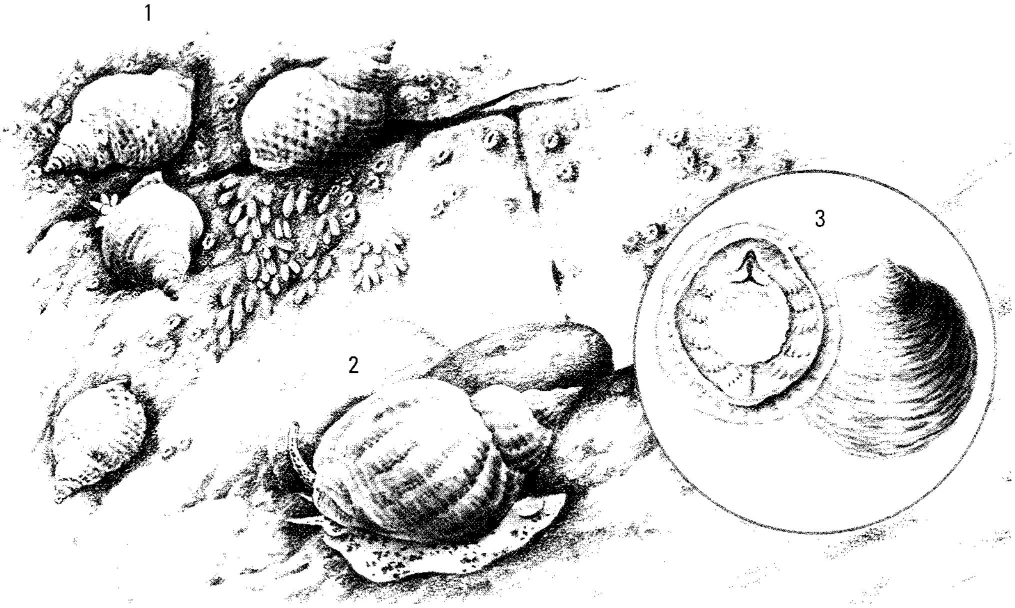
Sodium chloride (NaCl) is an example of a substance that has a lattice structure. The ions of sodium and chloride are so arranged that each sodium ion bonds equally with each of six equidistant chloride ions, and each chloride ion bonds equally with each of six equidistant sodium ions.

According to the molecular or kinetic theory of matter, molecules are in a state of constant motion. The higher the temperature, the more rapid the motion (see KINETIC THEORY).

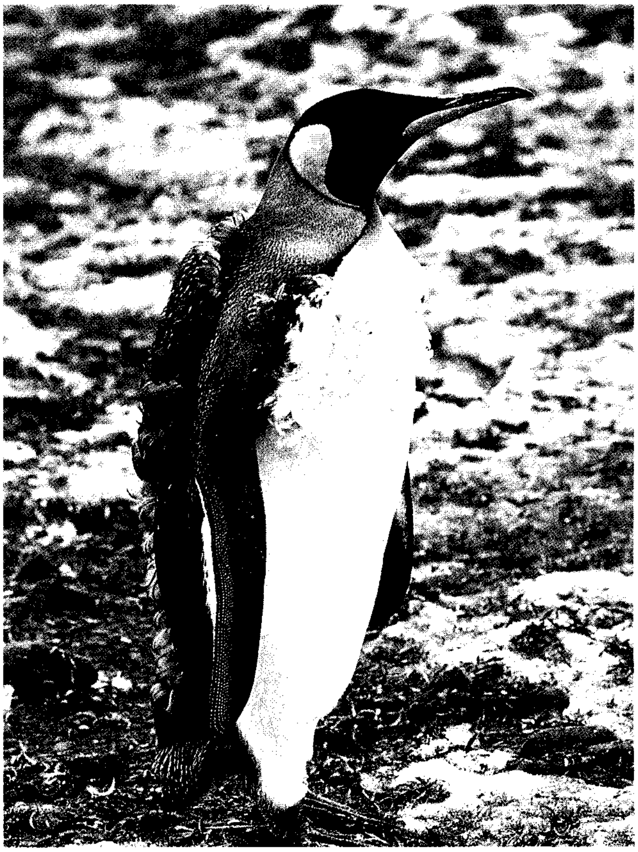
MOLLUSCA (mə lŭs′ kə) Mollusca is a large phylum of invertebrate animals (see INVERTEBRATE). There are more than 100,000 species of mollusks, and they include slugs, snails, clams, squids, and octopuses. Only the phylum Arthropoda has more species (see ARTHROPODA).

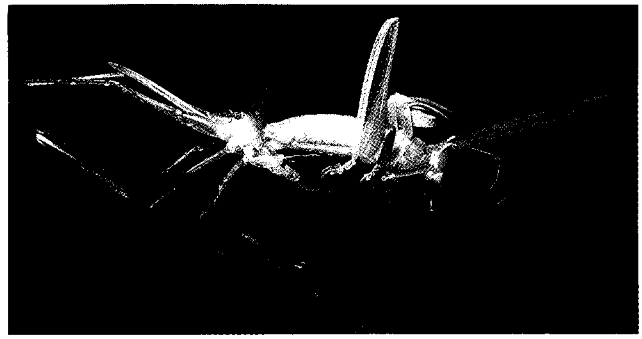
All mollusks have a mantle, a thick flap of skin that often surrounds the body like a cloak. Many mollusks also have a chalky shell produced by the mantle. Bivalves are mollusks that have two shells that open and close around the animal like a book (see BIVALVE). Other mollusks, such as snails, have a single shell. The octopus is a mollusk that does not have a shell.

Most mollusks live in the sea, but many live in fresh water. People eat some mollusks, such as clams, oysters, snails, and squid.



MOLLUSCA
Shell-less mollusks include slugs and the octopus (above), which can move very quickly over short distances. Mollusks also include soft-bodied animals with shells, such as the snail (top right) and the shellfish (right). Shown right are (1) dog whelks, (2) the European whelk, and (3) a deep-sea limpet.





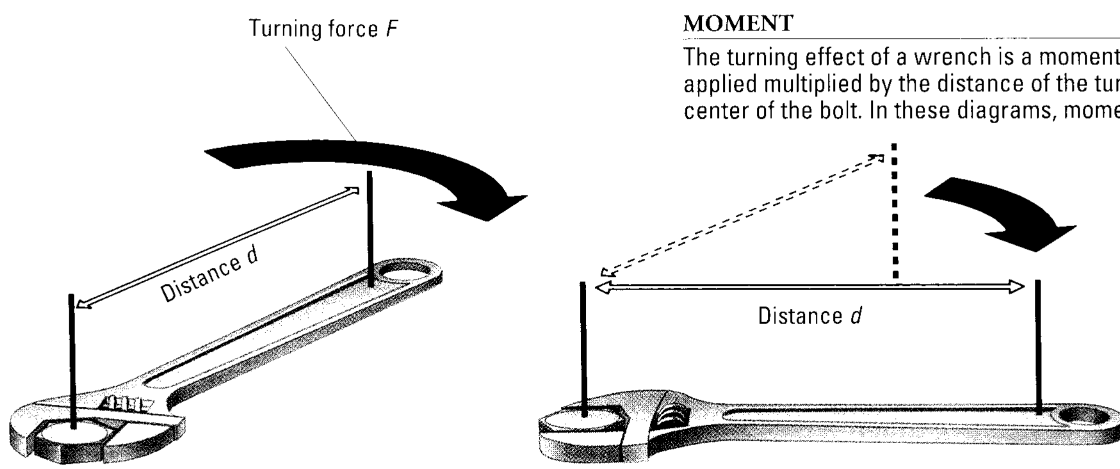
MOLTING
A young emperor penguin (left) molts off its juvenile feathers to reveal the bright plumage of the adult. The katydid (above) molts its skin as it grows.

MOLTING Molting is a process by which many animals shed their body covering (exoskeleton, skin, hair, or feathers) and replace it with a new one. Insects and other arthropods have a hard, protective coat called an exoskeleton (see SKELETON). The exoskeleton cannot increase in size, so it must be replaced as the animal grows larger. When the animal is ready to molt, the body releases a special hormone (see HORMONE). This hormone causes part of the old coat to be reabsorbed by the body. It also causes a new, soft coat to develop under the remains of the old one. The old exoskeleton dries, hardens, and splits. The animal breaks out of the old coat and usually stays in a protected place until its new coat has expanded and hardened.

Most scaly reptiles (such as snakes and lizards) molt regularly, each time shedding the outer layer of skin. Most birds molt at least once a year. When birds molt, they generally lose their feathers a few at a time in a regular order. The feathers are replaced in the same order, so that the bird is able to fly during the four to six weeks required for a complete molt. Most birds molt after the breeding season, and their new feathers last for about a year. Some birds molt again before the breeding season, and this is when many male birds get their bright breeding colors. Most mammals molt their winter fur in the spring.

See also ANTLER; METAMORPHOSIS.

MOMENT The moment of a force, or torque, is the turning effect that force produces. For example, when you unscrew the lid of a jar, turn a doorknob,



MOMENT
The turning effect of a wrench is a moment equal to the force applied multiplied by the distance of the turning force to the center of the bolt. In these diagrams, moment equals *F* x *d*.

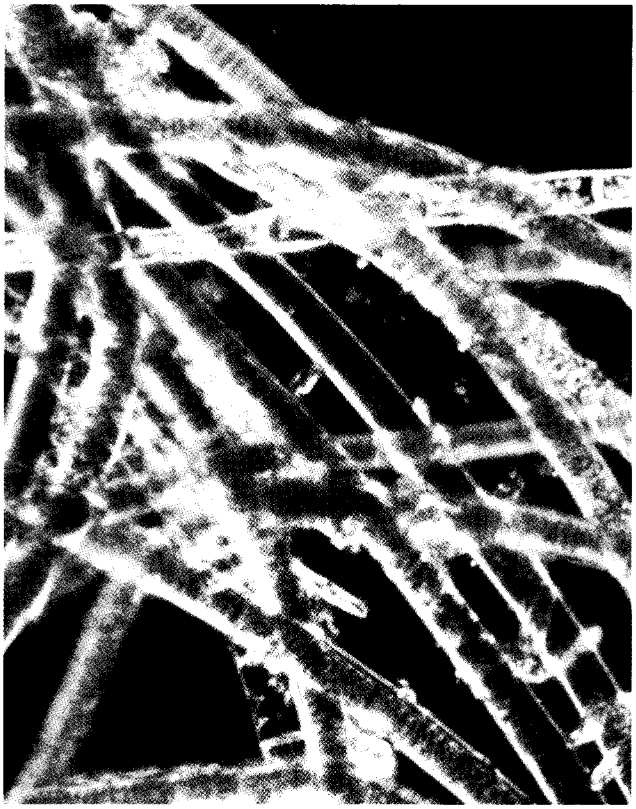
or undo a nut with a wrench, you are using a force to make something turn. The moment of force depends upon two factors: the amount of force applied and the distance of the force from the center of the object being turned. For instance, if you are turning a nut (a part used to secure a bolt) with a wrench, you can increase the turning effect by applying more force to the wrench handle. You can also increase the turning effect by holding on to the handle farther away from the nut. In mathematical terms, the turning effect of a force acting on an object equals the force applied multiplied by the perpendicular distance between the force and the point (called the fulcrum) about which the object turns (see FULCRUM).
See also TORQUE.

MOMENTUM A moving object tends to continue moving. It can only be stopped or slowed down if a force is applied to it. This is because all moving bodies have momentum. The greater the momentum of the body, the more difficult it is to stop that body.

The momentum of an object depends on its mass and its velocity. If the object is moving in a straight line, its momentum is found by multiplying its mass by its velocity. This is called linear momentum. If the object is moving in a circle, then its momentum is called angular momentum (see MASS; VELOCITY).

Suppose that a moving object hits another object that is not moving. The moving object has momentum, but the stationary one does not since it is not moving. After the collision, both objects will move. They both now have momentum. Their combined momentum after the collision is equal to the momentum of the moving object before the collision. This is a very important law in physics. It is called the law of conservation of momentum. PROJECT 32, 46

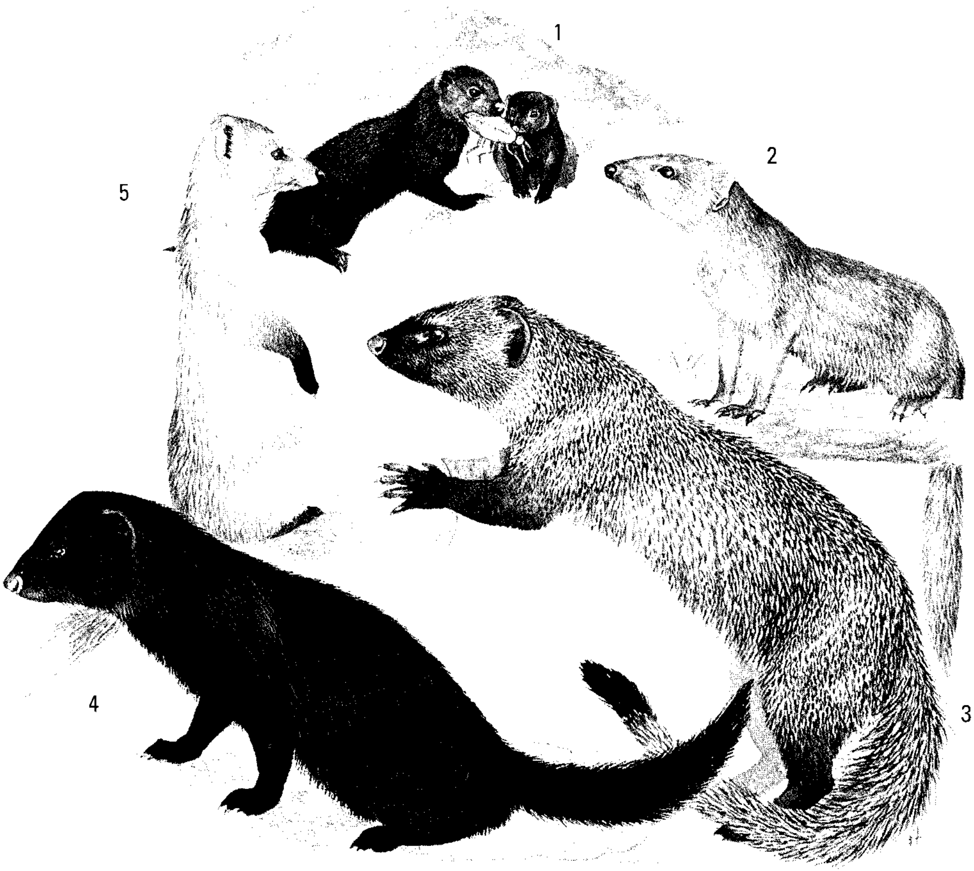
MONERA (mə nēr′ ə) Monera is a kingdom of organisms that includes bacteria and blue-green algae (see ALGAE; BACTERIA). Kingdom Monera is one of the five kingdoms in the classification system that most scientists today accept. The kingdom includes four phyla (plural of *phylum*), or divisions. Members of each division are single-celled, microscopic organisms that lack a nucleus and membrane-bound organelles (see CELL). Some monerans can produce their own food. Others are symbionts, saprophytes, or parasites, getting their nutrients from other living or dead organisms.
See also PARASITE; SAPROPHYTE; SYMBIOSIS.



MONERA
Monera is a kingdom that includes various single-celled organisms, such as these blue-green algae. Called *Phormidium*, they live in semisalt water.

MONGOOSE The mongoose is a slender, carnivorous mammal belonging to the family Viverridae (see CARNIVORE; MAMMAL). There are about fifty species of mongooses, all very much alike. Mongooses are native to Africa and southern Asia.

The best-known mongoose is the Egyptian mongoose, which lives all over Africa and also in southern Europe. It is up to 40 in. [1 m] long, including its tail, and has grayish brown fur. It was considered sacred by the ancient Egyptians. Mongooses are known for their ability to kill snakes. They are partially immune to snake venom (poison), but their swiftness allows them to seize



MONGOOSE

Among the fifty or so species of mongooses are (1) the dwarf mongoose, (2) the narrow-striped mongoose, (3) the Egyptian mongoose, (4) the marsh mongoose, and (5) the Selous' mongoose. Mongooses are skillful hunters and often hunt in family groups.

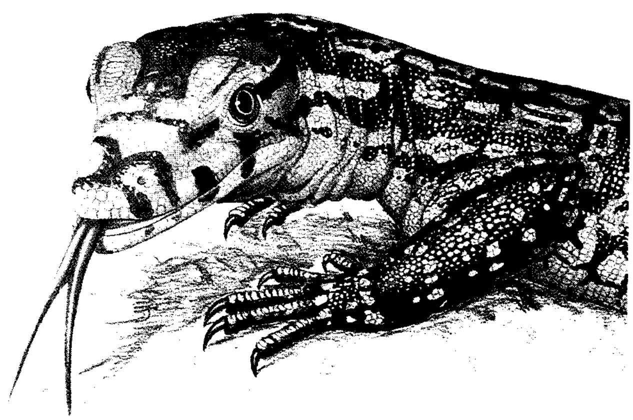
and kill poisonous snakes such as the cobra without getting bitten. The mongoose also kills rats and mice. It has been introduced into Hawaii, Puerto Rico, Jamaica, and Cuba to destroy rat populations. However, mongooses also kill poultry, wild birds, and other beneficial small animals and eat birds' eggs. Mongooses cannot be brought into the continental United States without a government permit.

MONITOR LIZARD The monitor lizards include the largest lizards in the world (see LIZARD). They belong to the family Varanidae. The biggest monitors range in length from 6.5 to 10 ft. [1.9 to 2.8 m] and are as powerful as a small crocodile, but there are also many smaller monitors. Some are only 8 or 9 in. [20 or 23 m] long.

The monitor lizard's stocky body is covered with rounded scales. It has a forked tongue that it can pull back into a protective sheath in its mouth. The tongue is used to detect odors in the air. Monitor lizards live in the hot parts of Africa, Asia, and Australia. They eat fish, amphibians, snakes, and other small animals, as well as eggs.

Monitor lizards are active hunters. They travel long distances in search of food, unlike most other lizards that run short distances to catch their prey. Among the fiercest of the monitor lizards is the Komodo dragon, which lives in Indonesia.

See also KOMODO DRAGON.



MONITOR LIZARD

The common Asian monitor flicks its long, forked tongue in and out to "scent" its surroundings. It has strong claws, which are typical of all monitor lizards.

MONKEY A monkey is any of about two hundred species of lively mammals belonging to the order Primates (see MAMMAL; PRIMATE). Monkeys are usually smaller and more agile than their relatives, the apes (see APE). Most monkeys have tails, whereas apes do not.

Monkeys live in tropical areas throughout the world. Most live in trees, though some species prefer the savannas (grasslands). Even these ground dwellers usually retreat to the trees at night for protection while sleeping. Monkeys vary greatly in size and appearance. The smallest, the pygmy marmoset, may be only 5 in. [12 cm] long (not including the tail) and weigh less than 0.2 lb. [90 g]. The largest, the mandrill, may be 48 in. [120 cm] long and weigh more than 90 lb. [40 kg].

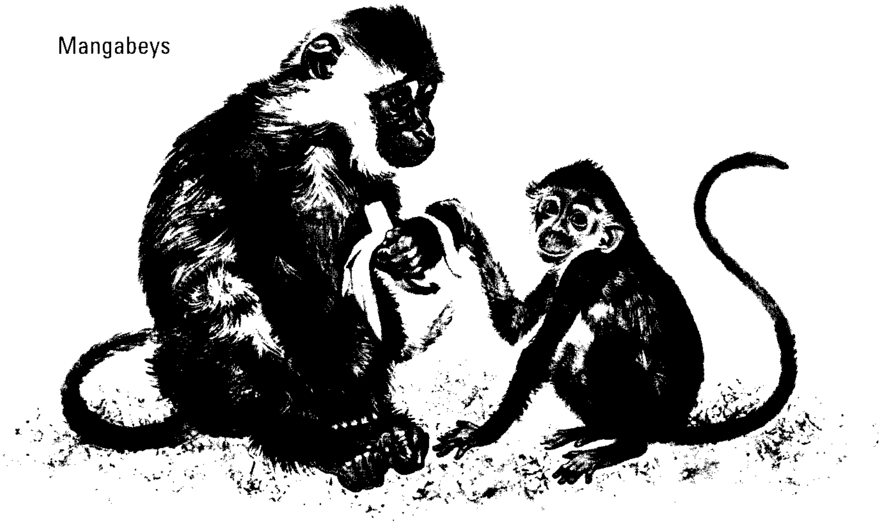
Monkeys have long arms and legs and are well suited for life in the trees. They have opposable thumbs and toes, so their hands and feet can grasp tree branches. Monkeys usually walk on all fours but may stand or run in an upright position, particularly when holding food in their hands. Monkeys have large, keen eyes that face forward and allow both depth and color perception (see EYE AND VISION).

Most monkeys are omnivores, eating plants, insects, and other small animals such as frogs and birds (see OMNIVORE). The larger monkeys, such as the baboons, sometimes prey on young small mammals.

A female monkey usually gives birth to one baby a year, after a gestation period (pregnancy) of four to eight months. She may nurse, protect, and teach her baby for as long as two years. During this time, the young monkey rarely strays far from its mother and often clings to her fur as she moves through the trees.

There are two main groups of monkeys: Old World monkeys and New World monkeys. Old World monkeys are native to Africa and Asia. They all belong to the family Cercopithecidae and include such types as the baboon, mandrill, proboscis monkey, colobus monkey, guenon, langur, and mangabey. Old World monkeys have

Mangabeys

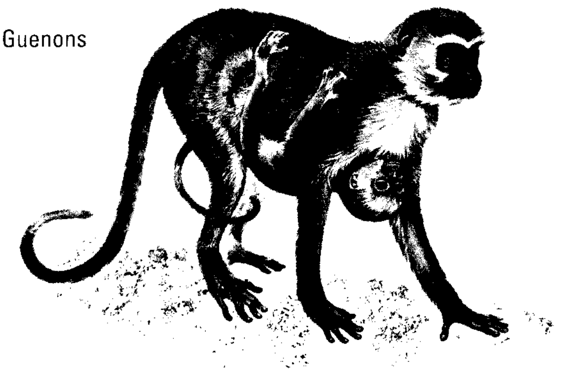


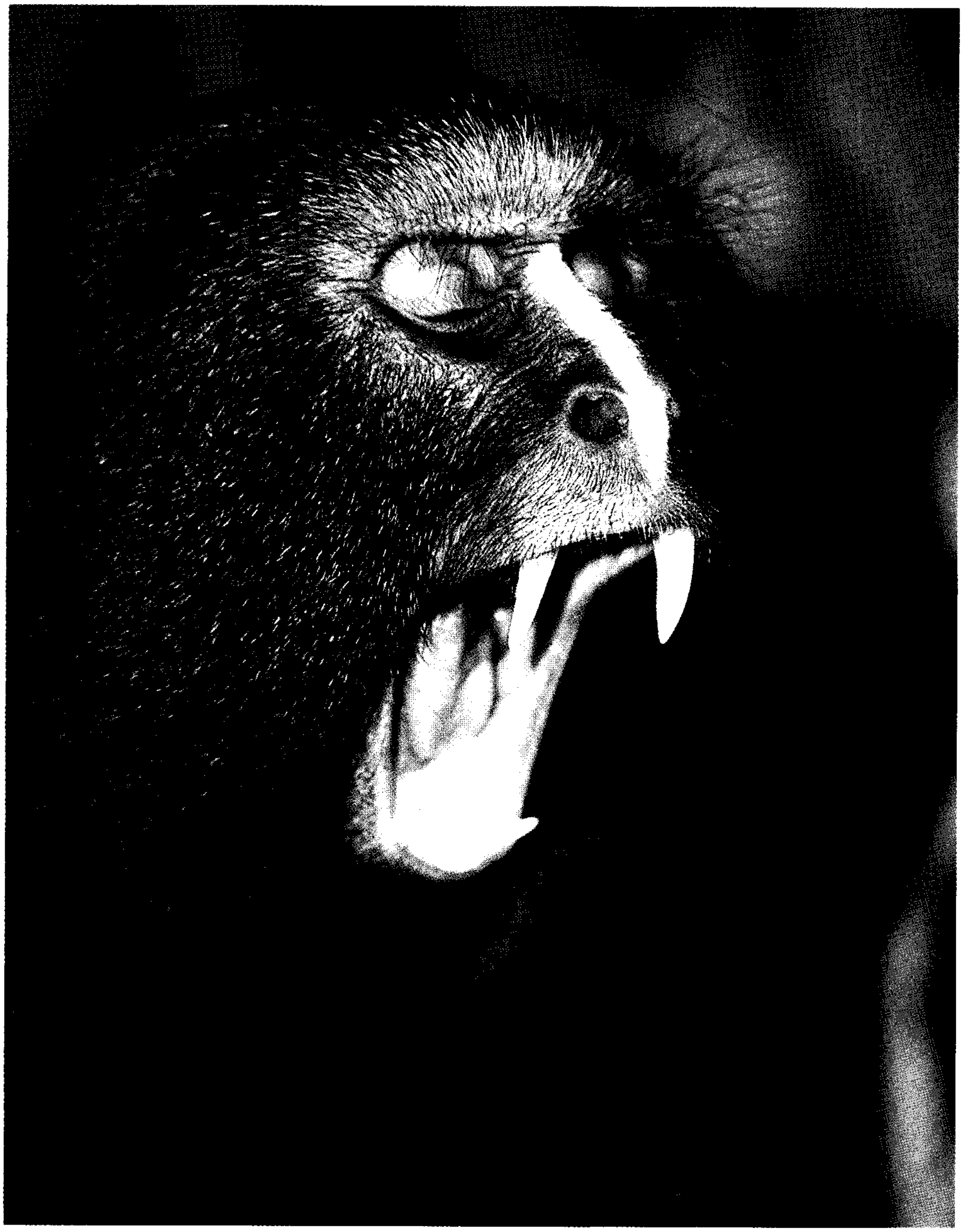
MONKEY—Old World

Monkeys that live in Africa and Asia are grouped together as Old World monkeys. The three species shown here with their young are all from Africa.

Colobus monkeys

Guenons



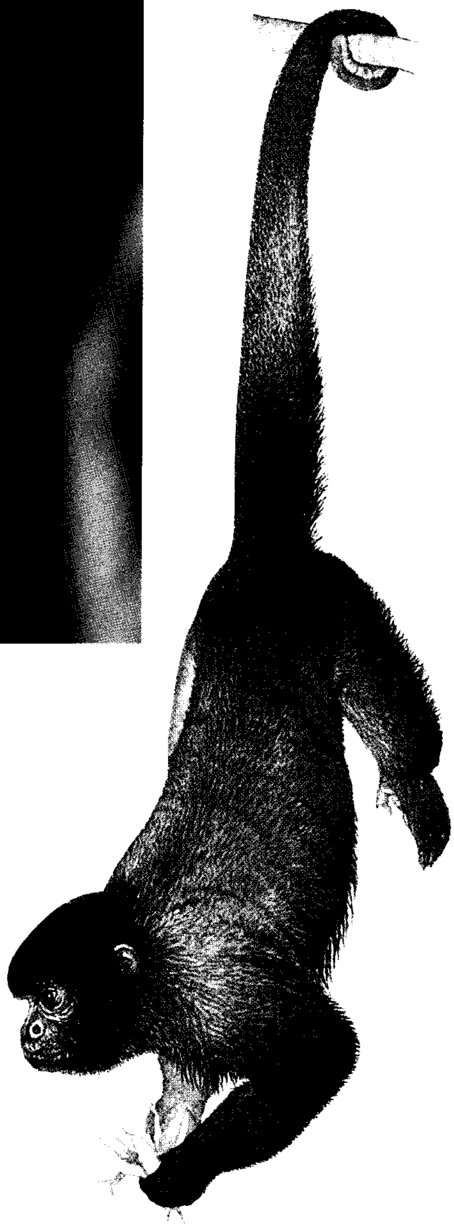


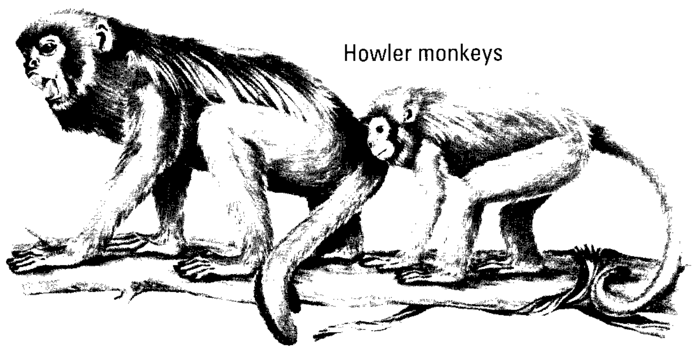
MONKEY—Features

The owl-faced monkey (left) is a type of guenon with long hair surrounding its face. It lives in African woodlands. The smoky woolly monkey (below) is a capuchin from South America. It uses its tail as a fifth "hand" to grasp branches.

thirty-two teeth and close-set nostrils that point downward. They cannot grab onto objects with their tails but use them mostly for balance.

In contrast, New World monkeys are native to Mexico and Central and South America. They have thirty-six teeth and widely spaced nostrils. Many have prehensile tails that can be used to grasp branches or other objects. Their thumbs are only partially opposable, offering less flexibility than the hands of the Old World monkeys. All the New World monkeys live in trees. The New World monkeys belong to two families. Family Callitrichidae includes the marmosets and tamarins. They are the only monkeys with claws instead of nails on their





MONKEY—New World

New World monkeys live in the Americas. They have broad noses and prehensile tails. Douroucoulis have large eyes and are nocturnal. The lack of hair on the face of the bald uakari makes it look like a human. Howler monkeys are named for their howling roar. Squirrel monkeys live in large groups of up to 500 animals.

fingers and toes. All other New World monkeys belong to the family Cebidae. These include the capuchin, howler monkey, spider monkey, squirrel monkey, and woolly monkey.

Monkeys usually live in well-organized social groups. Family groups consist of one adult male, one adult female, and their young. Multimale groups consist of several adult males, about twice as many females, and their young. Single-male groups consist of one adult male, several adult females, and their young. Often these groups establish a territory, which then becomes off-limits to outsiders (see DOMINANCE; TERRITORY). Monkeys frequently show affection and bond with other members of their social group by grooming each other.

Because of their similarities to human beings, monkeys are often used in medical and psychological research. Many of the natural living areas of monkeys have been destroyed by people. As a result, several species are endangered and may soon become extinct.

See also ENDANGERED SPECIES; EXTINCTION.