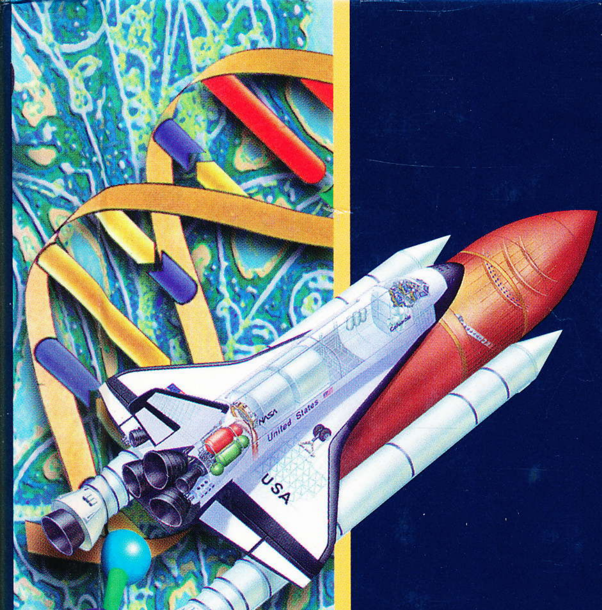
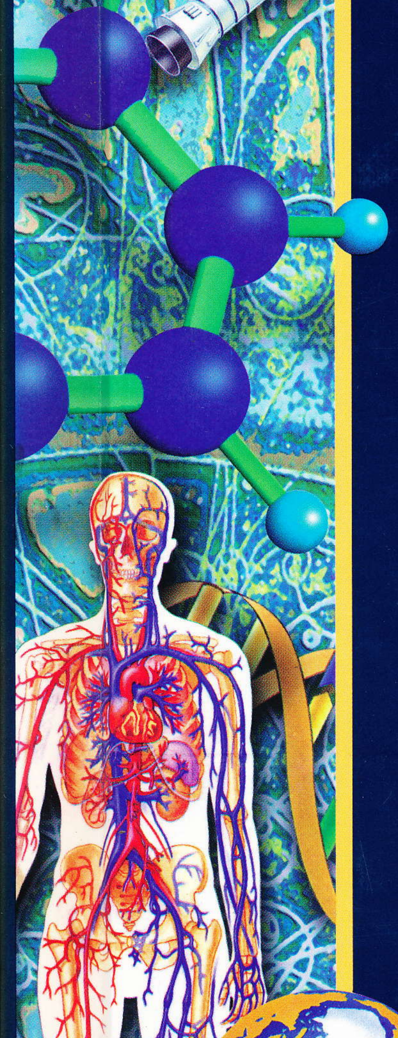

Raintree Steck-Vaughn

# *Illustrated* SCIENCE ENCYCLOPEDIA

Volume 1

Raintree Steck-Vaughn

# *Illustrated*
# SCIENCE ENCYCLOPEDIA

Volume
1

AAR – ANT

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*Austin, Texas*

# USING THE RAINTREE STECK-VAUGHN ILLUSTRATED SCIENCE ENCYCLOPEDIA

You are living in a world in which science, technology, and nature are very important. You see something about science almost every day. It might be on television, in the newspaper, in a book at school, or some other place. Often, you want more information about what you see.

The *Raintree Steck-Vaughn Illustrated Science Encyclopedia* will help you find what you want to know. It contains information on many science subjects. You may want to find out about computers, the environment, space exploration, biology, agriculture, or mathematics, for example. They are all in the *Raintree Steck-Vaughn Illustrated Science Encyclopedia.* There are many, many other subjects covered as well.

There are twenty-four volumes in the encyclopedia. The articles, which are called entries, are in alphabetical order through the first twenty-two volumes. On the spine of each volume, below the volume number, are some letters. The letters above the line are the first three letters of the first entry in that volume. The letters below the line are the first three letters of the last entry in that volume. In Volume 1, for example, you see that the first entry begins with **AAR** and that the last entry begins with **ANT**. Using the letters makes it easy to find the volume you need.

In Volume 23, there are three special features—reference charts and tables, a bibliography, and an index. In Volume 24, there are interesting projects that you can do on your own. The projects are fun to do, and they help you discover and understand important science principles. Many can give you ideas that can help you develop your own science fair projects.

**Main Entries** There are two kinds of main entries in the *Raintree Steck-Vaughn Illustrated Science Encyclopedia.* Many of the entries are major topics that are spread over several pages. The titles of these entries are shown at the top of the page in a yellow box. Other entries required less space to cover the topic fully. The titles of these main entries are printed in capital letters. They look like this: **ABALONE**. At the beginning of some entries, you will see a phonetic pronunciation of the entry title, such as (ăb′ ə lō′ nē). In the front of each volume, there is a pronunciation key. Use it the same way you use your dictionary's pronunciation key.

**Cross-References** Within the main entries are cross-references referring to other entries in the encyclopedia. Within an entry, they look like this: (see MAMMAL). At the end of an entry, they look like this: *See also* HYENA. These cross-references tell you where to find other helpful information on the subject you are reading about.

**Projects** At the end of some entries, you will see this symbol: PROJECT 1. It tells you which projects related to that entry are in Volume 24.

**Illustrations** There are thousands of photographs, drawings, graphs, diagrams, tables, and other illustrations in the *Raintree Steck-Vaughn Illustrated Science Encyclopedia.* They will help you better understand the entries you read. Captions describe the illustrations. Many of the illustrations also have labels that point out important parts.

**Activities** Some main entries include activities presented in a special box. These activities are short projects that give you a chance to work with science on your own.

**Index** In Volume 23, the index lists every main entry by volume and page number. Many subjects that are not main entries are also listed in the index, as well as the illustrations, projects, activities, and reference charts and tables.

**Bibliography** In Volume 23, there is also a bibliography for students. The books in this list are on a variety of topics and can supplement what you have learned in the *Raintree Steck-Vaughn Illustrated Science Encyclopedia.*

The *Raintree Steck-Vaughn Illustrated Science Encyclopedia* was designed especially for you, the student. It is a source of knowledge for the world of science, technology, and nature. Enjoy it!

## PRONUNCIATION KEY

Each symbol has the same sound as the darker letters in the sample words.

| | | | | | |
|---|---|---|---|---|---|
| ə | balloon, ago | îr | **deer**, **pier** | r | **r**oot, ti**r**e |
| ă | m**a**p, h**a**ve | j | **j**oin, **g**erm | s | **s**o, pre**ss** |
| ā | d**a**y, m**a**de | k | **k**ing, as**k** | sh | **sh**oot, ma**ch**ine |
| âr | c**ar**e, b**ear** | l | **l**et, coo**l** | t | **t**o, s**t**and |
| ä | f**a**ther, c**a**r | m | **m**an, sa**m**e | th | **th**in, dea**th** |
| b | **b**all, ri**b** | n | **n**o, tur**n** | *th* | **th**en, **th**is |
| ch | **ch**oose, na**t**ure | ng | bri**ng**, lo**ng** | ŭ | **u**p, c**u**t |
| d | **d**i**d**, a**dd** | ŏ | **o**dd, p**o**t | ûr | **ur**ge, h**ur**t |
| ĕ | b**e**ll, g**e**t | ō | c**o**ne, kn**ow** | v | **v**iew, gi**v**e |
| ē | sw**ee**t, **ea**sy | ô | **a**ll, s**aw** | w | **w**ood, glo**w**ing |
| f | **f**an, so**f**t | oi | b**oy**, b**oi**l | y | **y**es, **y**ear |
| g | **g**ood, bi**g** | ou | n**ow**, l**ou**d | z | **z**ero, rai**s**e |
| h | **h**urt, a**h**ead | o͝o | g**oo**d, t**oo**k | zh | lei**s**ure, vi**s**ion |
| ĭ | r**i**p, **i**ll | o͞o | b**oo**t, n**oo**n | ′ | strong accent |
| ī | s**i**de, sk**y** | p | **p**art, scra**p** | ′ | weak accent |

## GUIDE TO MEASUREMENT ABBREVIATIONS

All measurements in the *Raintree Steck-Vaughn Illustrated Science Encyclopedia* are given in both the customary system and the metric system [in brackets like these]. Following are the abbreviations used for various units of measure.

### Customary Units of Measure

| | |
|---|---|
| mi. = miles | cu. yd. = cubic yards |
| m.p.h. = miles per hour | cu. ft. = cubic feet |
| yd. = yards | cu. in. = cubic inches |
| ft. = feet | gal. = gallons |
| in. = inches | pt. = pints |
| sq. mi. = square miles | qt. = quarts |
| sq. yd. = square yards | lb. = pounds |
| sq. ft. = square feet | oz. = ounces |
| sq. in. = square inches | fl. oz. = fluid ounces |
| cu. mi. = cubic miles | °F = degrees Fahrenheit |

### Metric Units of Measure

| | |
|---|---|
| km = kilometers | cu. km = cubic kilometers |
| kph = kilometers per hour | cu. m = cubic meters |
| m = meters | cu. cm = cubic centimeters |
| cm = centimeters | ml = milliliters |
| mm = millimeters | kg = kilograms |
| sq. km = square kilometers | g = grams |
| sq. m = square meters | mg = milligrams |
| sq. cm = square centimeters | °C = degrees Celsius |

For information on how to convert customary measurements to metric measurements, see the Metric Conversions table in Volume 23.

# A

**AARDVARK** The aardvark is an African mammal of the family Orycteropodidae (see MAMMAL) which is found from Ethiopia to South Africa. The aardvark, whose name means "earth pig" in the Afrikaans language, is up to 6 ft. [180 cm] long. It has a long snout and its tongue can be extended up to 18 in. [45 cm]. Aardvarks range in color from glossy black to sandy yellow.

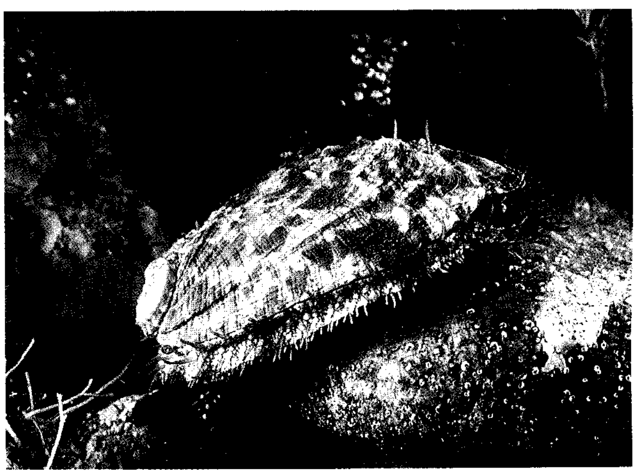
Aardvarks are nocturnal, which means they are active at night. They use their sharp claws to dig into ant and termite hills, then with their long tongues they scoop up and eat the insects.

**ABACUS** (ăb′ə kəs) An abacus is a device once widely used for counting and doing arithmetic. The abacus probably was invented thousands of years ago in the Middle East. An abacus is made of a wooden frame with beads strung on wires stretched between two of its sides. The beads stand for numbers. They are moved back and forth to show different amounts. The abacus is usually laid on a flat surface when in use.

Depending on where an abacus is made, the number of wires varies. The Russian abacus, for example, has ten wires with ten beads on each wire. The beads on the wire at the far right have the value of units, or ones. Those on the next wire stand for tens, those on the next wire stand for hundreds, and so on. Each time all of the beads on any one wire have been moved forward, one bead on the next wire is moved forward. The beads on the completed wire are moved back. For example, the number 149 is represented by one "hundreds" bead, four "tens" beads, and nine "ones" beads moved forward. Skilled abacus users are able to do arithmetic quickly by moving the beads.
*See also* COMPUTER.

**ABACUS**
In many parts of the world, such as the Far East, the abacus is still used for calculations.

**ABALONE** (ăb′ə lō′nē) The abalone is a large marine mollusk belonging to the class Gastropoda (see GASTROPOD). The abalone is found off the coasts of California, Mexico, Japan, Australia, and South Africa. The abalone has one shell, which is shaped like a bowl. It covers the top of the animal. The abalone grows up to 1 ft. [30 cm] long. There is a row of holes along one edge of the shell



**ABALONE**
The abalone is a single-shelled mollusk. A distinguishing feature of the abalone is the row of holes in its shell.

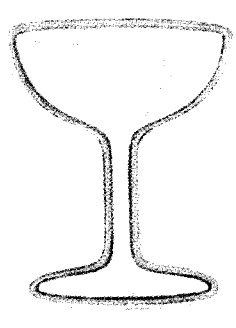
through which water passes. The gills of the abalone enable it to breathe the way fish breathe. The inside of the shell is a beautiful white mineral that is called mother-of-pearl. Mother-of-pearl is used in jewelry and other decorative items. The abalone's large, muscular foot is called abalone steak when it is eaten by humans.

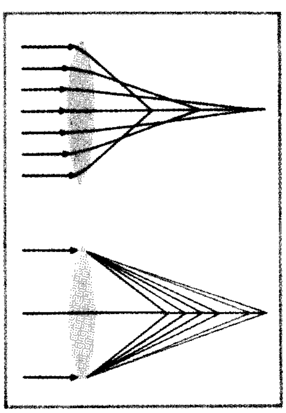
**ABDOMEN** The abdomen is a section of the body of an animal. People often call it the belly. In humans, the abdomen begins at the bottom of the ribs and ends at the hips. The abdomen contains many important organs, such as the stomach, the intestines, the kidneys, and the liver. These organs are kept in place by strong muscles. A muscular membrane called the diaphragm separates the abdomen from the chest cavity, where the lungs and heart are.

In insects, the abdomen is the last body region. No legs are attached to this part of the body.
*See also* ANATOMY; INSECT.

**ABERRATION** An aberration is a defect in an image formed by the lenses and curved mirrors of optical instruments, such as telescopes. The aberration occurs because the light rays from an object are not brought to a sharp focus.

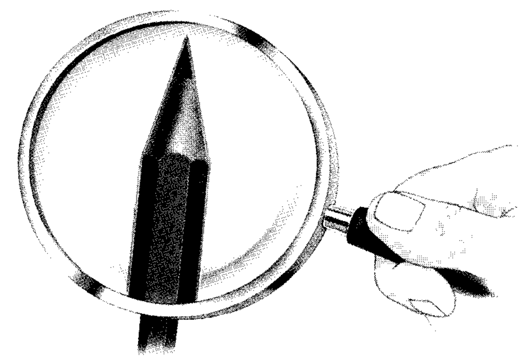
Two important forms of aberration are chromatic and spherical. Chromatic aberrations are the colored fringes that sometimes occur along the edge of an image produced by a lens or mirror. Chromatic aberration occurs because the lens or mirror bends blue light more than red light. A spherical aberration occurs when a lens or mirror brings light rays to focus in slightly different positions. This makes the image fuzzy.





**ABERRATION**
The colored sparkle of a wine glass (above left) is due to chromatic aberration. The diagram (above right) shows two kinds of aberration that are seen when light passes through a lens. The upper lens shows spherical aberration. The lower lens shows chromatic aberration.

**ACTIVITY** *How to see aberration*



Look at an object through a cheap lens (such as one in a toy magnifying glass). The colored fringe on the edge of the object is due to aberration.

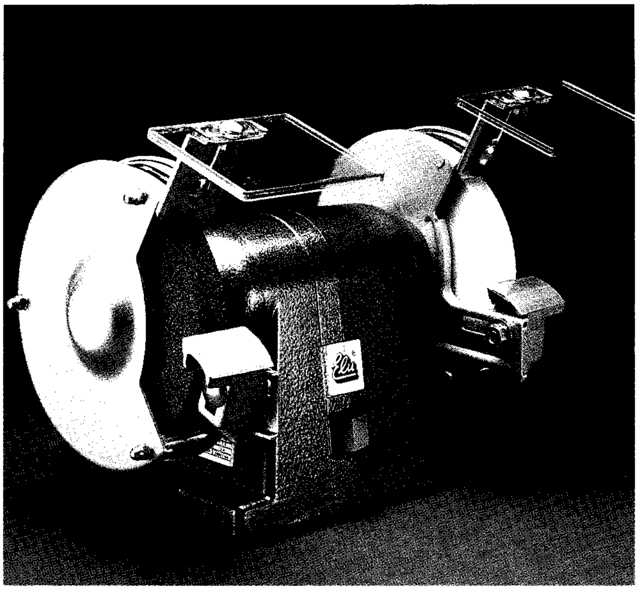
One well-known example of aberration occurred when the *Hubble* space telescope failed to work after being placed into orbit. The space shuttle *Endeavor* returned to the satellite. The space-walking crew used corrective lenses to fix the spherical aberration in the telescope. The mission was a success, and in 1994 *Hubble* began sending back sharp images of distant objects.
*See also* LENS; OPTICS.

**ABORTION** An abortion is the ending of a pregnancy before the fetus (unborn child) has a reasonable chance of survival. The mother's body will usually reject the fetus, causing it to leave her body. At other times, a doctor must remove the dead fetus. The abortion may be caused by many things. The fetus may develop incorrectly, or the mother may become ill or be injured. The natural expulsion of a fetus from the mother's body is also sometimes called a miscarriage.

**ABRASIVE** An abrasive is a material used to grind, wear down, scrape, or polish other materials. There are natural abrasives, such as sand, emery, and pumice, and synthetic abrasives, such as silicon carbide, also called Carborundum. Abrasive paper is made by coating paper with a glue and adding the abrasive substance. Sandpaper, emery paper, and Carborundum paper are made in this way. To make a grinding wheel, abrasive material such as quartz is mixed with clay and water. This mixture is then pressed into the desired size and shape and fired in a furnace. The heat makes a strong bond among the materials.

A grit number is used to describe the fineness or coarseness of the particles used in an abrasive material. Abrasives with a grit number of 60 are much finer than abrasives with a grit number of 30. The hardness of an abrasive is important. An abrasive must be harder than the material it is meant to grind or polish. The hardness of minerals is measured according to a scale known as the Mohs scale (see HARDNESS).

The most widely used abrasives are fused aluminum oxide ($Al_2O_3$) and silicon carbide (SiC). Aluminum oxide is known as alumina. It is used to grind and polish metals such as steel, wrought iron, and hard bronze. Silicon carbide is better known as Carborundum. It is made by fusing sand and coke in an electric furnace. Carborundum is used to grind and polish brass, copper, aluminum, stone, glass, and ceramics.



**ABRASIVE**
Abrasive wheels like these are used to grind and polish many different kinds of materials.

Varieties of quartz are also important abrasives. Pumice is a volcanic rock. When ground to a fine powder, it is used in scouring powders and soaps. Diatomite is the chalky remains of tiny organisms (see DIATOM). It is used in metal polishes. Crystalline iron oxide is used to polish jewelry and glass. It is known as jeweler's rouge because of its reddish color. Synthetic diamonds and diamonds not suitable for gemstones are used as abrasives. They provide a hard edge in the drill bits used in drilling through rock for oil. Tungsten carbide (WC) is used in the machine-tool industry for the drilling, cutting, and polishing of metals. The carbides, nitrides, and borides of tantalum, vanadium, and zirconium are similar in hardness to tungsten carbide and are used for the same purposes. Another important abrasive is boron carbide ($B_4C$). It is valuable because it is almost as hard as diamond.

**ABSOLUTE ZERO** Absolute zero is the lowest temperature possible. It is equal to -459.67°F (-273.15°C). In a substance at absolute zero, the atoms and molecules would be completely at rest, and the substance would possess no heat at all (see THERMODYNAMICS).

When substances are cooled well below ordinary temperatures, they behave in strange ways. Gases change to liquids or solids. Oxygen, for example, becomes a bluish-white solid at -353.9°F (-214.4°C). Closer to absolute zero, at -452.07°F (-268.93°C), helium turns from a gas to a liquid that creeps up the sides of its container. It is not possible to reach absolute zero, but scientists have come within a billionth of a degree of it.

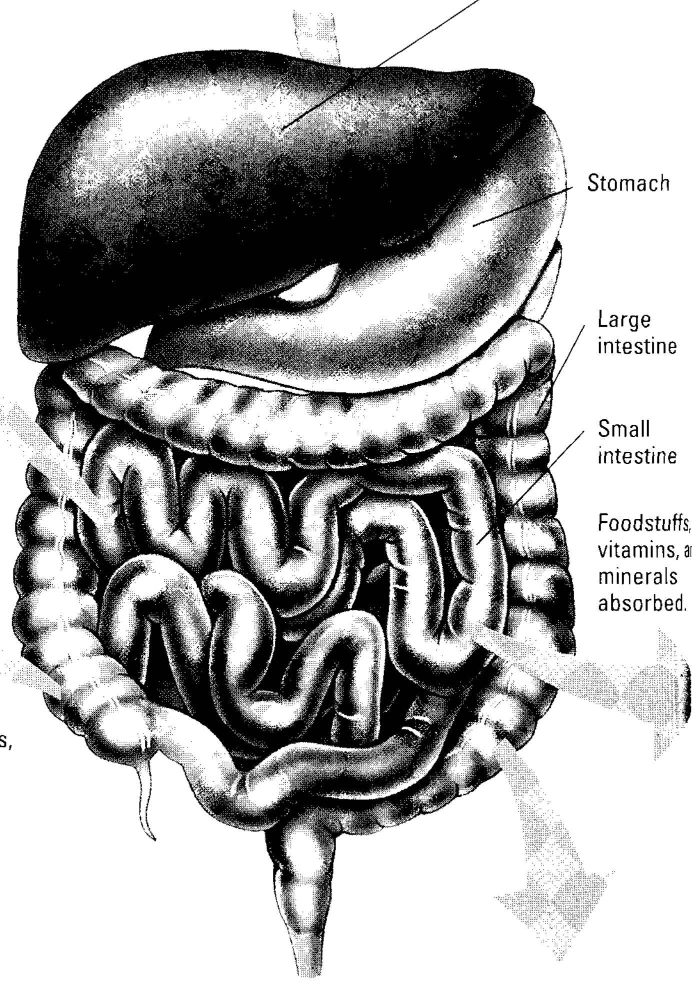
Scientists use the thermodynamic, or Kelvin, temperature scale, which is based on absolute zero. The unit of temperature is called the kelvin, after the nineteenth-century British physicist Lord Kelvin. The degree sign (°) is not used with the Kelvin scale. In size the kelvin (symbol K) is exactly equal to the Celsius or centigrade degree. But the zero of the Kelvin scale is set at absolute zero. This means that 0°C (32°F), the freezing point of water, is equivalent to 273.15 K.

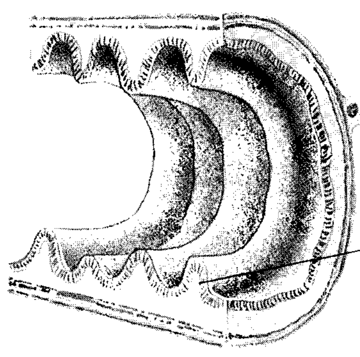
*See also* CRYOGENICS; KELVIN, LORD; KELVIN SCALE.

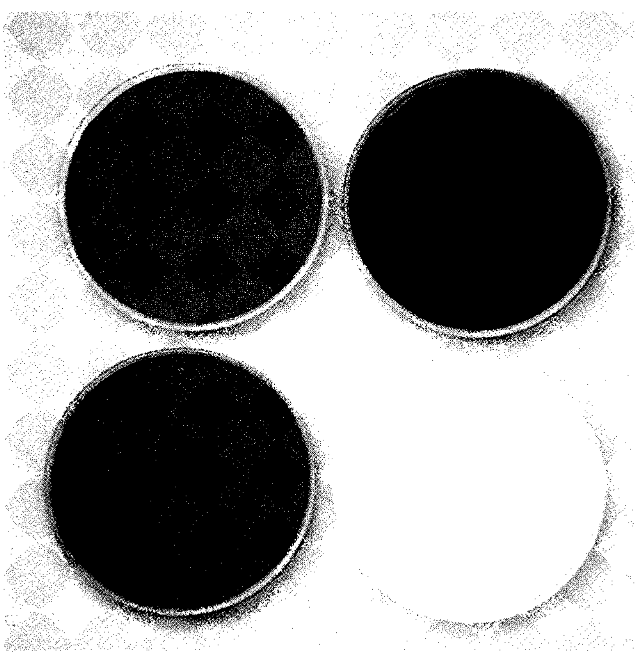
# ABSORPTION & ADSORPTION

Absorption and adsorption are two different ways for a substance to take up another substance. In absorption, the second substance becomes spread throughout the first substance. In adsorption, the second substance is spread only on the surface of the first substance.

Substances can also absorb various forms of energy, such as heat, light, and sound. When energy is absorbed by an object, the energy usually changes form. For example, when people absorb energy from the sun, they are warmed, and their skin may become reddened or darker. All colored objects have a certain color because they reflect that color. They absorb all the others. For example, a blue object absorbs nearly all the light striking its surface except blue light, which is reflected. Sunlight and other white light are a mixture of all colors. A black object absorbs all of the light falling on it. Sound is absorbed by heavy curtains and soundproofing materials. These materials are often found in recording studios, concert halls, and auditoriums. The materials absorb internally produced sounds and prevent them from producing echoes and reverberations.



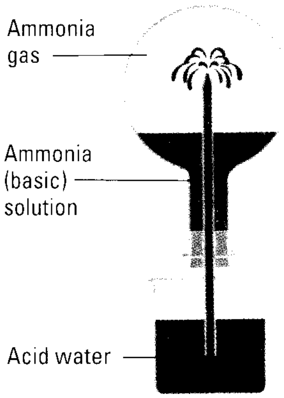



**REFLECTION AND ABSORPTION**

Objects appear as certain colors because they absorb some wavelengths of light, but reflect others back to our eyes. The paints in these pots all reflect different wavelengths, and we see each paint as the color of the light it reflects.

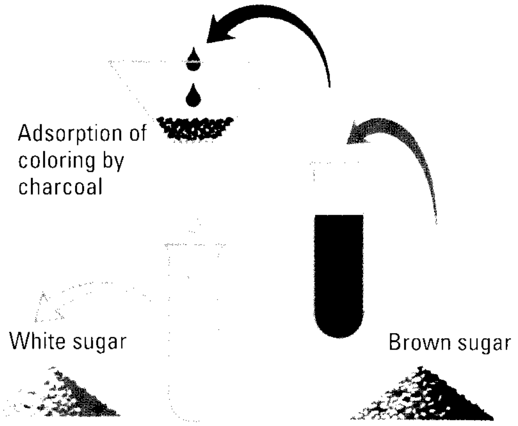
**DIGESTION**

The illustration above shows the parts of the body where digestion occurs.




**ABSORPTION AND ADSORPTION**

The "ammonia fountain" (left) shows chemical absorption. Acid water is drawn up through ammonia gas and is changed to a basic solution. Litmus dye shows the changing of acid (red) to base (blue). The coloring matter (right) of brown sugar is chemically adsorbed by charcoal. When a solution of brown sugar is filtered through charcoal, it loses its brown color. The brown pigments remain in the charcoal filter. The colorless liquid is a sugar solution. Crystals of white sugar are recovered from this solution.




Liquids absorb solids and gases by dissolving them. The sea absorbs oxygen from the air and from plant life in the water. The absorption of gases is important in industry. Many gases are purified by passing them up a tower containing streams of falling liquid. The liquid absorbs the impurities in the gases. The towers with these liquids are called absorption towers or scrubbers.

In the body, nutrients from food are absorbed after digestion through the wall of the gastrointestinal tract. Blood also absorbs oxygen from the air in the lungs and carries it to the body tissues.

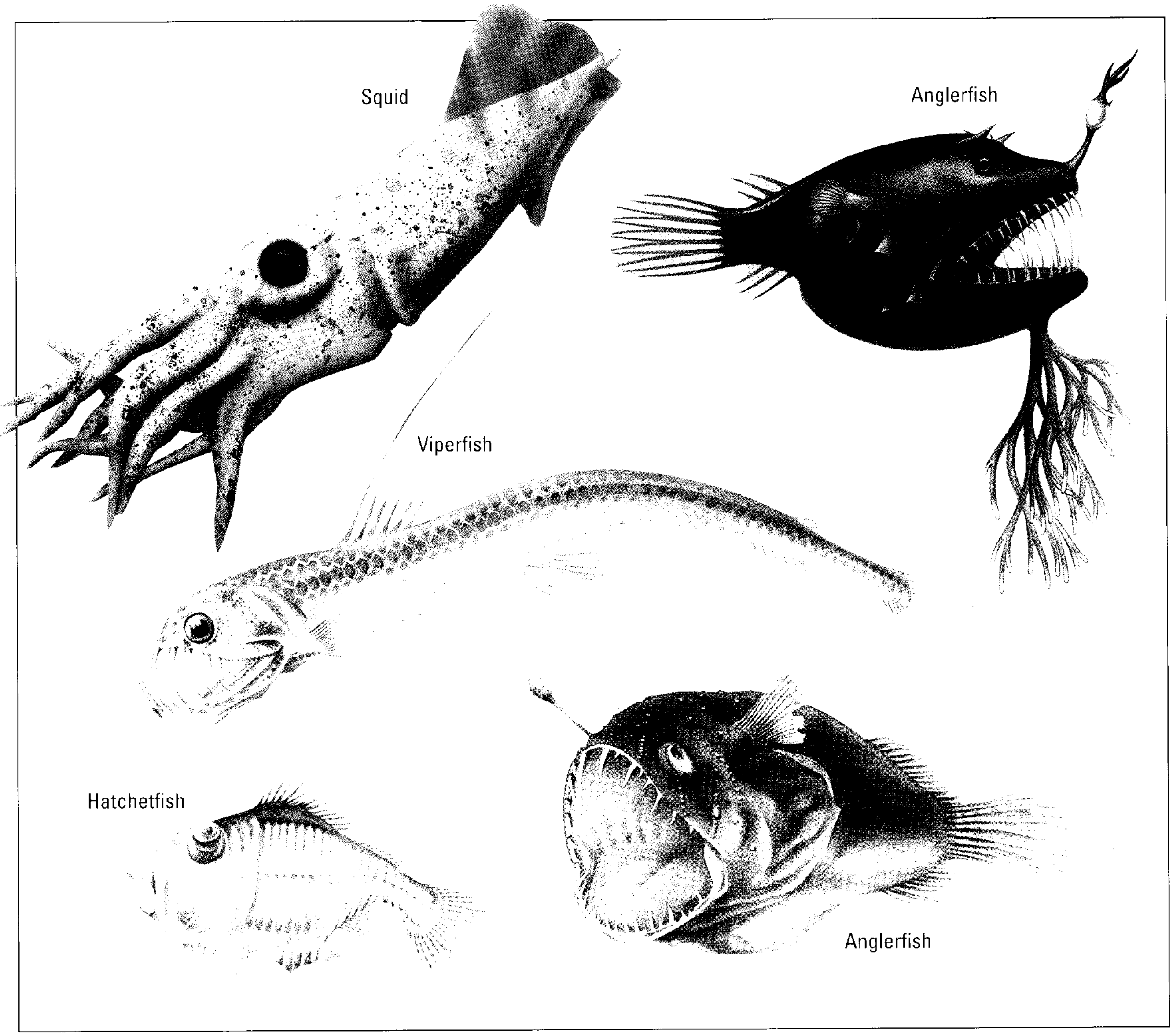
When a porous solid, such as a sponge or dry earth, absorbs a liquid, what actually happens is that the countless interior surfaces of the tiny pore spaces in the solid adsorb the liquid. Solids adsorb liquids by surface attraction.

Solids also adsorb gases. Powerful solid adsorbents, such as charcoal, can adsorb up to ninety times their volume of a gas. Charcoal is used in gas masks to remove large amounts of poisonous or impure gases from the air that the person wearing the mask breathes. Charcoal is also used to remove odors and coloring matter from solids and liquids.

PROJECT 5

**THE EARTH'S ABSORPTION**

In this photograph of a field, the earth, a solid, is absorbing rainwater, a liquid.




**ABYSSAL ZONE** The abyssal (ə bĭs'əl) zone is the deepest part of the ocean and includes over 75 percent of it. The abyssal zone begins at the point at which sunlight does not penetrate. That point is about 9,800 ft. [3,000 m] below the surface of the ocean. The abyssal zone ends at the ocean floor, or bottom.

The ocean floor is covered with sediment and with microscopic and decaying organisms. Because of the lack of light, there are no green plants on the ocean floor. The floor of the ocean ranges from flatlands to hills and ridges. Ridges, which often include inactive volcanoes, can extend from the ocean floor to the surface. The tops of the ridges may be visible as islands.

The abyssal zone is very cold. The cold temperature is caused by the lack of sunlight and the sinking of cold water near the north and south poles. The cold water then spreads along the ocean floor toward the equator.

The organisms found in the abyssal zone include cephalopods, crustaceans, diatoms, fish, sea cucumbers, and snails (see CEPHALOPOD; CRUSTACEAN; DIATOM; FISH; SEA CUCUMBER; SNAIL). The organisms that live in the abyssal zone have adapted to an environment without light

ABYSSAL ZONE

No sunlight ever reaches the abyssal zone of the oceans. Many creatures there are blind, but some can see, and even provide their own light. They have glowing spots on their bodies to attract prey. Anglerfish dangle glowing lures before their mouths. Like viperfish, they have long, sharp teeth with which to grip their prey. A few creatures, such as squid, can visit the surface waters and then return to the depths.

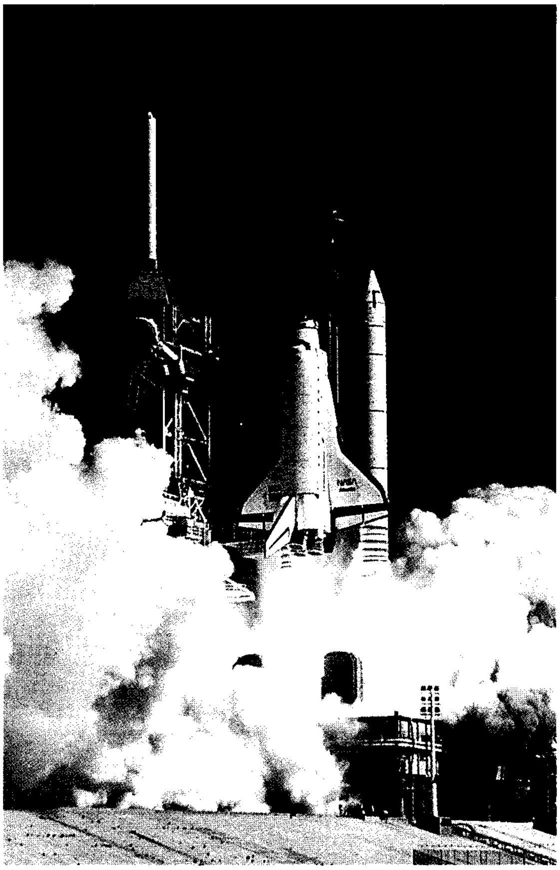
and to intense pressure from the water above. For example, some of the fish are blind. They use tentacles, or feelers, rather than eyes to help them find their way around. These tentacles also help them catch prey by detecting slight vibrations of moving organisms. Other organisms, such as certain cephalopods and crustaceans, have bioluminescent organs, which are organs that give off light. These organs help them attract mates or, sometimes, prey. Dead plants and animals that fall from the higher layers of the ocean are a major food source for animals in the abyssal zone.
*See also* OCEANOGRAPHY.

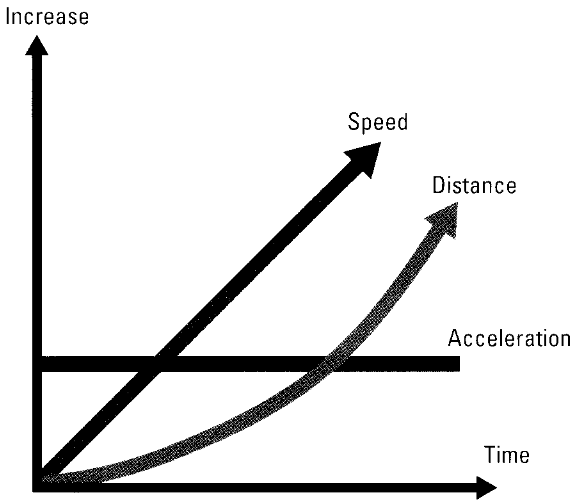
**ACCELERATION** Acceleration is the rate at which the velocity of something changes. Velocity is a speed in a particular direction (see VELOCITY). If either the speed or the direction changes, then the velocity also changes, and there is an acceleration. An airplane roaring down the runway during takeoff is accelerating rapidly. In a drag race, the drivers try to reach the highest possible speed after a short distance. To do this, they have to accelerate as much as possible.

Acceleration is always caused by a force. In a car the force is produced by the engine. The amount of acceleration for a body of a certain mass is directly related to the force. If the force is doubled, the acceleration is also doubled. However, if the body is twice as heavy, the same force accelerates it only half as much. This is why a truck needs a more powerful engine than a small car.

A force can also slow an object down. The force does this when it acts in the opposite direction to the motion. This is sometimes called deceleration.

A force can also act at an angle to the object's direction of movement. This changes the direction in which the object is going. This is also an acceleration, because the velocity has changed. When an object moves in a circle, its direction is continually changing. Therefore, its velocity is changing. For example, the velocity of a spacecraft in orbit is always changing, even when its speed stays the same. The force that causes the velocity to change is the force of gravity.
*See also* DYNAMICS.






**ACCELERATION**
A rocket (top) will accelerate to high speed in a short time and may cover a great distance. The graph (bottom) shows how these quantities are related. Amount of increase is shown by the black arrow pointing upward, and the amount of time is shown by the black arrow pointing to the side. Acceleration is the unchanging blue line. Speed is the straight red line that steadily increases. Distance is the curved green line that increases at an ever-greater rate because the force of gravity is less the further out the rocket travels.

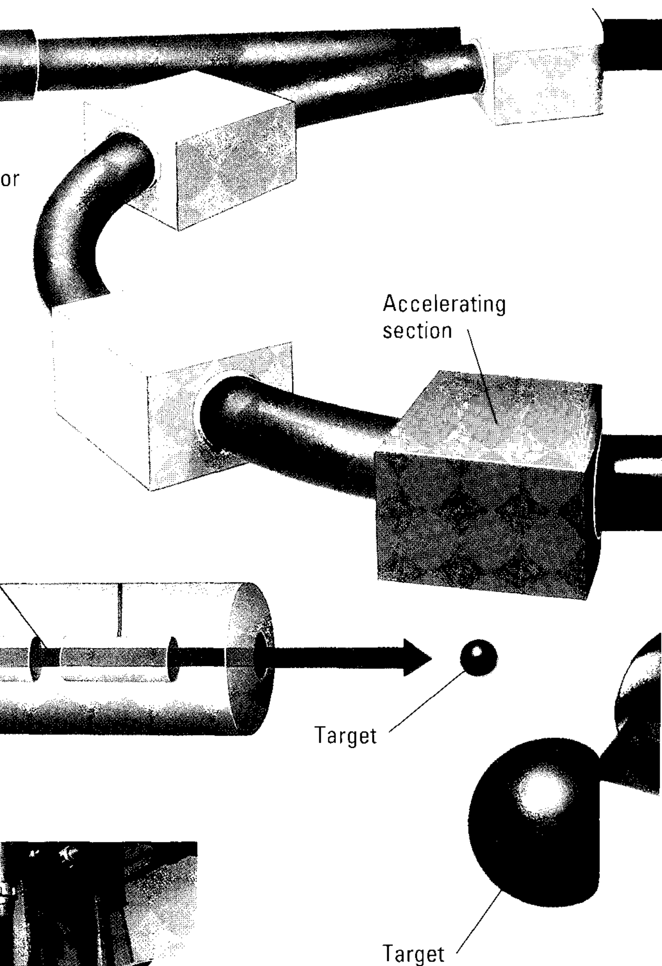
# ACCELERATORS, PARTICLE

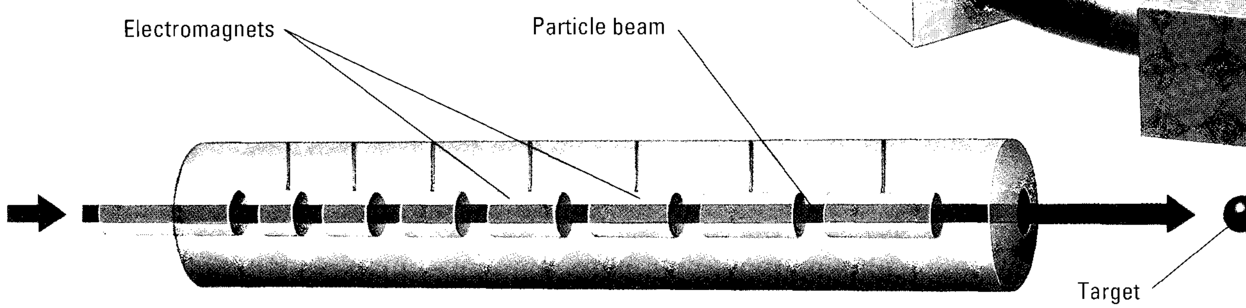
Particle accelerators are machines used by nuclear scientists to make subatomic particles travel fast (see ATOM). These high-speed particles are then sent smashing into a target consisting of a small amount of a material such as a metal. This process is called bombardment. The high-speed particles hit subatomic particles in the nuclei, or centers, of atoms in the target. Beams of high-speed particles can also be smashed into each other. This process is called collision. Depending on the process, new subatomic particles or new kinds of atoms may be formed.

There are three main types of accelerators: electrostatic, linear, and circular. The electrostatic accelerator (also called a Van de Graaff generator) uses very high voltage and gives only a single impulse, or push, to each particle. A linear accelerator runs in a long, straight line. It uses electromagnetic fields to give particles one boost after another as they move through long straight pipes called drift tubes (see ELECTROMAGNETISM). Circular accelerators, including cyclotrons and synchrotrons, use powerful magnets to bend the speeding particles into a circular path. Successive jolts of electricity make them go faster and faster. The energy acquired by

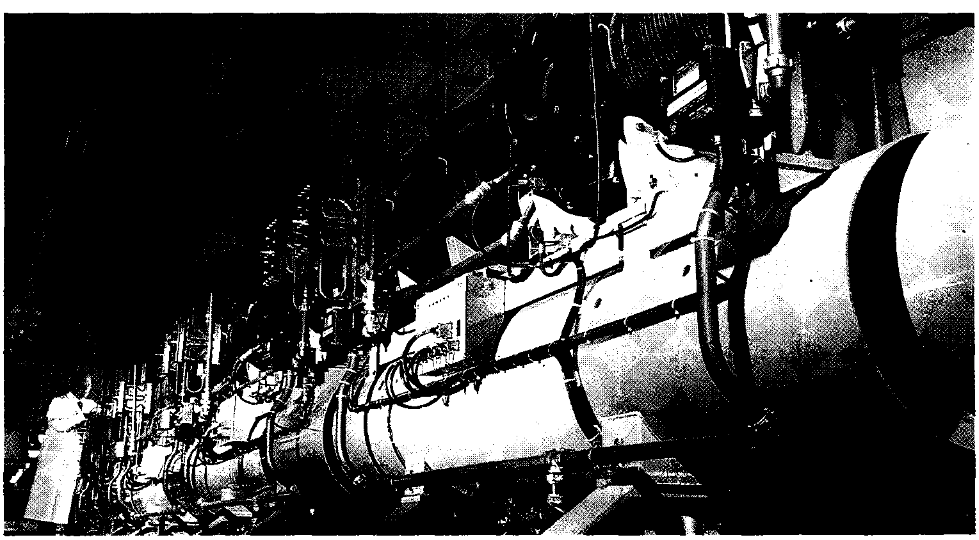
**DIFFERENT TYPES OF ACCELERATORS**

These diagrams show the internal structure of a linear accelerator and a circular accelerator.




Linear accelerator

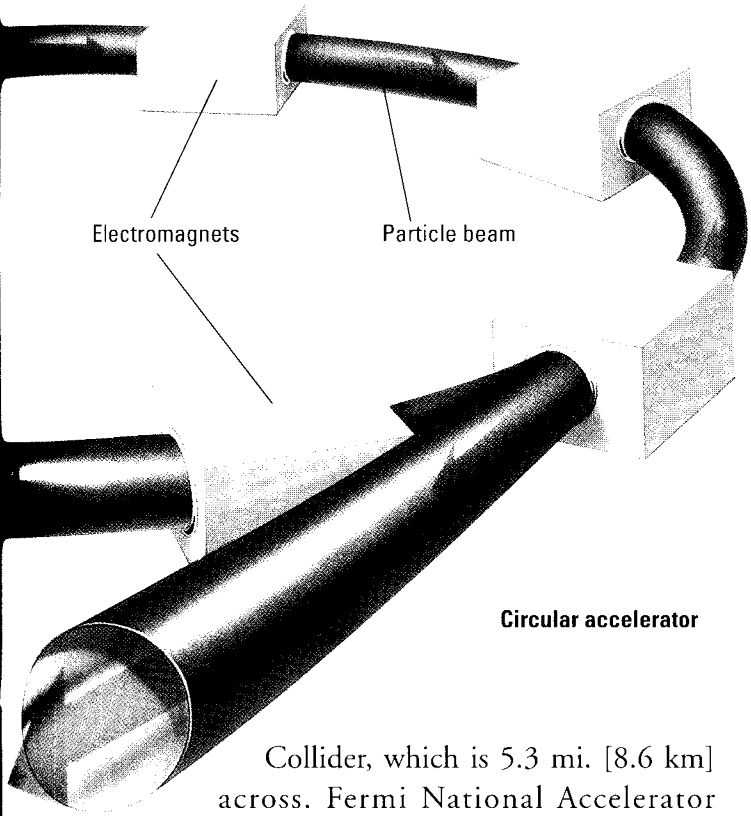


**LINEAR ACCELERATOR**

Subatomic particles can be raised to very high speeds in a straight line using a device called a linear accelerator, or linac. The linac is made of sections called drift tubes. A particle is boosted as it moves from one drift tube to the next.

a speeding particle in a very powerful machine can be the equivalent of a single boost of more than 1 trillion volts.

Particle accelerators are often very large. Stanford Linear Accelerator Center (SLAC) at Stanford University in California has a linear accelerator with a tube that is 2 mi. [3.2 km] long. The European Laboratory for Particle Physics (CERN) near Geneva, Switzerland, has a synchrotron called the Large Electron–Positron Collider, which is 5.3 mi. [8.6 km] across. Fermi National Accelerator Laboratory (Fermilab), near Batavia, Illinois, has a circular accelerator with a diameter of 1.25 mi. [2 km]. An accelerator may use as much electricity as an entire town.




Lord Ernest Rutherford, a British physicist, produced the first artificial nuclear reaction in 1919 (see RUTHERFORD, ERNEST). He bombarded nitrogen nuclei with naturally produced alpha particles (see ALPHA PARTICLE). However, naturally produced particles do not have enough energy to be able to cause nuclear reactions with most nuclei. Rutherford could go no further.

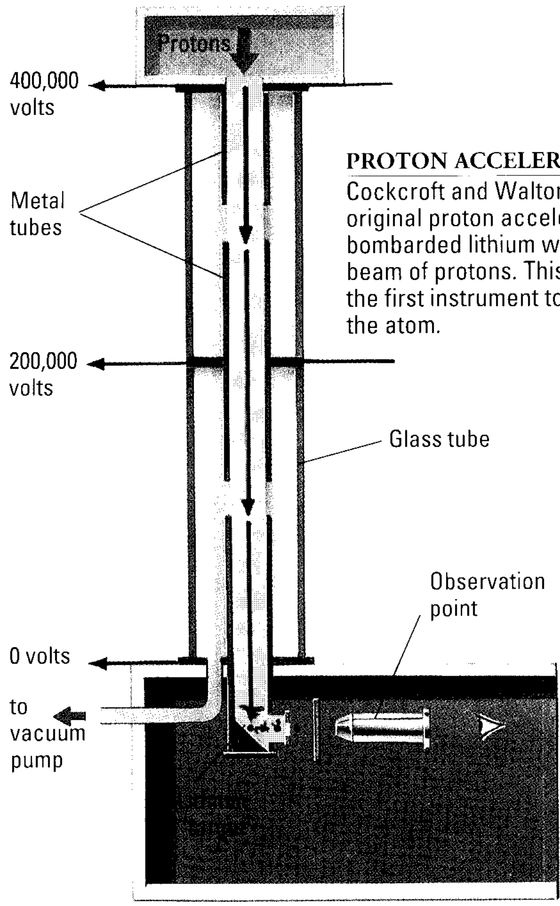
Then, in 1931, Dr. Ernest Orlando Lawrence, of the University of California, invented the cyclotron. The cyclotron was a circular accelerator that made particles go faster. It made a new range of experiments possible. A year later, in 1932, John Cockcroft and Ernest Walton, two British physicists, built the first linear accelerator. Using the new linear accelerator, the two scientists were able, for the first time in history, to accelerate particles to speeds that would allow them to split the nucleus of an atom, a process called fission (see FISSION). Cockcroft and Walton bombarded the element lithium with a beam of protons. Protons are the nuclei of hydrogen atoms and also occur in the nuclei of all other atoms (see PROTON). The lithium nucleus split into two halves. The nuclear fragments created in this way were themselves the nuclei of helium atoms.

**EUROPEAN ACCELERATORS**

The lines on this aerial view show where the hidden tunnels of CERN's accelerators run underground near Geneva, Switzerland. The biggest circle is LEP, the Large Electron-Positron Collider, 16 mi. [27 km] in circumference. The second-largest, just over 4 mi. [7 km] in circumference, is SPS, the Super Proton Synchrotron.

Protons, electrons, and the nuclei of the lighter atoms are the particles most often accelerated. If a nucleus in the target absorbs a bombarding particle, a different element can be formed. This is called transmutation (see TRANSMUTATION OF ELEMENTS). Scientists have produced several new artificial elements this way. They include neptunium, fermium, berkelium, and mendelevium. Experimenters have even been able to turn lead into gold. However, changing lead into gold in this way is much too costly for practical use.

Many other exciting discoveries have been made in accelerator experiments. Scientists have been able to find many subatomic particles that



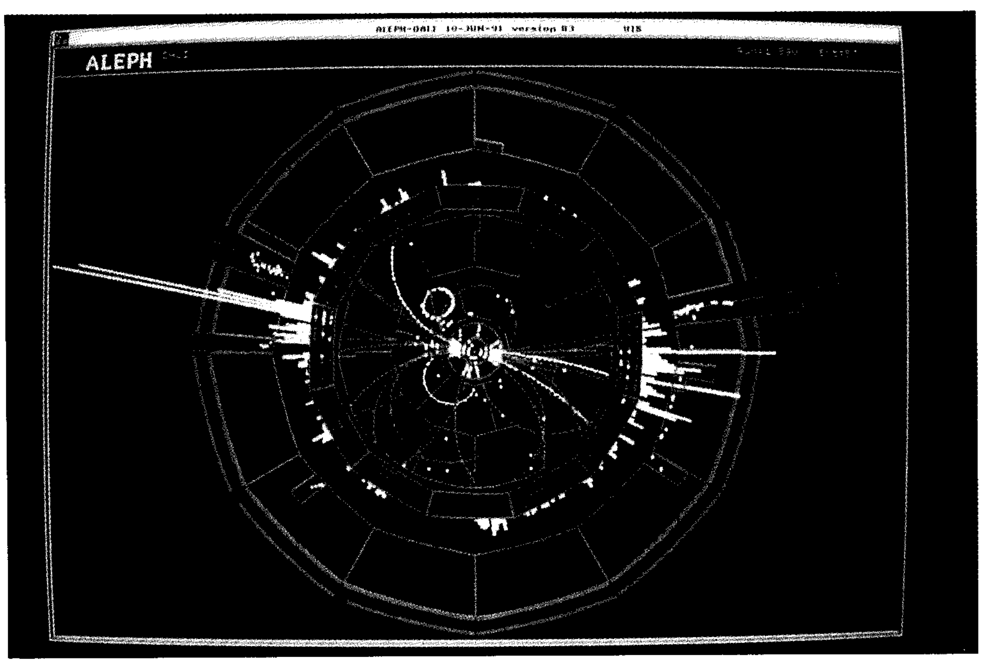

**PROTON ACCELERATOR**
Cockcroft and Walton's original proton accelerator bombarded lithium with a beam of protons. This was the first instrument to split the atom.

were only thought to exist. Many types of mesons were first discovered in particle accelerators, although others were first observed in cosmic rays. Mesons are lighter than protons but heavier than electrons (see MESON; COSMIC RAYS). Some mesons are short-lived, so they are difficult to observe. The neutrino is another particle that scientists have been able to create and study in particle accelerators. The neutrino is abundant in nature and has a mass that is very small—possibly zero (see NEUTRINO).

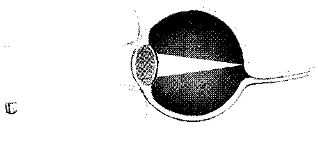
The study of how particles react when they collide at high speeds is called particle physics or high-energy physics (see PARTICLE PHYSICS). A high-energy physics center with a particle accelerator is a large place containing some of the most complicated and expensive equipment in the world. The hundreds of scientists and technicians who work there are carefully protected from the dangerous particle beams and the intense electrical voltages.

Thousands of reactions from bombardments and collisions must be analyzed before scientists can be sure of the results. Many kinds of detectors, or chambers, are used in this work. A bubble chamber is a tank containing a liquid that is near its boiling point. Particles from a reaction, made to travel through this liquid, leave behind a visible trail of bubbles. In a spark chamber, particles leave a trail of sparks as they pass between electrified metal plates. The trails produced in all kinds of detectors are photographed automatically and analyzed by computers.

*See also* ELECTRON; IONS AND IONIZATION; NEUTRON; NUCLEUS; PROTON.

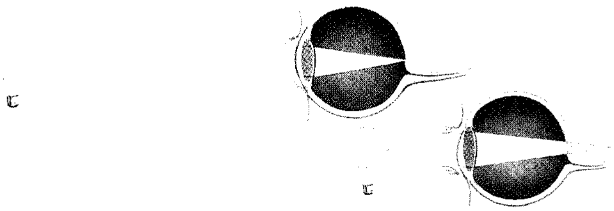



**COLLISION DETECTOR**
Particles have collided at the center of a detector in this computer display. A shower of new particles has been formed, and their curved tracks are shown in the central area. False colors make them clearer.



ACCOMMODATION

When a person looks at an object, the eye often must accommodate so that the object can be seen clearly. The light from a nearby object must be bent by the lens of each eye in order to focus the light on the retina. The lens accommodates by becoming thicker. The diagram above shows this.



Light from a faraway object is bent (refracted) in the cornea of the eye (above left). As a person ages, the lenses of the eyes accommodate less easily. Light from nearby objects focuses beyond the retina (above right) causing blurring or farsightedness. Glasses are needed to correct this.

**ACCOMMODATION** The automatic adjustment of the eyes that allows them to focus on an object is called accommodation. Each eye has a lens near its front that bends incoming light rays to focus on the light-sensitive lining of the eyeball, called the retina (see EYE AND VISION). The retina is connected to the brain by a nerve. The lens is flexible, and its thickness can be changed by muscles called ciliary muscles. During accommodation, the ciliary muscles make the lens thicker or thinner so that light rays from the object being looked at are clearly focused on the retina. Light from a faraway object needs less bending to focus on the retina of the eye. In this case, most of the bending of the light occurs in the cornea of the eye.

**ACETATE** (ăs′ĭ tāt′) An acetate is a salt or ester of acetic acid (see ESTER). Photographic film is made from cellulose triacetate, an ester formed by the action of acetic anhydride on cellulose. Lead acetate is a white, crystalline, water-soluble compound that is used to fix the color in fabric dyeing. Chemists often use the name *ethanoate* for an acetate.
*See also* ACETIC ACID.

**ACETIC ACID** (ə sē′tĭk ăs′ĭd) Acetic acid is an organic acid with a strong, vinegarlike smell. Acetic acid is formed in the fermentation process sometimes used for making vinegar. Vinegar contains about five percent acetic acid. Acetic acid is used to make acetates. Acetates are the substances that acetic acid forms with bases or alcohols (see ALCOHOL; BASE). The most important acetates are cellulose acetate and vinyl acetate. They are both used in plastics (see CELLULOSE ACETATE). Acetic acid is also used as a chemical solvent, as a food preservative, and in photographic processing. Chemists often call acetic acid *ethanoic acid.*

Pure acetic acid is a colorless liquid that corrodes other objects. The boiling point of acetic acid is 244°F [118°C]. Its freezing point is 62°F [17°C]. In a cool atmosphere, the pure acid turns solid, forming white, icy crystals. The pure form is known as glacial acetic acid.

**ACETONE** Acetone is a colorless liquid with a sweet odor. Acetone dissolves many substances. It is used as a solvent in industry. Acetone is also used in the making of acetate rayon, fibers, photographic film, and fingernail polish.

Acetone is also called dimethyl ketone or propanone. Acetone has a boiling point of 133.7°F [56.5°C]. Its freezing point is -139°F [-95°C]. Acetone can be obtained from the distillation of wood or from the bacterial fermentation of molasses. It can also be made by other chemical methods.
*See also* DISTILLATION; FERMENTATION.

**ACETYLCHOLINE** (ə sēt′l kō′lēn′) Acetylcholine is a chemical produced by nerve cells (neurons). It belongs to a family of substances called neurotransmitters.

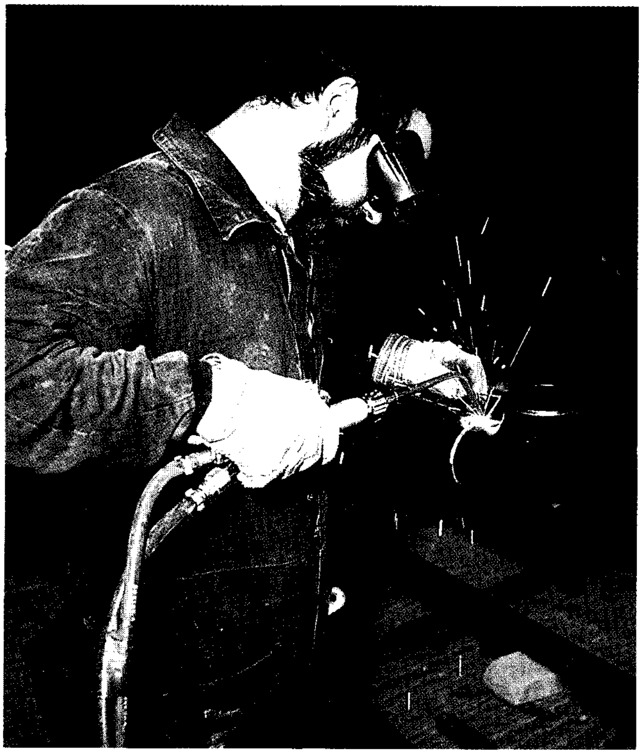
The nervous system consists of many millions of neurons interconnected to form a complex network throughout the body. Close microscopic examination of nerve tissue shows that, although the neurons lie very close to one another, they do not quite touch. There is a very small gap called a synapse between the end of one neuron and the end of another.

A nerve message is sent, for example, from a sense organ in the skin to tell the brain when a hand has touched something hot. The nerve message must cross the synapses between several neurons on the way to the brain. Scientists have found that acetylcholine is released into the gap between two neurons in response to a message arriving at the end of the nerve cell. If enough acetylcholine is produced in a very short period of time—about five one hundredths of a second—the next neuron in the line is stimulated to carry on the message from the sense organ. If insufficient acetylcholine is secreted into the gap, the nerve message does not cross to the next neuron.

Curare, the poison used by certain native South Americans on the tips of their arrows, works by stopping acetylcholine from crossing the synapses between nerve cells. If a hunted animal is hit by a poisoned arrow, the animal is paralyzed.

*See also* NERVE CELL.

**ACETYLENE** (ə sĕt'l ēn') Acetylene is a colorless, poisonous gas, with a chemical formula of $C_2H_2$. Acetylene is made from calcium carbide and water. Because it burns easily, the main use of acetylene is in the welding and cutting of metals using an oxyacetylene torch (see OXYACETYLENE TORCH). When acetylene burns, it reaches a temperature of 6,332°F [3,500°C] or more. At this high temperature, it can cut metal that is several inches thick. Chemists often call acetylene *ethyne.*



ACETYLENE

A worker uses an oxyacetylene torch. The torch provides enough heat to enable it to cut through metal.

Acetylene dissolves easily in acetone. It does not dissolve as well in water or alcohol. It dissolves more easily at low temperatures and under high pressure. Acetylene cannot be compressed without danger of explosion. It is stored and transported in cylinders containing acetone.

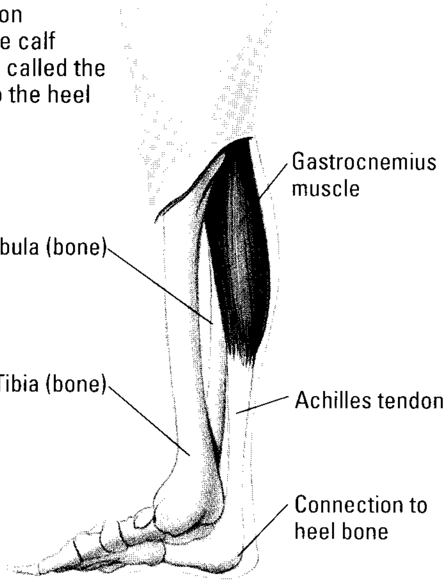
Substances made from acetylene include vinyl plastics, synthetic rubber and fibers, and many organic chemicals. Acetylene was once commonly used for light in portable lamps, buoys, and road signals.

**ACHILLES TENDON** The Achilles (ə kĭl'ēz) tendon is located on the lower leg of humans. It connects the gastrocnemius muscle, which is the large calf muscle of the leg, to the heel bone of the foot. The Achilles is the largest tendon in the human body (see TENDON). The gastrocnemius muscle and the Achilles tendon pull the heel bone up, making it possible for a person to walk, run, or stand on the toes.

The Achilles tendon gets its name from Greek

ACHILLES TENDON

The Achilles tendon connects the large calf muscle of the leg, called the gastrocnemius, to the heel bone of the foot.



mythology. It was said that the Greek hero Achilles could not be harmed or wounded anywhere on his body, except for the heel of his foot. This is where the Achilles tendon connects to the bone.

**ACID** Acids are a group of chemicals with certain similar characteristics. For example, all acids have a sour taste. The citric acid in lemon juice makes it taste sour. Vinegar tastes sour because it contains acetic acid. The acids in lemon juice and vinegar are diluted with water. They cause no harm to the body. However, other acids can be dangerous. For example, hydrofluoric acid is so powerful it can corrode and dissolve metals and glass. A substance that can corrode is also called caustic (see CORROSION).

Life depends on acid. For example, human stomachs contain diluted hydrochloric acid, which helps digest food (see HYDROCHLORIC ACID). Amino acids are also essential. Human beings need eight special amino acids to stay alive (see AMINO ACID). Ascorbic acid from fruits and vegetables is important as well. Ascorbic acid is vitamin C. If a person does not eat foods that contain vitamin C, he or she will become sick with the disease called scurvy (see SCURVY).

Acids are important in industry. For example, millions of tons of sulfuric acid are made every year. Sulfuric acid is used to dissolve the rust and scale on iron (see SULFURIC ACID). This type of cleaning is called pickling. Acids are also used in making fertilizers, pigments and dyes, plastics, and synthetic fibers. Aqua regia is a mixture of nitric and hydrochloric acids (see NITRIC ACID). Aqua regia is used to dissolve gold and platinum.

There are two main chemical groups of acids. They are inorganic acids and organic acids. Inorganic acids do not contain carbon; organic acids do. The one thing all acids have in common is that when they dissolve in water, they release hydrogen ions ($H^+$). Hydrogen ions are hydrogen atoms with a positive electric charge (see IONS AND IONIZATION). Acids that make a large number of hydrogen ions in water are strong acids. Hydrochloric acid, nitric acid, and sulfuric acid are examples of strong acids. With the strongest acids, such as hydrochloric acid, all the molecules split up to give hydrogen ions. Acids that make few hydrogen ions in water are weak acids. Acetic acid, citric acid, and carbonic acid are examples of weak acids.

Chemists can measure the strength of hydrogen ions in a solution. This is called the pH of a solution. Acids have a pH of less than 7. Acids with a low pH number, such as 2, are stronger than acids with a high pH number, such as 6.

One way to tell whether or not a substance is an acid is to use an indicator. An indicator is an object that turns a certain color in an acid. Litmus paper is an indicator that turns from blue to red in an acid. No one should ever taste unknown solutions to find out whether or not they are acids. Certain acids burn or wound the tongue and skin. Other acids are poisonous.

Many foods turn sour when they spoil. Their starches and sugars break down into acids. For example, when milk turns sour, some of the milk sugar is changed to lactic acid. Butter that spoils contains butyric acid.

If certain metals, such as iron or zinc, are added to acid solutions, the metal dissolves. Hydrogen gas ($H_2$) is also produced from this reaction. This happens because the atoms from the metal and the hydrogen ions from the acid react. Together, they make hydrogen gas and metal ions. The metal ions combine with the acid to produce a salt. In this way, the metal replaces the hydrogen in the acid. For example, if zinc (Zn) is added to hydrochloric acid (HCl), zinc chloride ($ZnCl_2$), a salt, and hydrogen gas ($H_2$) are produced.

*See also* BASE; NEUTRALIZATION. PROJECT 1

**ACID RAIN** Acid rain is pollution that falls to the earth as rain that is more acidic than natural rain. Scientists also include other forms of acidic precipitation, such as mist, hail, sleet, and snow, in the term *acid rain*. Acid rain is a serious problem all over the world. It weakens and kills many organisms. In some places, acid rain has permanently damaged trees, flowers, and other plants by changing their metabolisms. For example, trees affected by acid rain may not be able to prepare properly for cold weather. Acid rain has also caused many streams, lakes, and other bodies of water to become too acidic for fish and other organisms to live and reproduce in them. In some places, the rain is so acidic that it eats away at human-made objects such as buildings.

**ACID RAIN**
Acid rain has been shown to harm many different kinds of plants and trees. These larch trees are examples of the damage that can be caused by acid rain.

Acid rain forms when water and certain gases in the atmosphere mix. These gases contain sulfur and nitrogen. This mixture produces sulfuric and nitric acid. These acids later fall to the ground in acid rain. Some of the sulfur and nitrogen in the atmosphere come from natural sources. These include forest fires, volcanic eruptions, and lightning. However, human activities—such as burning coal and oil in factories and power plants and burning fuel in cars and trucks—also produce huge amounts of sulfur and nitrogen. Many scientists feel that these human activities produce most of the acid rain that falls.

Scientists call acid rain a long-range pollutant. The sulfur and nitrogen needed to make acid rain can travel long distances in the atmosphere. Acid rain can then fall hundreds of miles from the sources of nitrogen and sulfur that produced it. Thus, the fish in a stream in Vermont or the trees in a forest in Massachusetts may be harmed by acid rain caused by sulfur from a smokestack in Ohio or Pennsylvania.

Keeping the atmosphere clean from sulfur and nitrogen pollutants is the only answer to the problem. There is no effective, cost-efficient way to completely remove all the sulfur and nitrogen from the smoke and exhaust fumes that factories, power plants, and vehicles give off. However, steps are being taken by some coal-burning electric-power plants to reduce the amount of harmful chemicals the plants release into the atmosphere. If electric-power plants burn coal that contains large amounts of sulfur, much of this sulfur enters the atmosphere in the smoke that these plants release. Changing to low-sulfur coal helps reduce the amount of sulfur released. Electric-power companies also install "scrubbers," or filters, to remove sulfur from the smoke.

Fortunately, it is sometimes possible to undo the harm from acid rain. Scientists are starting to treat bodies of water harmed by acid rain with lime. The lime neutralizes the acid in the water, and, in many cases, fish and other organisms can live in it again. However, the water may never return to the condition it was before being polluted.

*See also* ACID; NITROGEN; POLLUTION; SULFUR.

**ACNE** Acne is a disorder of the sebaceous glands of the skin. Sebaceous glands normally secrete a fatty substance called sebum. If allowed to accumulate, sebum becomes mixed with dust and bacteria, causing inflammation and the eruption of pimples. Because acne is related to hormonal changes that occur during adolescence, teenagers often have acne. Cleanliness and diet also affect the condition of a person's skin. To treat acne, doctors recommend keeping one's skin clean by washing with a mild soap or cleanser, and not eating a lot of sugary foods. Serious cases of acne are treated with prescription drugs.

*See also* SKIN.

# ACOUSTICS

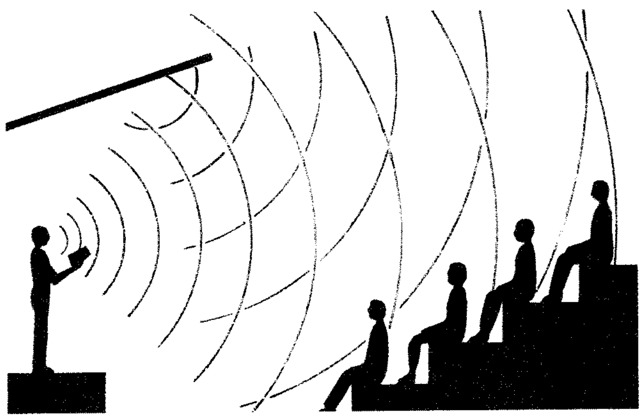
Acoustics is the branch of the science and technology of sound that deals with how to use and control sound waves. An important part of acoustics is the study of architectural acoustics, or how sound behaves in a room or building.

**Architectural acoustics** The aim of architectural acoustics is to design rooms with good sound qualities. This is very important in buildings such as concert halls and theaters. In these buildings, the sound should be neither too loud nor too soft. People expect to be able to hear clearly wherever they are sitting.

In a room, some materials, such as plaster, reflect sound. Other materials, such as carpets, absorb sound. In an auditorium, there has to be just the right balance and placement of materials. This ensures that the sound is evenly spread.

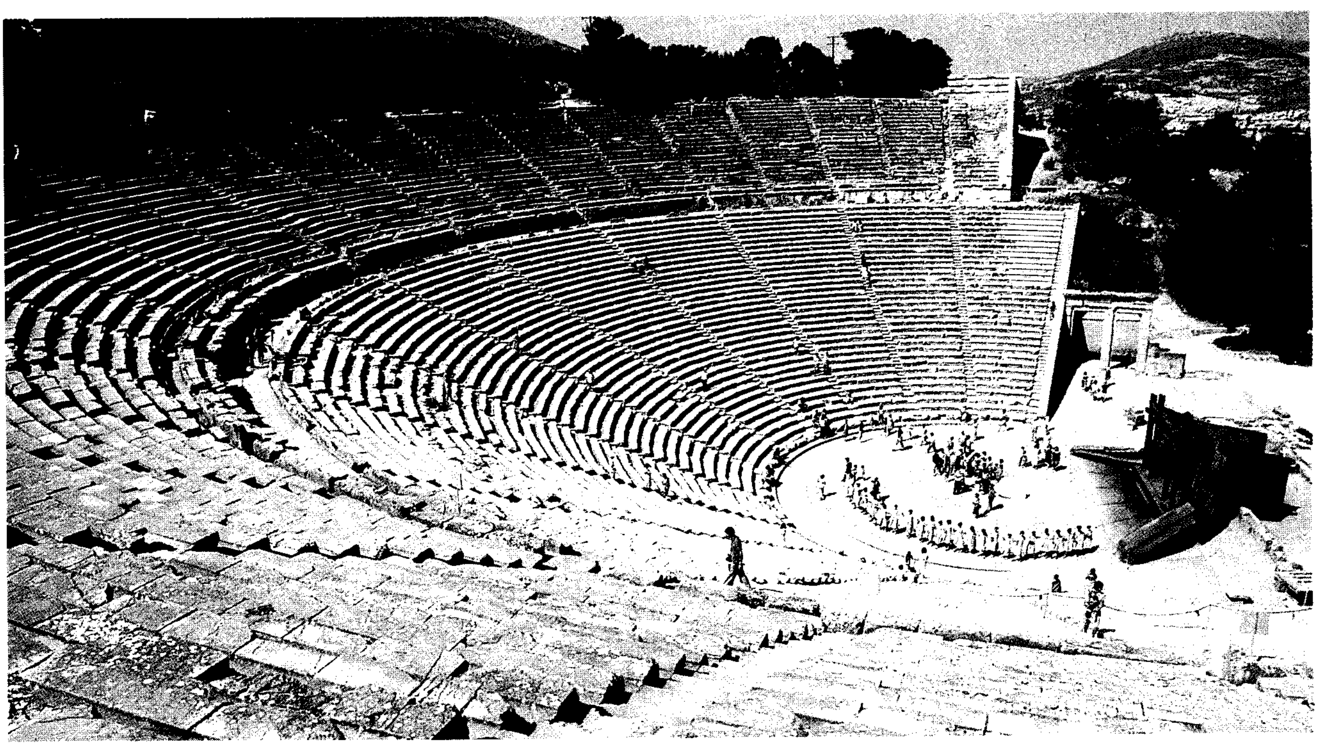
Sound has two properties that are very important in acoustics. These properties are echo and reverberation. An echo is a sound that has been reflected (thrown back) from a surface. Materials that reflect sound well produce strong echoes. In an auditorium, people hear the sound both directly from the stage and from the echo. Because the echo has bounced off a surface, it has traveled farther than the direct sound. This means that it reaches the ear after the direct sound does. In a well-designed room, the echo and the direct sound are heard almost at the same time. The sound is then clearly heard (see ECHO).

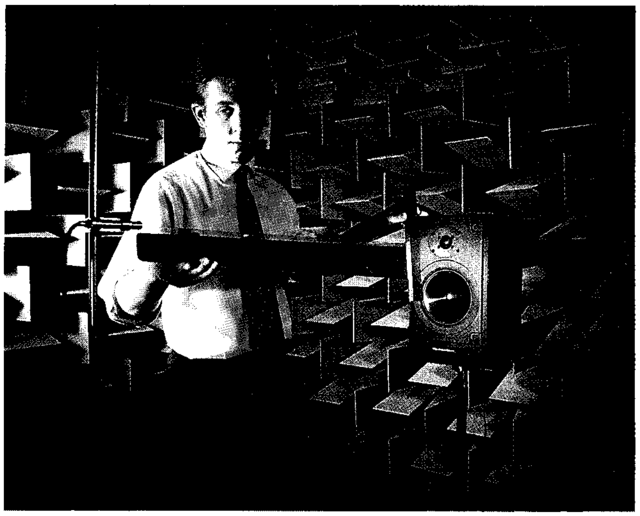
A reverberation is a closely grouped series of echoes. Each echo is quieter than the one before.



**TRAVELING SOUND WAVES**
In a well-designed auditorium (above), direct sounds and echoes reach members of the audience almost simultaneously.

**ANCIENT ACOUSTICS**
The audience could hear well in the ancient theater at Epidaurus in Greece (below). Nothing blocked the sound on its way from the actors and musicians to the spectators.





**QUIET ROOM**

An engineer tests the performance of a loudspeaker in a special anechoic chamber (echo-free room).

Rooms could be built with sound-absorbent materials to remove reverberations and echoes. However, the sound in such a room would have a dead quality. A certain amount of reverberation is necessary for good sound quality. In general, the reverberations should last between 1 and 2.5 seconds. This is called the reverberation time. It is the time taken for all echoes to die away. Rooms used for music should have a slightly longer reverberation time than rooms used for speech.

Another problem in designing an auditorium is the volume of sound. People sitting at the back should be able to hear clearly. Sometimes, this means that the sound has to be amplified by loudspeakers. Unfortunately, loudspeakers rarely reproduce the sound accurately (see LOUDSPEAKER).

The pitch, or frequency, of a sound must also be considered. Sounds with different pitch can be reflected from surfaces in different amounts. Resonance must also be avoided (see FREQUENCY; RESONANCE). Both these effects cause either the high or the low frequencies to sound too loud. If the high frequencies are too loud, the sound has a shrill, thin quality. If the low frequencies are too loud, the sound is dull and muffled.

The ancient Greeks were the first to build their theaters acoustically. They placed their audiences on steep hillsides where sound could travel to them directly. Their theaters were called amphitheaters. The stage was at the bottom of rows of seating that were steeply inclined. Every member of the audience could see and hear well. This idea was copied by the Romans. The Hollywood Bowl, in California, is a modern-day amphitheater.

**Other branches of acoustics** Although architectural acoustics is an important field, acoustics has other very different branches.

In communications acoustics, engineers are trying to build machines that can speak and hear. This is a very difficult task. Human speech is a complicated mixture of frequencies. The brain can easily put all these different frequencies together so that a spoken word is heard. Machines cannot do this yet, but progress is being made. Such machines would be very useful in banks. In a bank, the identity of a customer is checked by his or her signature. It is very difficult for anybody to copy another person's signature. However, it is not impossible. A better method of checking a person's identity would be from the pattern of his or her speech. This pattern, called a voice print, is unique and impossible to copy.

Machines that can speak and hear can also be useful in the field of computers. A number of computer functions can now be activated by human speech. In addition, computers have the ability to talk to people through voice synthesizers. Today, for example, many automatic banking machines, automobiles, videocassette recorders, and other appliances have voice synthesizers. A synthesized voice may give the correct telephone numbers to people who dial directory assistance.

Ultrasonics is another important branch of acoustics. Ultrasonics is the study of sound waves that have too high a frequency to be heard. Normally, a sound wave travels smoothly through an object. However, if the object has a crack in it, the waves are reflected and refracted (bent). Ultrasonics is used to detect cracks in such objects as engine parts. Ultrasonic waves, rather than ordinary sound waves, are used because they are refracted at a larger angle. This makes the cracks easier to detect.

*See also* SOUND; ULTRASOUND.

**ACRYLIC** An acrylic is any of a group of synthetic (human-made) products made mostly from petroleum. Acrylics are manufactured as fibers, plastics, or resins (see FIBER; PLASTIC; RESIN).

Acrylic fibers are made into many kinds of fabrics. These fabrics are used in blankets, carpets, underwear, and knitwear. Common trade names for some acrylic fibers are Acrilan, Creslan, Zefran, and Orlon.

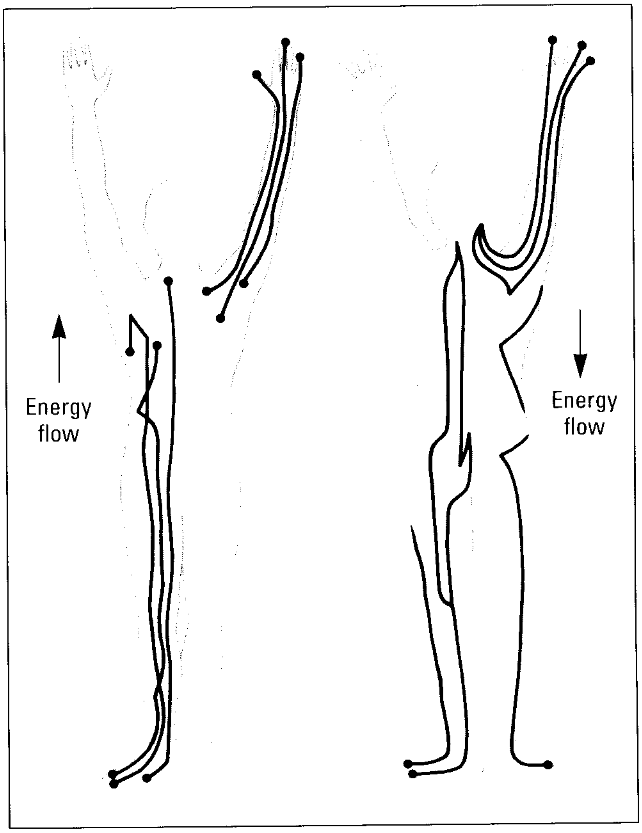
A widely-used acrylic plastic is polymethyl methacrylate. Plastics made from this substance are better known as Plexiglas and Lucite. They are important because they are transparent. They are used to make windows, television lenses, outdoor signs, automobile taillights, dishes, surgical tools, and costume jewelry.

Although acrylics stand up well under bad weather conditions, they are softer than glass. Therefore, they scratch easily.

**ACTINIDES** (ăk′tə nīdz′) The actinides are the group of 15 elements with atomic numbers from 89 to 103—actinium, thorium, proactinium, uranium, neptunium, plutonium, americium, curium, berkelium, californium, einsteinium, fermium, mendelevium, nobelium, and lawrencium. They have similar chemical properties and are all radioactive. Apart from plutonium, actinides with atomic numbers greater than 92 (uranium) do not exist in nature but can be made in the laboratory. *See also* ACCELERATORS, PARTICLE; PLUTONIUM; URANIUM.

**ACUPUNCTURE** (ăk′yŏŏ pŭngk′chər) Acupuncture is an ancient Chinese technique for relieving pain for such conditions as arthritis, asthma, migraine headaches, and ulcers. The technique involves inserting long, thin needles into specific points on the body. There are about one thousand acupuncture points, each identified by a name and number. Each point belongs to one of fourteen groups associated with particular internal body organs. Treatment involves inserting a number of needles at various angles and depths. The needles are twisted, vibrated, or connected to a low-voltage electrical current to provide stimulation. This stimulation may provide permanent or temporary relief, depending on the condition.

Traditional Chinese theories state that acupuncture relieves pain because it restores the balance of the body's inner life force or energy. One modern scientific theory suggests that acupuncture works by triggering the release of pain-relieving substances called endorphins (see ENDORPHIN). Another theory says that acupuncture stimulates certain nerves to carry non-pain impulses. A third theory claims that movements of the needles block nerve pathways to the brain and spinal cord. These scientific theories have made acupuncture more widely accepted.




**ACUPUNCTURE**
The points on the body used in acupuncture are located along the lines, called meridian lines, shown in black on this diagram. The body's energy is said to flow along these lines in the direction of the arrows.

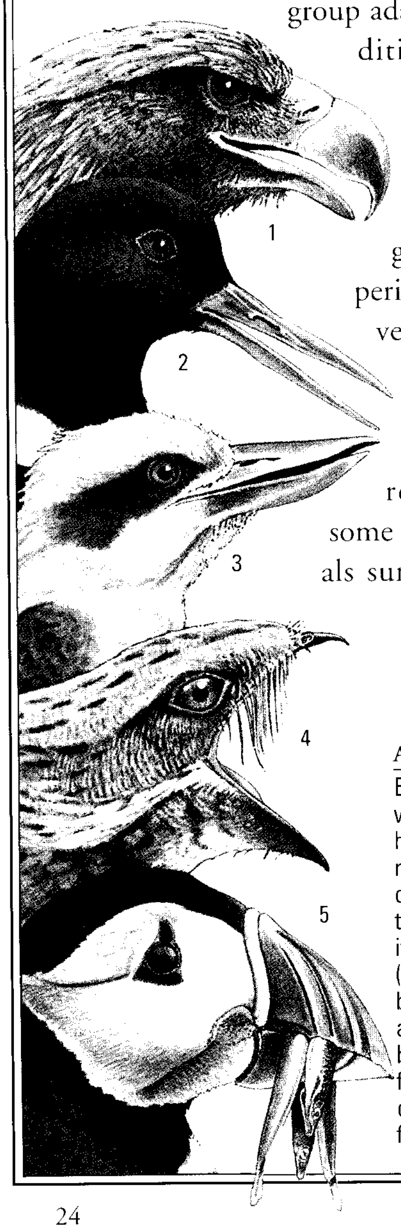
Acupuncture is now sometimes used as an alternative to drugs and anesthetics in the United States and other Western countries (see ANESTHETIC). Because acupuncture carries a slight risk of infection or damage to nerves and blood vessels, some states require acupuncturists (those who perform acupuncture) to be medical doctors.

# ADAPTATION

Adaptation is a process in which living things change with new environmental conditions. There are two kinds of adaptation. One is the kind that occurs in an individual organism during its lifetime. The other kind occurs, through evolution, in a group of organisms over thousands or millions of years (see EVOLUTION).

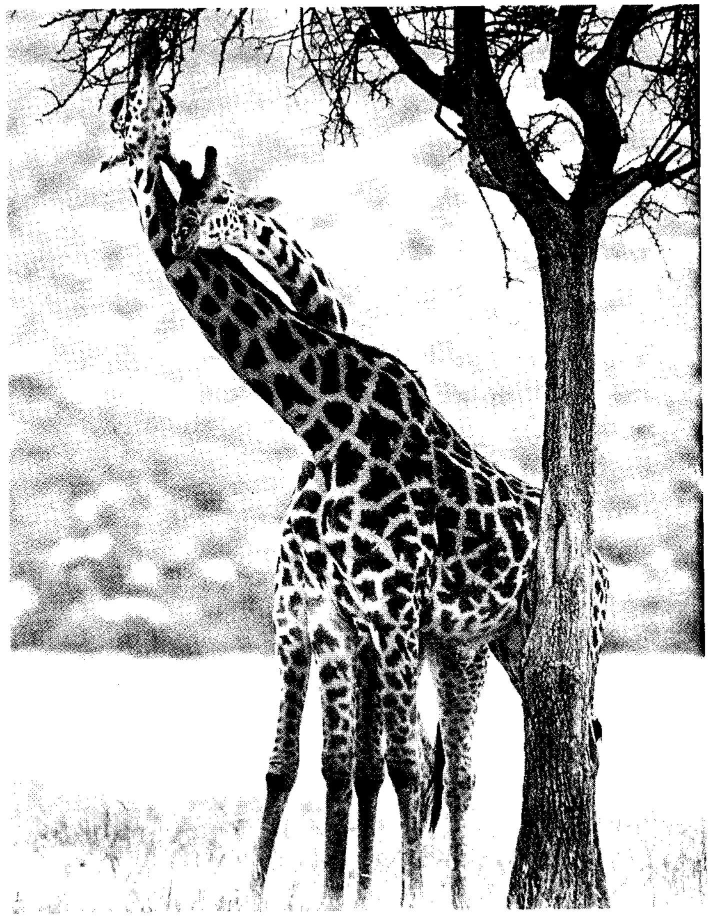
If a person begins a new nighttime job—after working during the day all of his or her life—he or she must adapt to a new way of life. At first, the person may have difficulty sleeping during the day. After a while, however, he or she sleeps easily. The person has adapted. This is an example of individual adaptation.

The giraffe provides an example of how a group adapts to changing conditions through evolution. Millions of years ago, giraffes, like horses, had short necks and ate grass. During long dry periods, while the shorter vegetation was quickly eaten, the giraffes with the longest necks were able to reach the leaves of some trees. Those individuals survived the periods of




ADAPTATION IN BIRDS

Birds' beaks are adapted to what they eat. (1) The hooked bill of an eagle can rip open carcasses. (2) The oystercatcher opens the shells of mollusks with its long, pointed beak. (3) The kookabura's heavy bill is used to catch lizards and snakes. (4) The gaping beak of the nightjar traps flying insects. (5) The puffin can hold more than 20 small fish in its serrated beak.

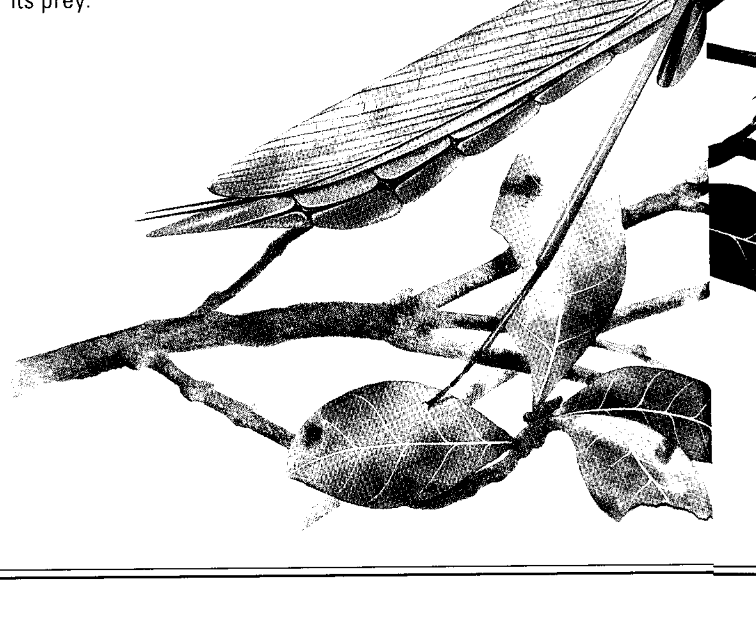


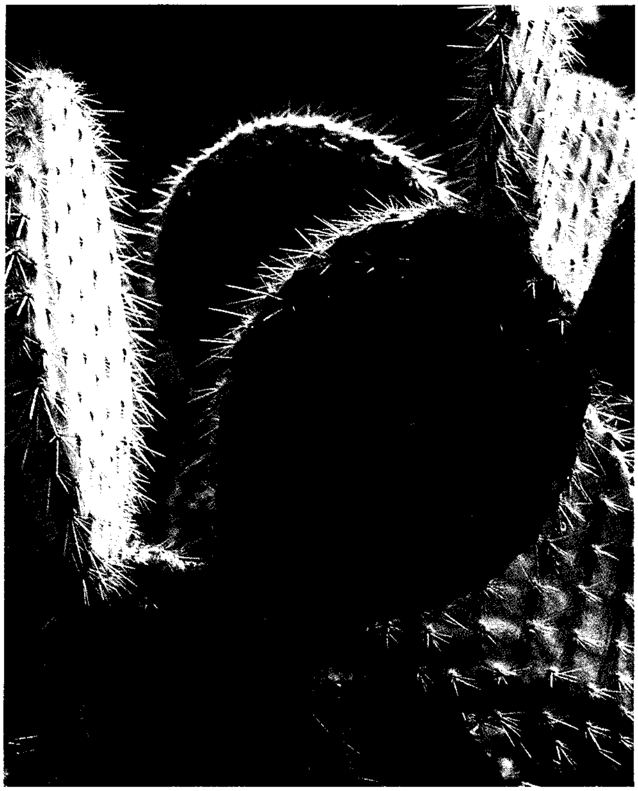
ANIMAL ADAPTATION

The long legs and necks of giraffes, together with a long, flexible tongue, are adaptations to feeding on the leaves of tall trees.

INSECT ADAPTATION

The shape and coloring of the European praying mantis are adaptations to its hunting way of life. Its coloring blends in with the surrounding plants, and the long, twig-like shape of the praying mantis helps conceal it from its prey.





**PLANT ADAPTATION**

The leaves of the prickly pear cactus (left) have adapted to the hot, dry desert climate by evolving into spines. These reduce the amount of water the cactus loses. The fleshy stem of the cactus is adapted to the hot conditions by being able to store water.

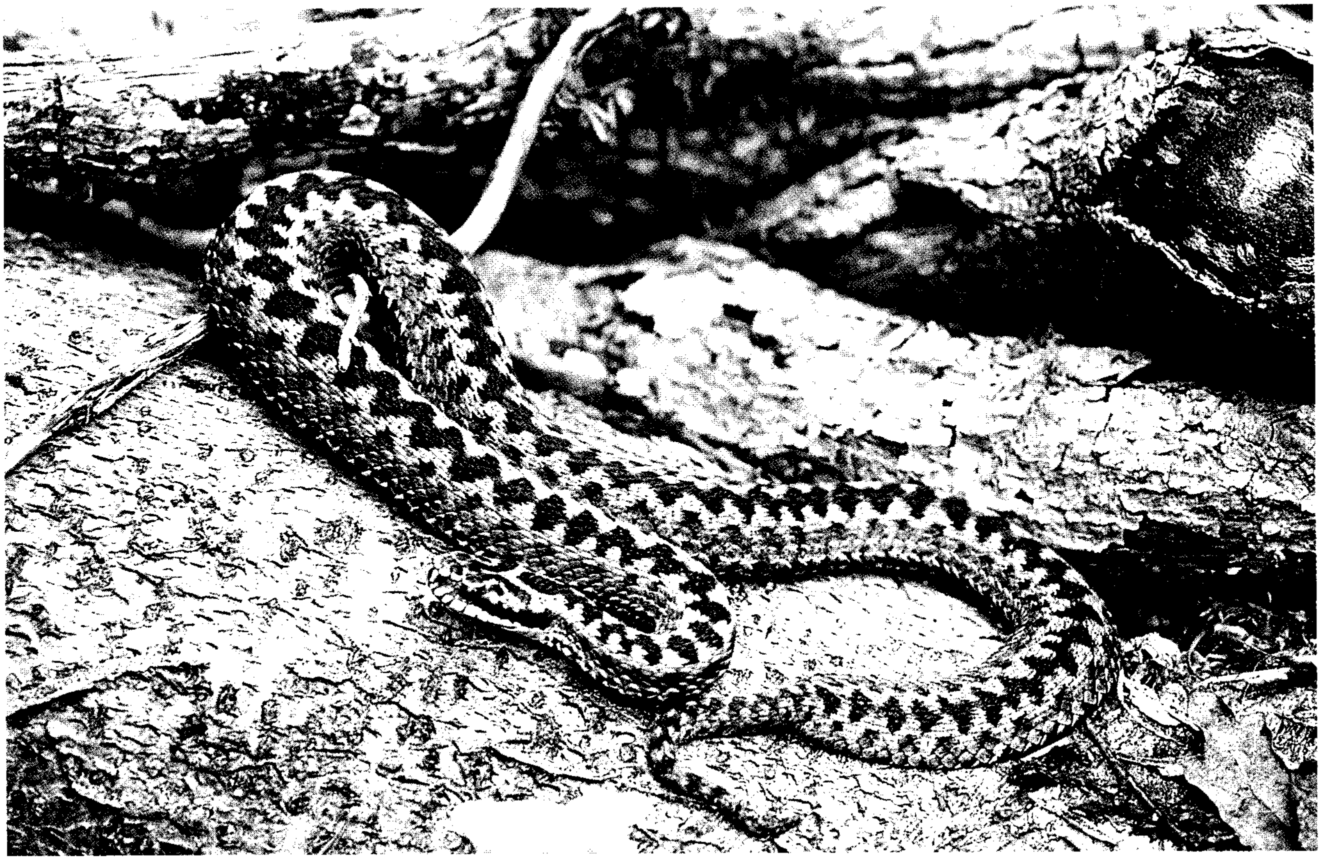
food shortage and then produced new offspring.

Their offspring had long necks also. As time went on, long-necked giraffes always had an advantage. The result was that giraffes today have much longer necks than giraffes of long ago.

Some living things are able to adapt quickly, while others cannot. If a species cannot adapt quickly, it may become extinct. An example of a species adapting very quickly to changing conditions is seen in the case of the peppered moth. Over a very short period of time, it developed dark coloring to help camouflage it when resting in dirty industrial areas. Humans are also very adaptable. With special equipment, we can live anywhere on Earth. We can even visit the moon.

**HUMAN ADAPTATION**

Innuit have adapted to a cold, harsh climate. Animal skins help keep them warm.



ADDER

The European adder is about 2 ft. [0.6 m] long. It is easily recognized by the zigzag pattern on its back. Like other vipers, this snake has fangs that inject venom set on a movable bone at the front of its upper jaw.

**ADDER** *Adder* is the name for several species of snake. Some are poisonous. There are many species of adders found in Europe, Asia, and Africa. Adders grow from 1 ft. [0.3 m] to 5 ft. [1.5 m] in length. Their colors vary with species and geographical location. Poisonous adders kill their prey by biting. The snake injects venom, a poisonous substance, with its two long fangs. After the bitten animal dies, the adder swallows it whole. An adder can kill as soon as it is born or hatches from its egg. Adders found in the cooler regions of Europe and Asia spend the winter in hibernation (see HIBERNATION).

One of the best-known adders is the European adder or viper. Like most adders, it belongs to the viper family (see VIPER). It lives in Europe and Asia as far north as the arctic circle. It hunts during the day for rodents, birds, lizards, and amphibians. The European adder grows to a length of 2 ft. [0.6 m]. Its bite is rarely fatal to humans. The puff adder of Africa is one of the largest, growing to a length of 4.5 ft. [1.35 m]. The puff adder is as thick as a person's arm and also has a poisonous bite.

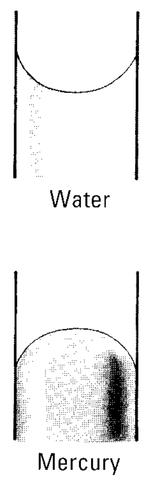
**ADDICTION** Addiction is a harmful psychological and physical dependence that can result from regular use of certain drugs, such as alcohol, amphetamines, and heroin and other narcotics. Although a person may become psychologically dependent on the caffeine in coffee or the nicotine in cigarettes, such habits can be broken. With development of addiction, changes in the body's chemistry produce unpleasant, even painful, symptoms when the drug is withheld. In addition, drug addiction is often the cause of serious medical problems such as liver damage.

Social complications also are common with addiction. When a person is addicted to a drug, he or she may have problems with family, friends, work, or school. Also, the illegal trade in drugs gives rise to many other crimes.

*See also* DRUG.

**ADENOIDS** The adenoids are a mass of tissue found at the back of the nasal passages leading to the throat. The adenoids, a kind of tonsil, help protect the body against infection. However, the adenoids themselves often become infected and swollen. This causes a sore throat and may make breathing difficult. It may also lead to loss of hearing. Thus, when adenoids become infected, a surgeon will often remove them. A person can stay healthy without adenoids.
*See also* LYMPHATIC SYSTEM; TONSIL.

**ADHESION** Adhesion is the attraction of molecules of one substance to those of a different substance. The substances will stick together. If you put your finger in a glass of water, some of the water will cling to your finger after you withdraw it. This is adhesion. However, if a person puts a well-greased finger into a glass of water, no water will cling to the finger when he or she removes it. That is because the force of attraction between the molecules of water is greater than the force of adhesion between the molecules of water and the grease on the skin. The attraction of molecules to other molecules of the same substance is called cohesion.
*See also* COHESION; MOLECULE; SURFACE TENSION.




**ADHESION**
Water in a glass tube adheres, or clings, to the walls of the tube, forming a meniscus, or curved surface, that is concave. The water molecules are attracted to the molecules of the glass. However, the molecules of mercury attract one another more than they are attracted to the glass of a tube. This causes a convex meniscus.

**ACTIVITY** *Testing adhesion*

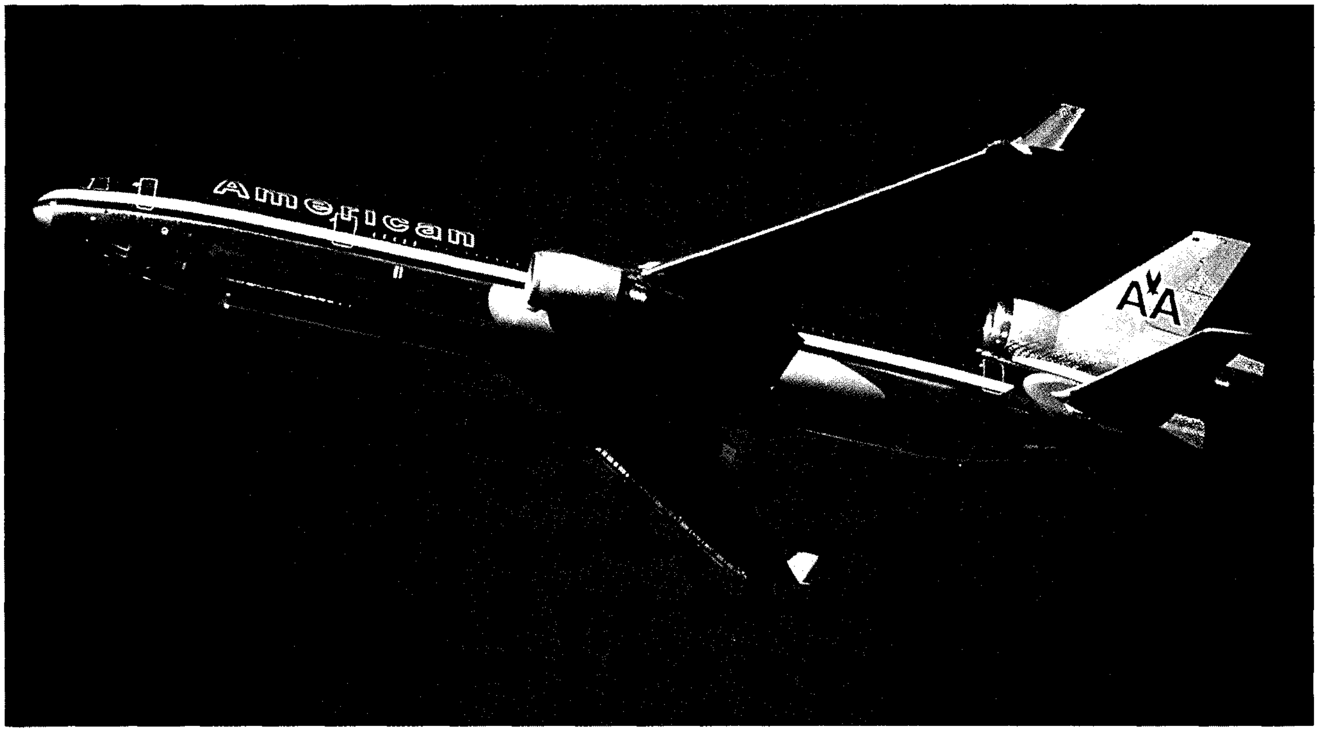
Dip your hand into water. Dry your hand, smear it with butter, and repeat. Notice that the water no longer adheres to your hand. The article explains why this is so.

**ADHESIVE** Adhesives are substances that stick to other substances. They make it possible for materials to be joined together. There are three main types of adhesives: structural, holding, and sealing.

A good example of a structural adhesive is the cement used for making model airplanes. Waterproof glues used in boat building are another example. Holding adhesives include library paste, mucilage, and cellophane tape. They are used to stick paper together or fasten light objects to walls. Sealing adhesives are used to stop leaks in boats or between bathroom tiles.

Adhesives used to be made from animal and plant sources. Early glues were made by boiling fish heads and bones. Others were made from gums, like gum arabic, that come from trees. Today, most household glues are made from chemicals. Of these chemical glues, plastic adhesives make up the largest groups. The epoxy resin types are among the strongest and most useful. The epoxies allow wood, metal, glass, concrete, and ceramics to be joined together. The joints are very strong, usually much stronger than the materials being joined. Epoxies are made in two parts: the base and the catalyst. A chemical reaction occurs when the two are mixed together. The glue must be used quickly or it will harden and become useless (see EPOXY RESIN).

Rubber serves as the base for a group of adhesives. This group is used for joining leather, rubber, textiles, plastics, and paper. Rubber-based glues and cements are used when the object to be glued will be around water. For example, rubber-based adhesives are used to stick plastic tiles to cement floors in kitchens and bathrooms.




ADHESIVE

Some of today's modern adhesives are so incredibly strong that they are used to glue parts of aircraft together.

Adhesives without a rubber base would not hold down the tiles if water were spilled.

Special household glues have been developed. They are called instant glues and do not require any mixing. They are so strong that a single drop can hold thousands of pounds of weight. Portland cement is another kind of adhesive. It hardens to form a bond between sand and stones to make concrete.

*See also* ADHESION; CEMENT AND CONCRETE.

**ADOLESCENCE** Adolescence is a time of growth and change that commonly begins with sexual maturing, called puberty (see PUBERTY). Growth during adolescence, which usually occurs between the ages of twelve and twenty, depends on increased activity by the adrenal, pituitary, and sex glands (see ADRENAL GLANDS; ENDOCRINE; HORMONE). This increased activity causes physical changes to occur in adolescents. For example, hair begins growing on the faces of adolescent boys, and menstruation begins in adolescent girls (see MENSTRUAL CYCLE). These physical changes happen at different rates among adolescents. Most young people can reproduce by the age of fourteen or fifteen (see REPRODUCTION).

Adolescence is also a time for social growth. Adolescents develop socially by learning to act independently and by accepting responsibility for their actions. All adolescents face problems from time to time. Most problems center on school, handling money, and relationships with family and friends.

**ADRENAL GLANDS** The adrenal glands are small glands located above the kidneys. They are part of the endocrine system, a group of glands in the body that produces chemicals called hormones. Hormones are released into the bloodstream to control many of the body's functions. Each hormone controls a different function (see ENDOCRINE; HORMONE).

The adrenal glands have two parts: the adrenal cortex on the outside and the adrenal medulla on the inside. The adrenal cortex produces many hormones. Some regulate the way the body uses sugar. Other hormones from the adrenal cortex keep the amount of salt in the blood at the right level. If the adrenal cortex does not produce enough hormones, serious illness or even death may result.

The adrenal cortex produces its hormones when another hormone, adrenocorticotropic hormone, known by its initials ACTH, enters the adrenal glands from the bloodstream. ACTH is produced in the pituitary gland, which is located at the base of the brain. The best known hormone of the adrenal cortex is cortisol.

When the adrenal medulla receives a certain signal from the brain, it produces a hormone called adrenaline or epinephrine. Adrenaline gives the body extra energy in times of stress. Someone who has been frightened is able to run faster and longer than usual because of the adrenaline released into the bloodstream by the adrenal medulla. When a person is frightened, but does not run, his or her hands may shake due to the adrenaline in the blood.

**ADSORPTION** *See* ABSORPTION AND ADSORPTION.

**AEROBE** An aerobe is an organism that uses the oxygen in the air in order to live. In the process of respiration, an aerobe uses the oxygen mostly in order to break down food to obtain energy (see RESPIRATION). Many forms of life, including human beings, are aerobes. The major exceptions are certain microorganisms, such as some types of bacteria, fungi, and protozoans.
*See also* AEROBIC RESPIRATION; ANAEROBE; ANAEROBIC RESPIRATION; FERMENTATION; MICROORGANISM.

**AEROBIC RESPIRATION** Aerobic respiration is respiration that requires oxygen. It is a series of chemical changes that takes place inside most living cells in order to convert the energy contained in food into a form of energy that living things can use. The chemical changes can be summarized in this word equation for aerobic respiration:

oxygen + glucose (sugar) → carbon dioxide + water + energy

Aerobic respiration is similar to burning, because it combines food—the fuel—with oxygen to release energy, as well as carbon dioxide gas and water as waste products. But there is an important difference. Burning happens very quickly, and it releases energy in a rush. Aerobic respiration involves many chemical reactions, and it releases energy in a slower, more controlled way.
*See also* ANAEROBIC RESPIRATION.

**ADRENAL GLANDS**
The hormone adrenaline helps prey animals, such as the rabbits in this picture, escape from a predator, such as an eagle owl. Molecules of the hormone circulate rapidly in the rabbits' blood and help the liver and the muscles break down sugar to release large amounts of energy. The extra energy is used by the leg muscles for running faster and by the heart, which also consists of muscle, for beating faster so that more blood is pumped around the body. This is why you feel your heart is pounding, or "in your mouth," when you get excited.

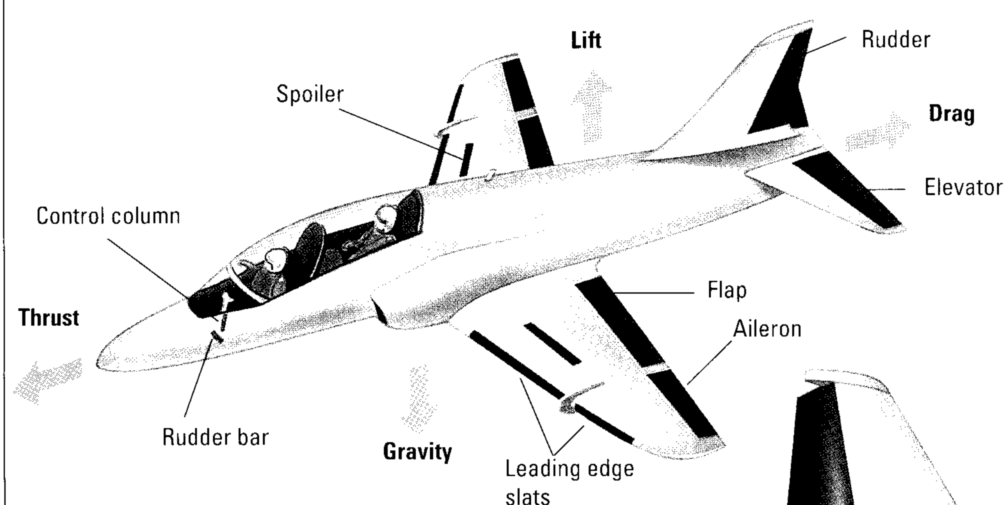
# AERODYNAMICS

Aerodynamics is the study of gases in motion. This includes the study of how air flows around objects. Aerodynamics is closely related to aeronautics because it studies the flight of airplanes and other machines that are heavier than air. The principles of aerodynamics also apply to the flow of air past buildings and bridges (see AERONAUTICS).

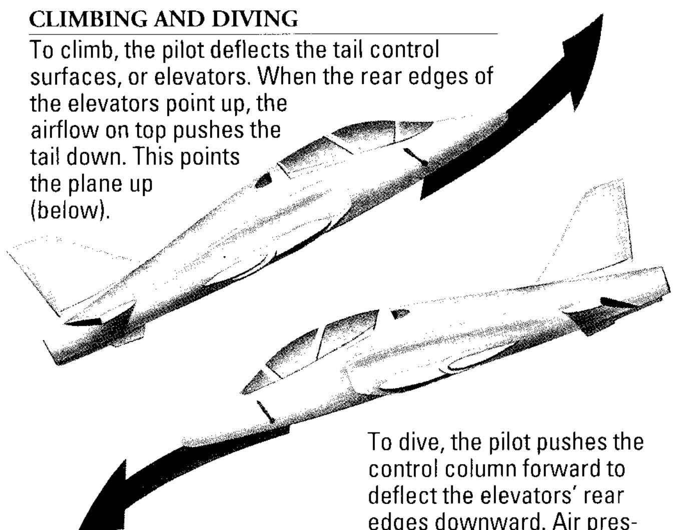
Four main forces act on a powered airplane in flight: lift, drag, gravity, and thrust. Lift and drag are results of airflow over the plane's surfaces.

**Lift** The wings lift the airplane. The wings' shape, angle of attachment, and area are what cause this lift. Seen in cross-section, the wing has a rounded nose, a sharply curved upper surface, and a flatter bottom surface. Both surfaces taper to a sharp trailing edge. A body, such as the wing, designed to produce a desired effect in relation to the air surrounding it is called an airfoil. As the airplane flies, the air passing over the top of the wing has a greater distance to travel. Therefore, the air passing over the top of the wing must flow faster than the air flowing along the bottom of the wing. The pressure of the faster-moving air on top decreases. At the same time, the pressure of the slower-moving air across the underside of the wing increases. The difference between the upward pressure from below and the downward pressure from above lifts the airplane as it moves through the air (see AIRFOIL; BERNOULLI EFFECT).

The angle at which the wing is attached to the

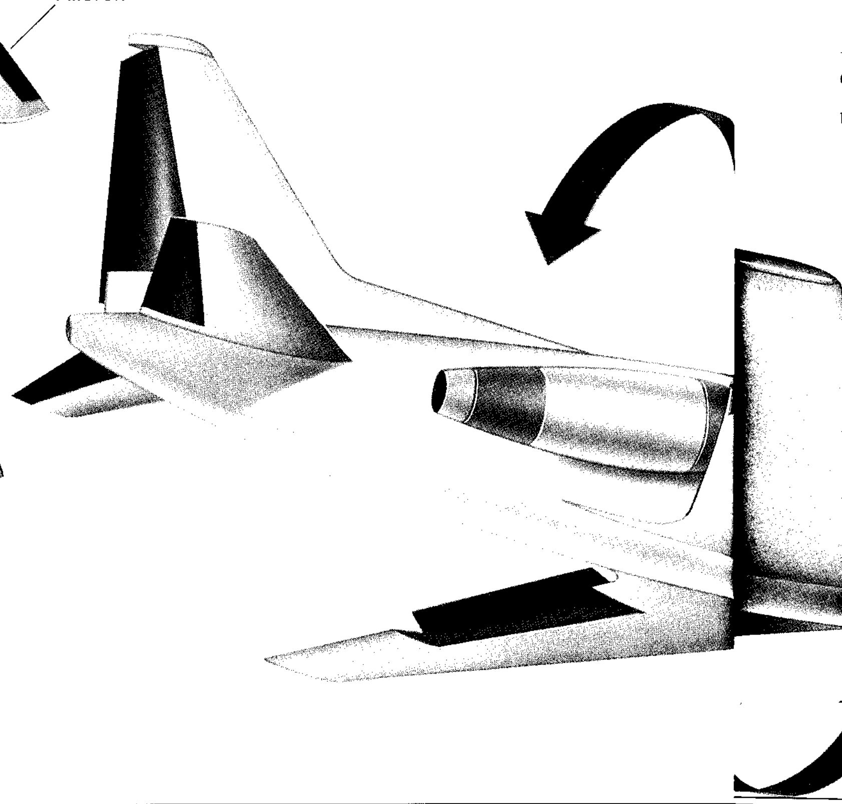


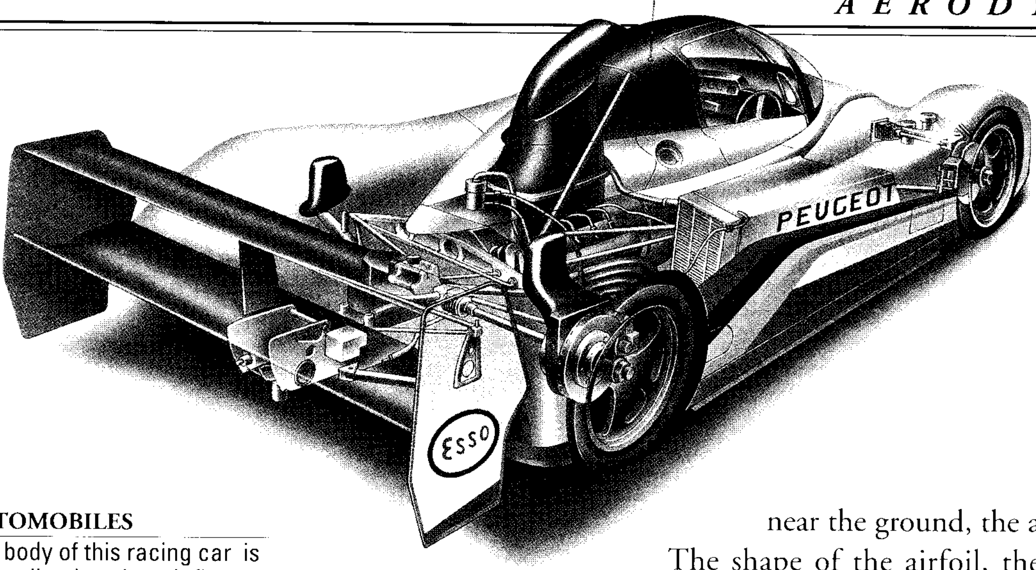

**CONTROL SURFACES**
The diagram (left) shows the main control surfaces of a fighter jet plane. It also shows the four main forces that act on an airplane: thrust, lift, drag, and gravity.



**CLIMBING AND DIVING**
To climb, the pilot deflects the tail control surfaces, or elevators. When the rear edges of the elevators point up, the airflow on top pushes the tail down. This points the plane up (below).

To dive, the pilot pushes the control column forward to deflect the elevators' rear edges downward. Air pressure then pushes the tail up (above).

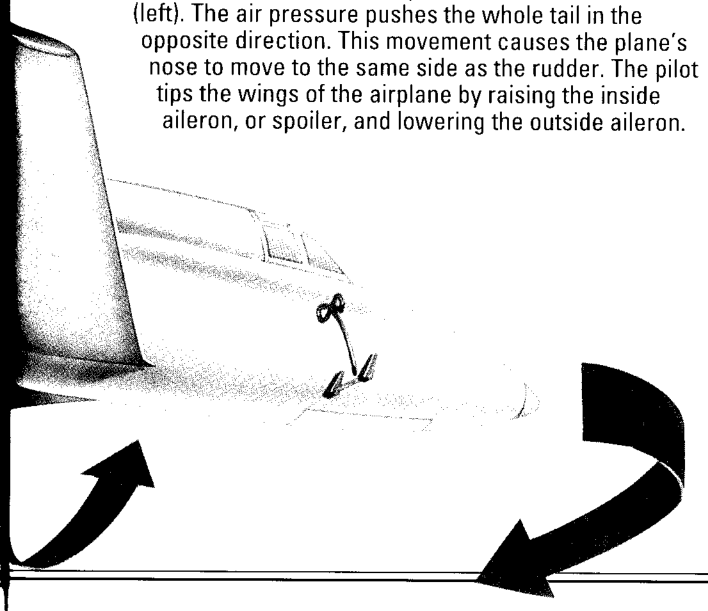





**AUTOMOBILES**
The body of this racing car is streamlined so that air flows smoothly around it with as little drag as possible. An airfoil (wing) at the back pushes it down firmly so that it can corner faster.

body of the airplane is called the angle of incidence. The angle of incidence also has a part in lift. The front edge of the wing is tilted upward to increase the air pressure on the underside of the wing. The angle at which the airflow hits the wing is called the angle of attack. If the angle is increased, it increases lift. If the wing is tilted upward too much for a given speed, the airflow across the top of the wing breaks off. The lifting force of the wing disappears. This is called a stall. If a stall occurs during flight, the airplane must be put into an immediate dive. Then it can pick up enough speed so that air can begin flowing across the top of the wing again. If the stall happens near the ground, the airplane may crash.

**TURNING**
To turn, the pilot moves the plane's rudder to one side (left). The air pressure pushes the whole tail in the opposite direction. This movement causes the plane's nose to move to the same side as the rudder. The pilot tips the wings of the airplane by raising the inside aileron, or spoiler, and lowering the outside aileron.



The shape of the airfoil, the total area of the wings, the angle of attack, the speed of airflow, and the density of the air all contribute to lift. Larger wings provide more lift. Increased speed also provides lift. Lift is less at higher altitudes, where the air is less dense.

At speeds faster than sound, shock waves develop over the surfaces of the wings. These reduce lift by disturbing the smooth flow of air over the wings and other surfaces (see SUPERSONIC FLIGHT).

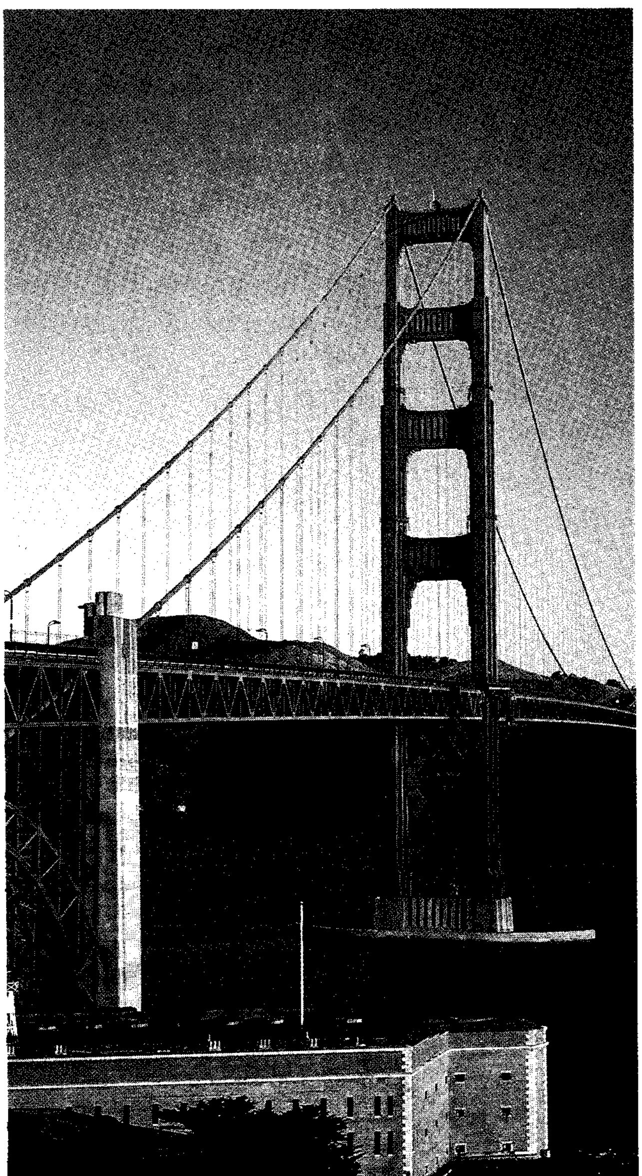
**Drag** The force that fights against the forward progress of an airplane is called drag. If the shape of the body of the airplane is properly streamlined, the air will flow around it smoothly and cause little drag. A badly shaped body results in poor airflow and more drag. As a result, more energy is needed to push the airplane forward.

Skin friction, caused by roughness on the surface of the plane's body, also slows the forward progress of an airplane. Even the smallest bumps on the plane disturb the air. Disturbed air absorbs energy by friction. Skin friction can be reduced by making the surface of the plane's body very smooth. This is why airplanes are constantly cleaned and polished. Another kind of drag is called induced drag. Induced drag is caused by disturbed air at the tips of the wings.

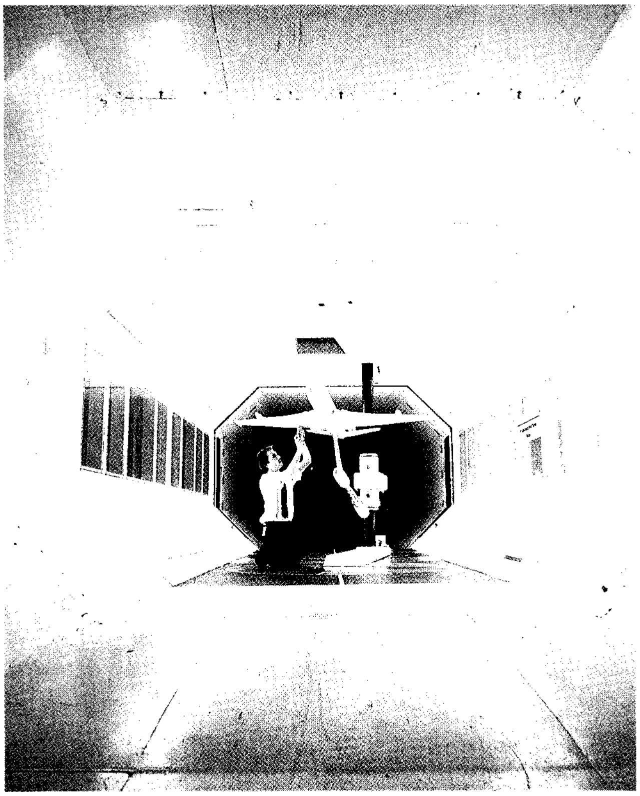
**Gravity** Gravity is the force that pulls an airplane downward. The greater the mass, or weight, of the airplane, the more gravity will pull it down. Weight, as a force, is the opposite of lift.

**Thrust** Thrust is the force that propels an airplane forward. It is created by the engine, or engines, of the plane. Thrust is the opposite of drag.

**Wind tunnels** Airplane engineers test scale models of their designs in wind tunnels. These are large chambers with powerful fans blowing air through the tunnels in one direction. A model plane is suspended by wires or mounted on a string in the airflow. The airflow is made visible by letting smoke stream around the model or by viewing the inside of the tunnel with polarized light. Designers study the model to see how it reacts to airflow. Measurements of all forces on the model are taken with sensitive instruments.



LARGE STRUCTURES
The architects of San Francisco's Golden Gate Bridge had to understand aerodynamics to reduce wind forces.



WIND TUNNELS
A new design of plane is tested in a wind tunnel. If the design is good, the airstream will flow smoothly around the model.

Wind tunnels are also used by automobile engineers and civil engineers to study the effects of airflow. Automobile shapes are designed to reduce drag. Race cars even have airfoils shaped like upside-down wings to create a downward thrust. These keep the car's wheels pressed firmly on the track at high speeds. Designers of tall buildings and bridges also test models in wind tunnels to be sure the structures will be strong enough to resist high winds.

The theories of aerodynamics date back to Leonardo da Vinci, in the fifteenth and early sixteenth century. He studied birds in flight. He even designed a flying machine that had birdlike wings. Otto Lilienthal provided further research with his study of unpowered flight in the 1880s. Samuel Langley published the first papers on aerodynamics in 1891. The Wright brothers flew the first powered airplane in 1903.

*See also* AIRPLANE.

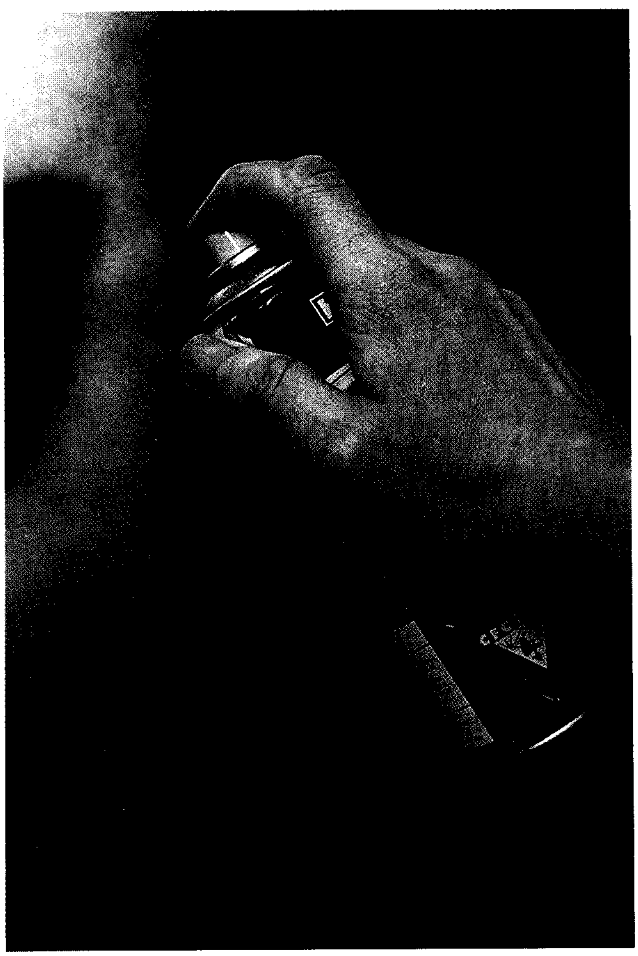
PROJECT 38

**AERONAUTICS** Aeronautics is the science of flight through the air. Aeronautical engineering is a general name for the study, design, building, and operating principles of aircraft.

Aviation is part of aeronautics. It refers most of the time to flight by heavier-than-air machines, such as airplanes and helicopters. Aerostatics is the part of aeronautics concerned with lighter-than-air machines, such as balloons and airships. Missiles that fly in the earth's atmosphere are also included in the field of aeronautics. However, long voyages outside the earth's atmosphere by crafts such as satellites belong to the field of astronautics.

*See also* AERODYNAMICS; AIRPLANE; ASTRONAUTICS; DIRIGIBLE; MISSILE. PROJECT 38

**AEROSOL** An aerosol is a mist of tiny particles of liquid or solid suspended in air. Clouds and fog are examples of natural aerosols. Aerosols can also be human-made. Human-made aerosols include some forms of paints, perfumes, deodorants, and insecticides. Aerosols can be stored in spray cans that contain an active ingredient, such as paint or perfume, and a propellant. The active ingredient is a liquid, and the propellant is a liquefied gas. The propellant and the active ingredient mix in the can. The can is sealed under pressure. When the button on the top of the can is pressed, the propellant forces the mixture out. The propellant evaporates, leaving a fine spray of the active ingredient.



**AEROSOL**
Aerosols are an inexpensive and convenient way of applying paints, insecticides, and many other liquids.

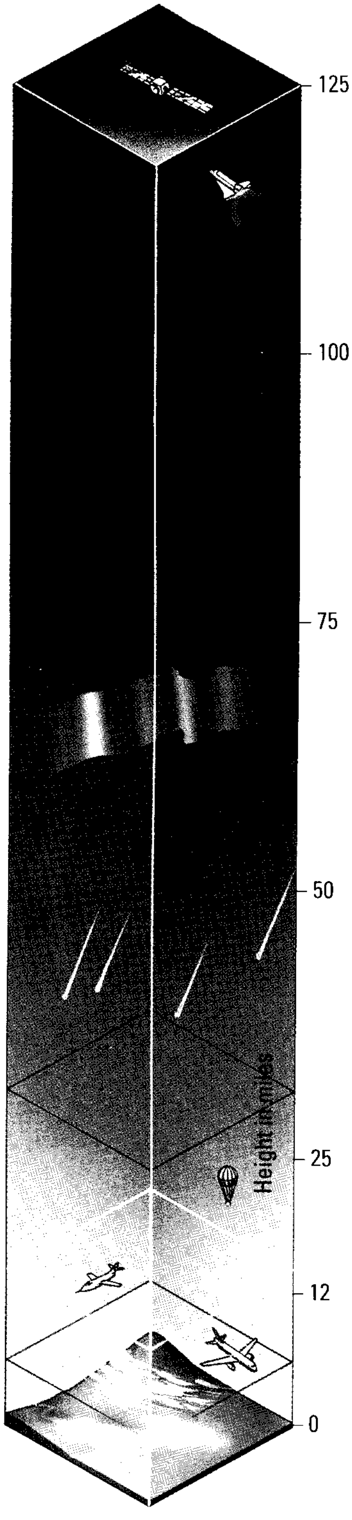
Until the late 1970s, the most common propellant used in the manufacture of aerosol products was a chlorofluorocarbon (CFC) called Freon. Aerosol products are popular, and huge amounts of Freon were released into the atmosphere. Many scientists believe that Freon is dangerous because it breaks down in the upper atmosphere to produce chlorine, which destroys ozone. For that reason, the use of Freon in aerosols was banned in 1978. Other propellants are now used which are more environmentally friendly.

*See also* CHLOROFLUOROCARBON; OZONE LAYER.

**AEROSPACE** *Aerospace* refers to the region that includes everything from the surface of the earth outward. Scientists believe that the earth's atmosphere and outer space are one vast region. *Aerospace* is a term taken from the words *aeronautics* and *space.*

*Aerospace* also refers to the science of all flight within this region, which includes aeronautics and astronautics. One goal of aerospace science is to study the planets at close range. The science of astronomy is also part of aerospace.

The desire to develop air transportation and to explore space led to the aerospace industry. Some discoveries in this field are already part of everyday life. More than 200 million passengers use air transportation each year. Such transportation has proven to be safe, fast, and economical. Television programs and telephone calls from other continents are sent by satellites that orbit the earth.




AEROSPACE

The earth's atmosphere thins out at high altitudes and gradually merges with outer space, with no definite boundary.

Other satellites provide accurate maps and weather forecasts.

*See also* AERONAUTICS; ASTRONAUTICS; ASTRONOMY; SATELLITE; SPACE EXPLORATION.

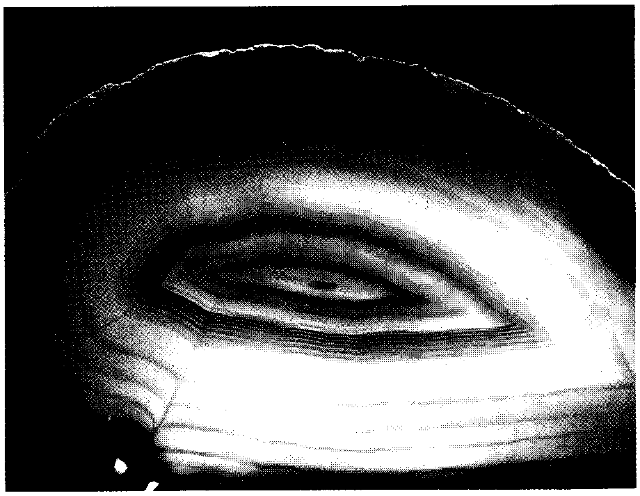
**AGAR** (ä'gär') Agar is a substance found in the cell walls of certain red algae (see ALGAE). When separated from the algae, agar is useful as a thickener. Agar absorbs up to twenty times its weight in water. Agar is used in cosmetic products, such as lipsticks and soaps, and in foods, such as ice cream and jelly. Since the late 1800s, scientists have used agar to study microorganisms, such as bacteria. Most microorganisms grow easily on agar when it is mixed with nutrients, such as sugar or starch.

*See also* MICROORGANISM.

**AGASSIZ, LOUIS** (1807–1873) Louis Agassiz was a Swiss-American naturalist responsible for many important scientific discoveries. He was born in Môtiers, Switzerland, and studied medicine in various European schools. He never practiced medicine because he was more interested in nature. He became a professor of natural history at the University of Neuchatel in Switzerland. Agassiz traveled a great deal and studied fish fossils and the movement of glaciers. He was the first person to propose the idea of continental glaciation. His idea described how, thousands of years ago, much of Europe, Asia, and North America was covered by huge sheets of ice. This ice cover was responsible for creating many of the valleys, lakes, and mountains that exist today (see GLACIATION).

In 1846, Professor Agassiz came to the United States. He was a very popular public figure and traveled around the country lecturing on natural history. He also taught at Harvard University. Agassiz continued to study glaciers and discovered evidence of a large prehistoric lake that covered parts of North Dakota, Minnesota, and Canada. This lake is now called Lake Agassiz.

**AGATE** (ăg'ĭt) Agate is a semiprecious mineral from the quartz family. An agate is a microcrystalline form of quartz, meaning the individual grains of quartz can only be seen with a microscope. Agates usually occur in bright solid colors. Sometimes an agate has bands or other patterns of colors running through it (see QUARTZ).



AGATE
Polishing a piece of agate shows its colored bands well. Agate is used for jewelry, ornaments, and marbles.

Agate probably gets its name from the Achates River in Sicily, where it was first found. Today, it can be found in many places in the world, including the western part of the United States. Agate is very hard. It is used to make decorative items, small implements, and marbles. Some cameos are cut from the onyx variety of agate. A cameo is an ornament showing a raised design in solid color against a lighter background.
*See also* ONYX.

AGAVE
A rosette of the *Agave lopanta* shows the pointed, toothed leaves.

**AGAVE** (ə gä'vē) Agaves are a group of plants belonging to the agave family, Agavaceae. Agaves are found in Mexico and the southwestern United States. A waxy coating on their thick, leathery leaves prevents loss of water. This allows the plants to live in hot, dry areas.

Agaves grow bunches of pointed, toothed leaves called rosettes. A flowering stem grows up from the middle of the rosette. The plant's first flowers may appear between one and forty years.

Agaves have many uses. For example, the leaves of one species are used in making sisal, a strong fiber used in rope. The roots of others have been used to make soap.

**AGGLOMERATE** (ə glŏm'ər ĭt) Agglomerate is a dark, rough volcanic rock made up of hardened lava mixed with dust and ash, all of which are the products of a volcanic eruption. The volcano is also the source of the heat that serves to bind these materials together to form a rock.
*See also* IGNEOUS ROCK.

**AGING** As an animal gets older, or ages, the cells in its body gradually deteriorate. Some cells, particularly those in the nervous system, die and are not replaced. For example, up to 50,000 nerve cells die each day in humans between the ages of 20 and 70. Most animals in the wild die before they reach the end of their natural lifespan, because of disease and predators that hunt them. However, humans are not exposed to many natural threats and so aging is much more commonly seen.

Over a period of time, a wide variety of changes affect the whole body and produce the appearance of aging, which is also called senescence. These changes include failure of sight, hearing, and memory, a loss of elasticity in the skin, increasing stiffness in the joints, and a greater likelihood of problems with the heart and blood vessels (see ALZHEIMER'S DISEASE; ARTERIOSCLEROSIS; ARTHRITIS).

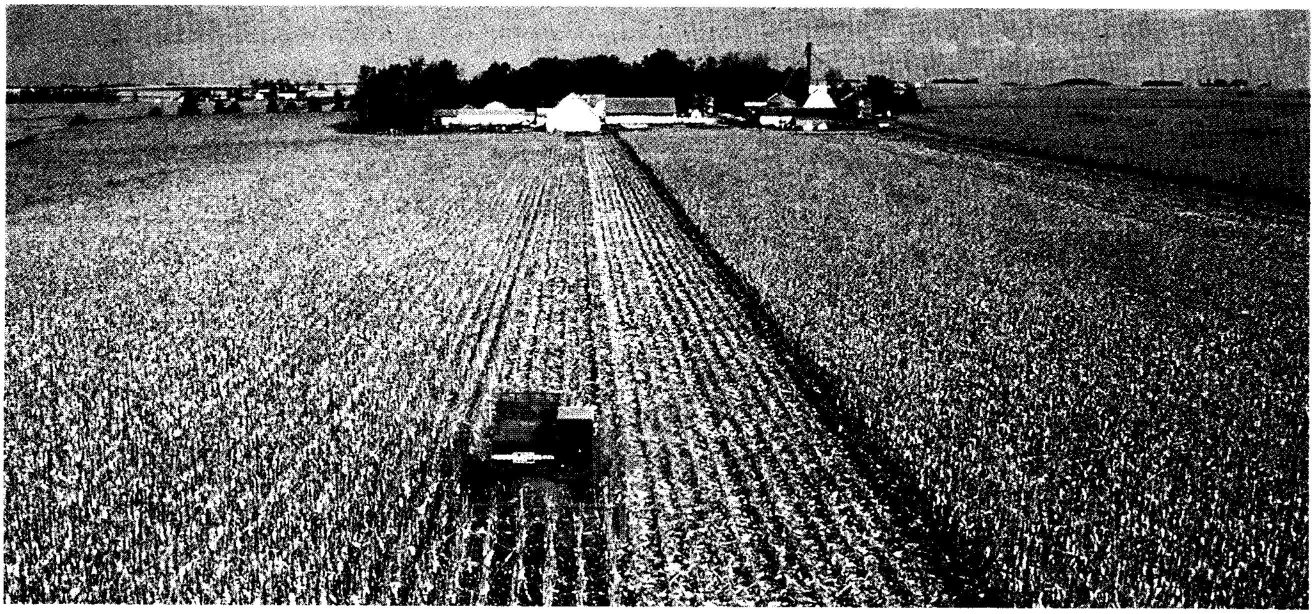
Scientists do not know exactly why aging occurs. It may be caused by a build-up of poisonous waste products from chemical reactions or the body changes may be programmed by genes.

# AGRICULTURE

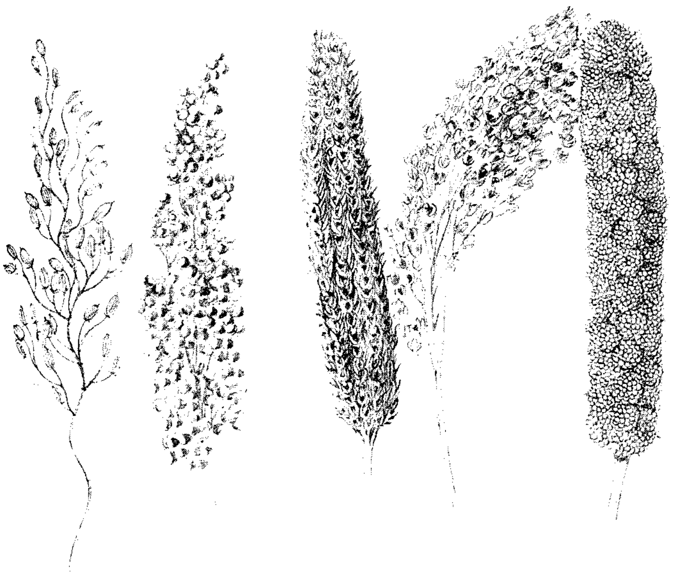
Agriculture, or farming, is the scientific practice of raising plants and animals as crops (see CROP). Farming includes some or all of the following four main activities: cultivating (preparing) the soil, planting, harvesting, and marketing the crop. Examples of crops raised for food include cattle, hogs, fruits, grains, and vegetables. The raising of fish, shellfish, or seaweed for food is called aquaculture. Other kinds of crops include trees raised for lumber, and cotton and silkworms raised for cloth. People who raise animals are often called ranchers or herders, rather than farmers.

**Earliest agriculture** Early humans were hunters and gatherers who moved from place to place in search of food. When people learned to plant and harvest food, they were able to stay in one place. This allowed the development of villages and the start of civilization. It is believed that farming began about 10,000 B.C. in the Middle East. Knowledge of farming spread from that area to northern Africa. Wheat became the major food crop in northern Africa and throughout the Mediterranean region. Rice became the major food crop in the Far East. Corn became the major food crop in North and South America. These early farmers used simple tools to help them produce larger and healthier crops. In about 6000 B.C., people in Europe and the Middle East learned to capture, tame, and raise animals for food—knowledge later spread to the Americas. Aquaculture is another early example of farming. Aquaculture was practiced in China as early as 4,000 years ago.

**Modern agriculture** In the 1800s, Gregor Mendel discovered how characteristics of plants and animals are inherited from their parents' (see MENDEL, GREGOR). This discovery opened new possibilities in the study of genetics (see



HARVESTING CROPS
Modern farming is highly mechanized. Field sizes have increased to allow efficient use of farm machines like this mechanical harvester.



**CEREALS**
The most important cereal crops are (above, from left to right) bread wheat, hard (durum) wheat, rye, oats, six-rowed barley, corn, rice, sorghum, finger millet, common millet, and foxtail millet.

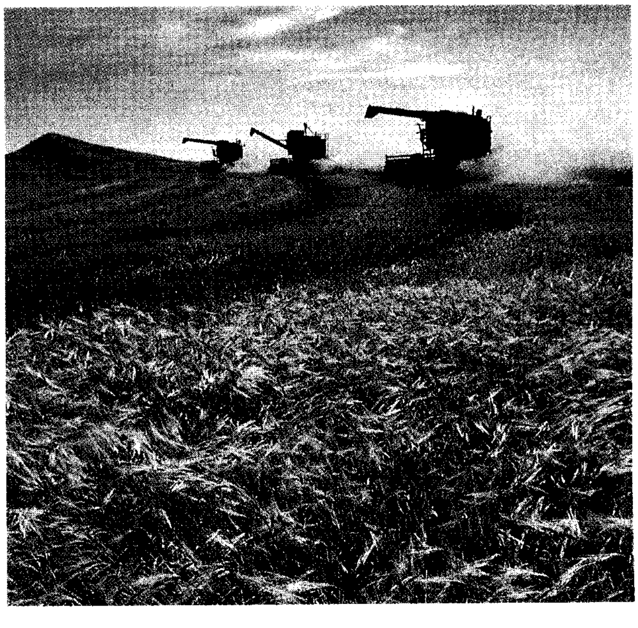
GENETICS). By controlling which animals are bred or which seeds are planted, a farmer can achieve desired characteristics (see BREEDING). These characteristics include sweeter apples and leaner hogs. As another example, an ear of modern corn may have twice the number of kernels on it as an ear of wild corn.

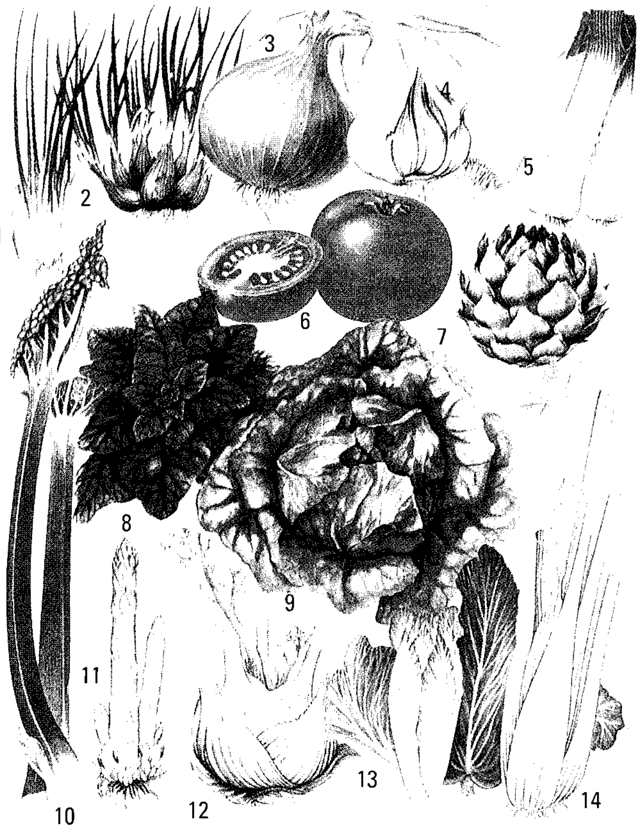
Since the early 1900s, the use of the gasoline engine and special machines has greatly helped farmers. In developed countries, such as the United States, farmers no longer have to rely on hand tools or horses for planting, plowing, and harvesting. Farmers can grow and harvest large amounts of food quickly using tractors and combines. A tractor is a large machine used to pull other equipment. A combine is a machine that harvests grain. The combine largely replaced two machines, called the reaper and the thresher, in the early 1900s. The reaper cut the stalks, and the thresher separated the kernels of grain from the stalks. Advances in technology have helped agriculture in many other ways as well. Special buildings have been designed to house animals or store grain. Some large dairy farms have conveyors, or moving belts, that deliver food to each animal, mechanical milking machines, and mechanical floor scrapers for removing manure (animal waste). Electricity lights and heats barns. Electricity also keeps chicken eggs warm to help them hatch. Refrigeration keeps food from spoiling while it is being stored or delivered.

Modern agriculture involves branches of bacteriology, chemistry, climatology, engineering, and meteorology (see BACTERIA; CHEMISTRY; CLIMATE; ENGINEERING; METEOROLOGY). For example, chemists have developed products that control weeds, insect pests, and diseases (see HERBICIDE; INSECTICIDE; PESTICIDE). Agricultural engineers have designed tractors that use laser beams to guide the plowing of sloped land. Plowing with the help of laser beams helps control soil erosion. Weather information conveyed by satellites, aerial photographs, and computers help farmers decide when to plant crops and help them monitor the crops' progress. Farmers also use computers to receive information about crop prices.

Modern agriculture often involves diversified farming. A diversified farm raises different kinds of plants and/or animals. A diversified farmer may raise some crops that are not usually produced in his or her area, such as ginseng (see GINSENG FAMILY). Ginseng is added to such products as shampoos and

**BARLEY HARVEST**
Advancements in plant genetics have had an impact on the modern farm by producing breeds of barley and other grains that give high yields and are disease resistant.






**COMMON VEGETABLES**

Almost all of the harvest of vegetables goes to canning and freezing. Some common vegetables are: (1) chives, (2) shallot, (3) onion, (4) garlic, (5) leek, (6) tomato, (7) globe artichoke, (8) spinach, (9) lettuce, (10) rhubarb, (11) asparagus, (12) Florence fennel, (13) chicory, and (14) celery.

soft drinks. Many people believe the root of the ginseng plant can cure illnesses. A farmer in the United States or Russia might also try practicing aquaculture. Aquaculture is mainly practiced today in China. A farmer can raise aquacultural products, such as fish, in an enclosure built on land or in natural bodies of water. Lobsters and oysters are examples of crops grown in salt water. Catfish and sturgeons are examples of crops grown in fresh water.

**Environmental concerns** Modern agricultural practices have caused a rising number of environmental concerns. One of these practices is that of planting the same crop on the same piece of land every year. Planting the same crop year after year removes certain nutrients, such as nitrogen, from the soil (see NITROGEN; NITROGEN CYCLE). The practice of replacing nutrients with synthetic, or human-made, fertilizers has led to another concern (see FERTILIZER). Residues, or traces, of these fertilizers may remain on fruits, grains, and vegetables, or run off into drinking water supplies. These residues may be poisonous to humans and other animals. Another environmental concern is the use of chemicals to kill insect pests. Over the years, certain pests may develop in such a way so that they are no longer harmed by the chemical. The chemical then has to be made stronger. If these chemicals are improperly used, they may pollute drinking water.

Soil erosion, or the loss of the top layer of soil due to wind or water, is another concern (see EROSION). Plowing has contributed to soil erosion. If the soil continues to be eroded, fertile farmland may become desertlike. However, techniques used today, such as strip cropping and contour plowing, help reduce erosion from rainwater on sloping land. In strip cropping, grass is planted between strips of crops to slow the flow of rainwater. In contour plowing, the farmer plows along the curve of the slope, rather than up and down. This also slows the flow of rainwater.

The raising of animals, such as cattle, also affects the environment. For example, cattle farming requires large amounts of water. It takes 2,500 gal. [9,460 liters] of water to produce 1 lb. [0.45 kg] of beef. However, it takes only 60 gal. [227 liters] of water to produce 1 lb. [0.45 kg] of wheat. Also, many forests in the United States and tropical rain forests around the world have been chopped down and burned to clear land for crops

**CHICKENS**

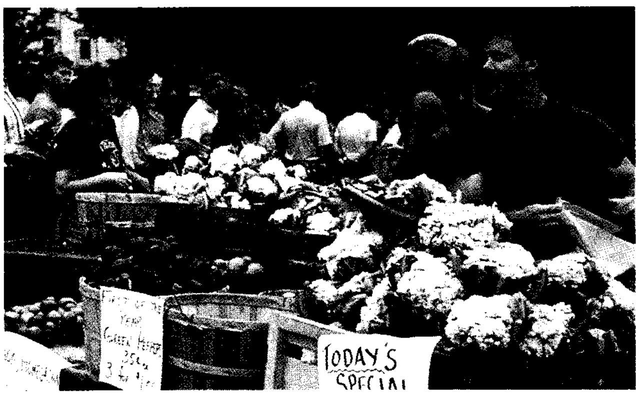
Today's farm animals are the result of hundreds of years of careful breeding to select varieties giving the greatest yield.

CATTLE
Increasing amounts of land are being used to raise livestock, such as these cows in New Mexico.

and livestock. Some scientists believe the chopping down of forests will affect the worldwide environment.

**Alternative agriculture** Some farmers have started using alternative methods of farming along with conventional methods. The goal of alternative agriculture (often called sustainable agriculture) is to produce high-quality crops at a profit while protecting the environment. A farmer practicing alternative agriculture also tries to use the resources he or she has on the farm, such as manure, instead of relying on purchased resources, such as human-made fertilizers. One method of alternative agriculture is planting different crops in the same field each year to preserve and even add nutrients to the soil. This practice is called crop rotation. Crop rotation helps preserve nutrients because every crop takes different amounts of different nutrients out of the soil. Another method of alternative agriculture is called integrated pest management. This method limits the amount of synthetic insecticides and pesticides applied to a field. Natural enemies are also used to fight off pests (see BIOLOGICAL CONTROL). Farmers are also leaving harvest debris, such as stalks, in the fields. This debris fertilizes the soil, helps control erosion, and provides shelter for wildlife.

VEGETABLE AND FRUIT MARKETS
Markets make it possible for people who live in towns and cities to buy fresh produce directly from the farmers who raised it.




One way to achieve some of the goals of alternative agriculture is through organic farming. In organic farming, chemicals are not used. Biodynamic farming is a branch of organic farming. Biodynamic farming attempts to restore the nutrients in the soil by adding compost, manure, and mulch (see COMPOST; MULCH). The practice of permaculture is another approach to alternative agriculture. This practice tries to create an efficient ecological system on the farm. It involves managing crops, land, water, and animals so that both the products and waste from each part of the system are used. For example, hogs not only produce meat, but also manure for fertilizer. A pond may provide water to raise fish, irrigate land, water livestock, and act as a fire barrier.

**Agriculture and society** The world's population is growing rapidly. There are more people to feed today, but less land for farming. Factories, office buildings, and homes are often constructed on what could be good cropland. Land used to graze livestock is also increasing. This is in spite of the fact that studies show that peas or beans yield ten times as much protein per acre as livestock. In addition, fewer people are farming now. Many farmers' children move away to get other jobs. Other people no longer farm because they cannot make enough money. There is a trend for large corporations to own farms. However, the majority of American farms are still family owned. Producing enough food and providing farmers with a profit while staying in harmony with the environment is a constant challenge.

PROJECT 20

**AGRONOMY** (ə grŏn′ə mē) Agronomy is the branch of agriculture that deals with the study of field crops. Most agronomy is concerned with helping production of the world's ten major food crops—barley, corn, millet, potatoes, rice, sorghum, soybeans, sweet potatoes, wheat, and cassava. Cassava is a small shrub grown in Africa, India, Indonesia, and South America. The roots and leaves of the cassava plant are eaten.

Agronomists design new plant breeds that have higher yields or better nutritional quality (see BREEDING). Agronomists also advise farmers on ways to control weeds and insect pests without harming the environment.
*See also* AGRICULTURE.

AGRONOMY
This agronomist is artificially pollinating corn plants in an effort to develop improved breeds. Agronomists work with crops to do such things as improve their yield, make them disease resistant, and make them able to withstand unfavorable growing conditions.

**AIDS** Acquired immune deficiency syndrome, or AIDS, is a disease that affects the body's immune system by destroying its ability to fight many other diseases. There is no known cure for AIDS. It almost always results in death. People with AIDS do not die of AIDS itself. Rather, they die of some other disease, such as pneumonia or cancer, that their bodies cannot resist.

*Acquired* means that AIDS is not an inherited disease. Instead, it is caused by a virus called HIV (human immunodeficiency virus). The virus is often called the AIDS virus as well. Viruses are microscopic organisms, some of which cause disease. The AIDS virus lives in certain body fluids such as blood, blood plasma, and semen. *Immune deficiency* means that those systems that normally protect the body from disease do not work properly. *Syndrome* means that persons with AIDS usually show physical symptoms resulting from the disease. AIDS is suspected when certain serious infections occur that usually only develop when the HIV virus is present. Tests are then performed to see if the person actually has the HIV virus. Sometimes, an individual can be infected with the AIDS virus but will not actually develop AIDS. This is known as ARC (AIDS-related complex). People with ARC may have fever, fatigue, diarrhea, and weight loss.

Most people with AIDS or ARC catch the disease through sexual contact with someone infected with the AIDS virus. Others are infected by using hypodermic needles or syringes contaminated with the AIDS virus to inject themselves with drugs. In the past, a small number of people have gotten the disease from AIDS-contaminated blood transfusions. Also, each year, a growing number of children are born with AIDS that they catch from their mothers' infected blood. Hospital employees have to be careful not to come into contact with contaminated blood, particularly if they have any open wounds.

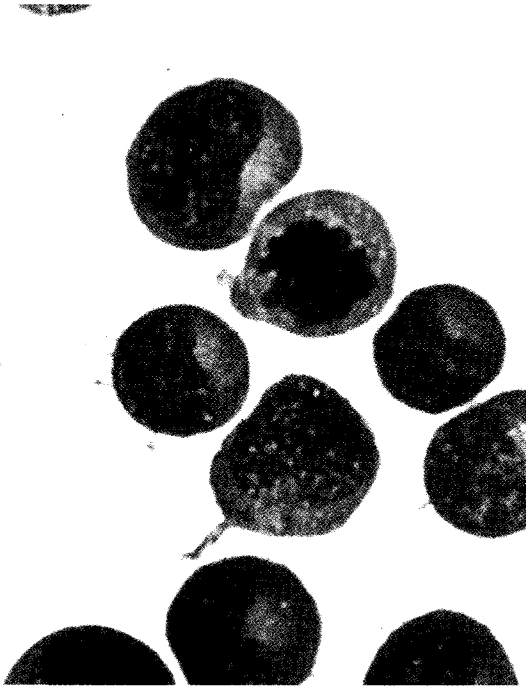
Once in the body, the AIDS virus enters the bloodstream. There it kills many of the special kind of white blood cell—called the helper T cell—that helps the body protect itself against infection.

Nonsexual contact between people does not spread the AIDS virus. There are no known cases in which AIDS has been spread because of eating, kissing, coughing, sneezing, playing, shaking hands, or working with someone who has AIDS.

Drugs have been developed that may help people with AIDS live longer. These drugs help fight off the infections that the body cannot. Scientists hope to develop drugs that prevent AIDS. At this time, the only certain way to prevent AIDS is to avoid the kind of behavior that spreads the disease. One such behavior is using infected needles or syringes. Another risky behavior is having sexual contact with a person, or variety of people, without using a condom.

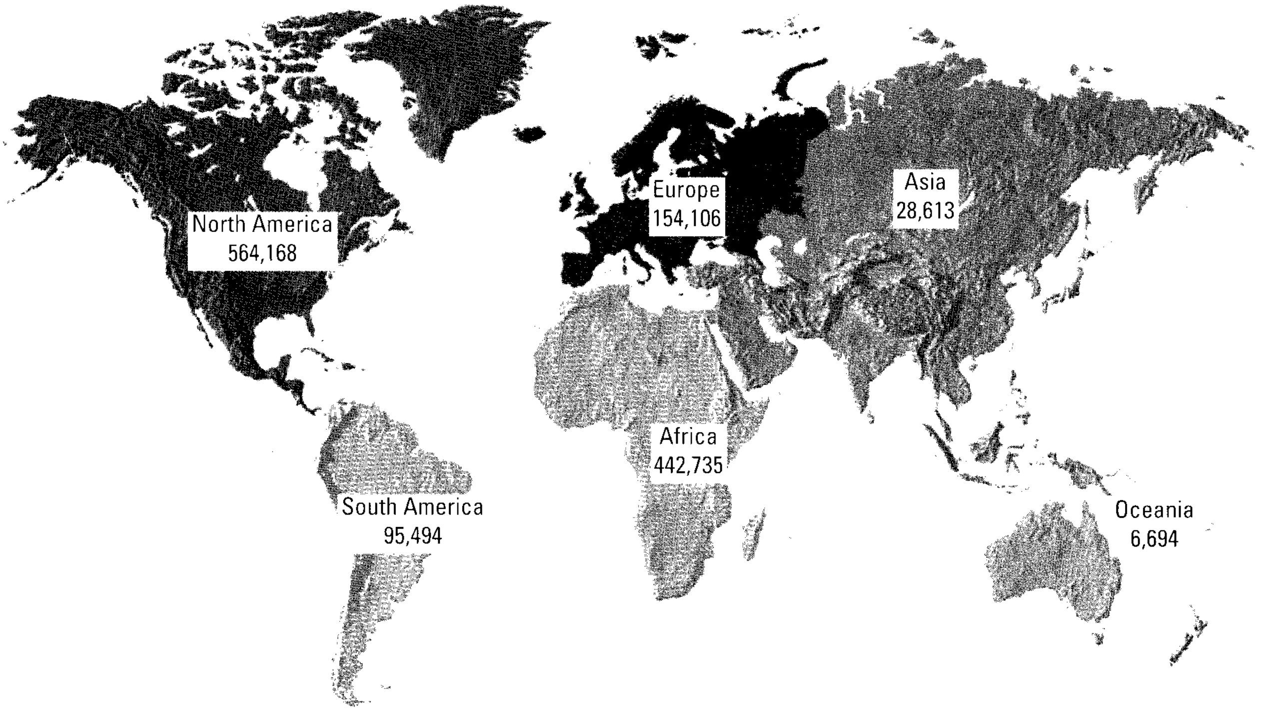
The number of AIDS cases is rising rapidly and has become a major health crisis in many parts of the United States and the rest of the world. There is little evidence that the worldwide AIDS epidemic is being controlled. Many experts fear that AIDS will remain a major health problem for many years.

*See also* BLOOD; BLOOD TRANSFUSION; COCAINE; DISEASE; HIV; IMMUNITY; VIRUS.



**AIDS—Cells**

Normal, healthy T cells are shown (left). The T cells pictured above have been infected by the acquired immune deficiency syndrome (AIDS) virus.



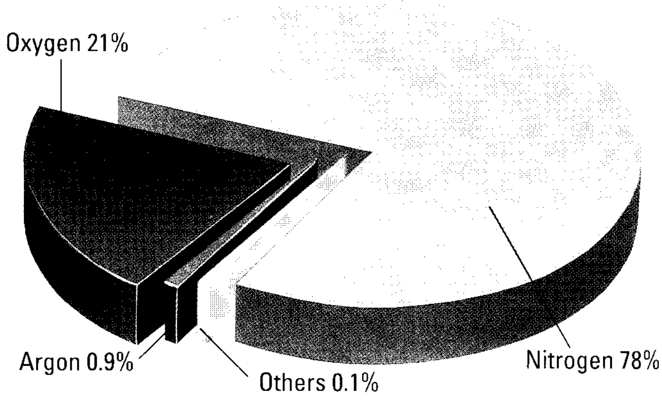

(Source: World Health Organization.
Based on reports received through 15 December 1995.)

**AIDS—Distribution of reported cases**

This map shows the distribution of AIDS across the world.

# AIR

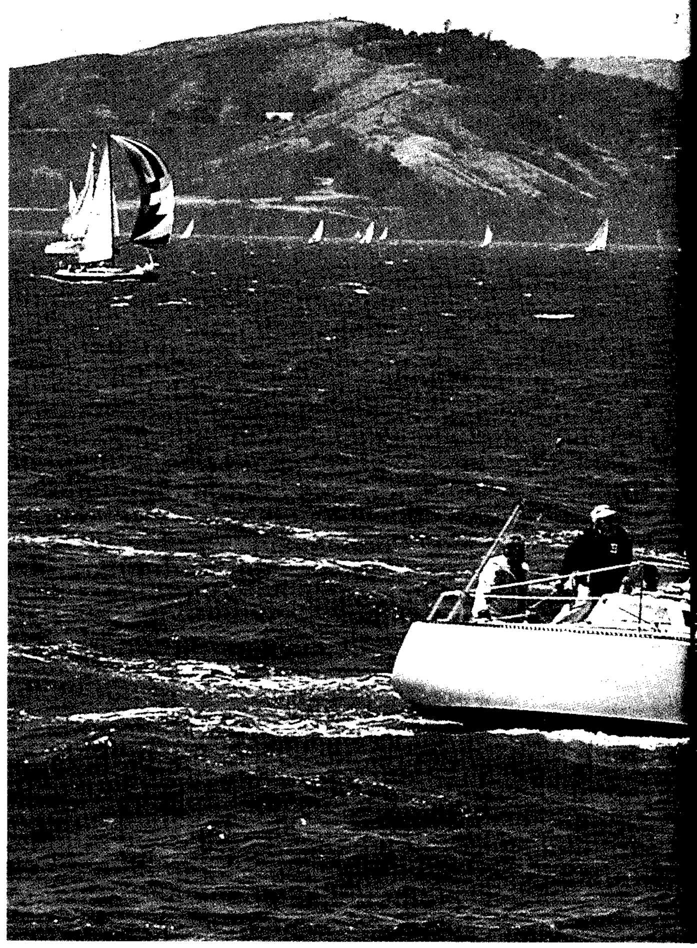
Air is the mixture of gases that surrounds the earth. It is invisible and tasteless and has no smell. Air extends great distances above the earth. One half of the air, by weight, is within 3.5 mi. [5.6 km] of the earth's surface. The other half is spread over hundreds of miles beyond that. The layer of air surrounding the earth makes life possible. It is prevented from escaping into space by gravity (see GAS; GRAVITY).




**COMPOSITION OF AIR**
The air consists largely of nitrogen. Plants generate the oxygen, which is vital for almost all living things.

**Composition of air** Nitrogen makes up about 78 percent of the air, oxygen 21 percent, and argon almost one percent. More accurately, these gases make up 99.77 percent of the air. The remaining gases include tiny percentages of carbon dioxide, helium, krypton, neon, ozone, and xenon.

The amount of carbon dioxide in the air varies from place to place. The highest amounts of carbon dioxide are found in cities and in places such as closed rooms. Carbon dioxide is a very important gas. It is used by green plants in photosynthesis (see PHOTOSYNTHESIS). Air also contains moisture in the form of water vapor, which is a gas. The amount of water vapor in the air depends upon the temperature. Warm air can hold much more water vapor than cold air. Dust in the air serves as a center around which water vapor collects. This dust may come from dust storms, automobile exhaust, or smoke from factories. Dust also includes plant pollen, bacteria, and tiny salt particles. When warm air cools, it may reach the dew point. The dew point is the temperature at which the air is holding all the water it possibly can. The term relative humidity is used to describe the amount of water vapor in the air compared with the amount of water vapor the air can hold at a given temperature. When air reaches the dew point, the relative humidity is 100 percent (see DEW POINT; HUMIDITY).



Cooling may also cause water vapor to surround specks of dust to form tiny water droplets. A mass of these droplets forms a cloud. If the conditions are right, clouds may produce rain or snow. High up in the atmosphere, where it is very cold, water vapor may become ice crystals by a process called sublimation. A mass of ice crystals forms cirrus clouds high in the atmosphere (see ATMOSPHERE; CLOUD).

The air surrounding the earth is divided into layers. From the earth's surface to about 7 mi. [11 km] up is the troposphere. This is where almost all of the earth's weather occurs. Above this layer are the stratosphere and the ionosphere. The exosphere is where the air thins out into space.

**Air weight and pressure** The force of gravity holds the air and gives it weight. At sea level, 1 cu. ft. [0.03 cu. m] of air weighs 0.081 lb. [0.037 kg]. However, the hundreds of miles of air above the earth weigh so much that the total force on 10.7 sq. ft. [1 sq. m] of surface is about 22,604 lb. [10,253 kg]. Air pressure is the measure of the force of air on a given area. Air pressure at the earth's surface is equal in all directions. People do not feel this pressure because their bodies are supported by equal pressure on the inside. In the atmosphere, air pressure varies and is measured by

WIND

The wind that is moving these yachts is an indication that the air is in constant motion.

**HOT-AIR BALLOONS**

Warm air inside this balloon is less dense than the cold air outside, and so the balloon floats upward—just as wood floats on water.

instruments called barometers.
Weather forecasts are based partly on changes in barometric pressure (see BAROMETER; WEATHER).

Air pressure decreases above sea level. At 18,500 ft. [5,640 m] high, the pressure is half as great as it is at the earth's surface. For this reason, airplanes have pressurized cabins to make flying more comfortable. Air pressure is used as a force in pumps. Air pressure keeps automobile tires from going flat.

**Air resistance** People move through air easily, as they do in walking. However, a piece of paper dropped in the air floats slowly to the ground. The falling of the paper is slowed down because of the air resistance acting on the large surface area of the paper. A bullet moves quickly through the air. Its smooth surface and pointed end reduce air resistance.

**Air motion** Although it may seem to be motionless on a hot summer's day, air is never still. Molecules of air are in constant motion. Large masses of air also move. This motion is measured as wind. The sun provides the energy that causes the air to move. Because air is always moving, the weather is always changing (see AIR MASS; WIND).

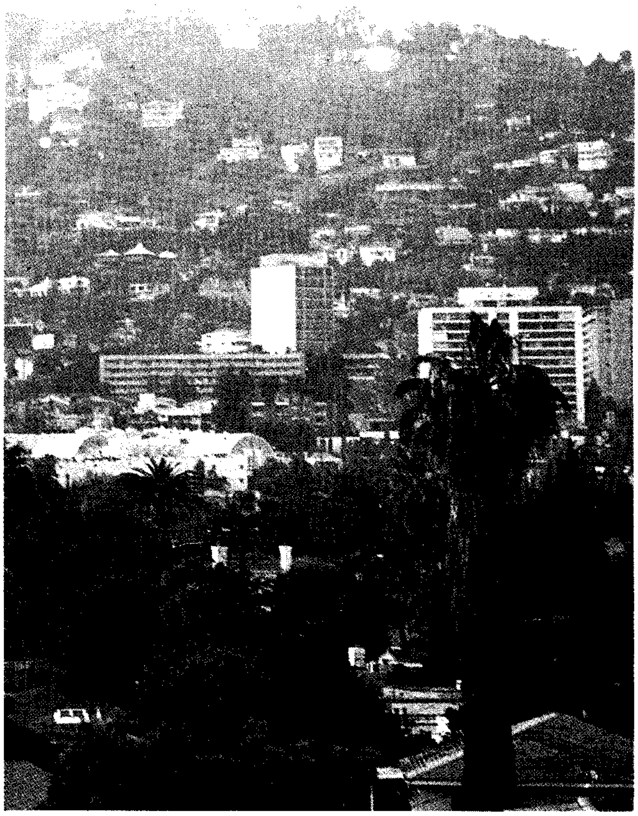
**Air pollution** Air pollution is a serious problem in the United States and other countries. Pollutants enter the air from many sources. Automobiles,

**AIR POLLUTION**

Power plants such as this one are one of the major sources of air pollution.

electric-power plants, factories, and other sources release chemicals into the atmosphere. Many of these chemicals are harmful to the environment.

For example, the sulfur and nitrogen released in the smoke of many coal-burning electric-power plants combine with the water in the atmosphere to produce acid rain. Acid rain is harmful to plants and animals (see ACID RAIN). Industrial processes that involve the production of coke (coal that has been heated to a high temperature without air) release a chemical called benzene into the atmosphere. Benzene is known to affect the blood and can cause severe leukemia (a form of cancer) and anemia (a condition in which the number of healthy red blood cells in the human body falls below normal) (see BENZENE). Other chemicals, called chlorofluorocarbons, are used as refrigerants in air conditioners and refrigerators and to make plastic foams. When released into the atmosphere, they destroy the ozone layer in the upper stratosphere (see ATMOSPHERE; CHLOROFLUOROCARBON; OZONE LAYER). The exhaust from automobiles combines with oxygen in the atmosphere to form smog (see SMOG). Exhaust also contains carbon dioxide, which is the main gas responsible for the greenhouse effect. In the greenhouse effect, pollution in the atmosphere helps trap the sun's heat above the earth. This may cause the earth's temperature to rise (see GREENHOUSE EFFECT).



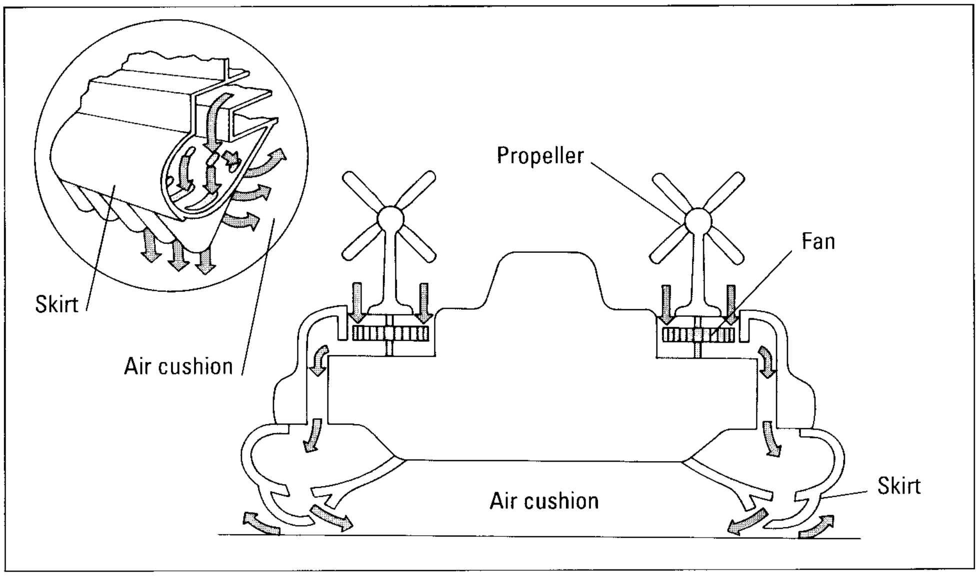
**CITY POLLUTION**

Smog over the city of Los Angeles, California, shows the pollution in the city, caused largely by automobile exhaust.

In recent years, the federal, state, and local governments have worked together to try to control air pollution. One major step by the federal government to control pollution was the 1970 Clean Air Act. This act set limits on the amount of pollution that could be released in automobile exhaust, factories, and electric-power plants. A new Clean Air Act became law in 1990. It requires greatly lowered levels of pollution from automobiles, factories, and power plants. It also requires the use of reformulated fuels and gasohol (containing methanol) and requires the sale of cars that use the new fuels. The federal government also issues air-quality standards. The state and local governments must then enforce measures so these standards are met.

*See also* GASOLINE; POLLUTION.

PROJECT 2, 22, 23, 24, 26, 49




**AIR-CUSHION VEHICLE**

Large fans mounted in the top of this air-cushion vehicle, or hovercraft, are powered by the same engines that drive the propellers. The fans draw in air and force it down beneath the craft. Some is blown out and under the craft to form a high-pressure air-cushion on which the vehicle rides (inset). The rest is blown downward through apertures in the flexible skirt, which makes contact with the water surface or ground.

**AIR-CUSHION VEHICLE** An air-cushion vehicle, also called a hovercraft or surface-effect ship, hovers over the ground on a cushion of air. It can travel over any fairly flat surface, on either land or water.

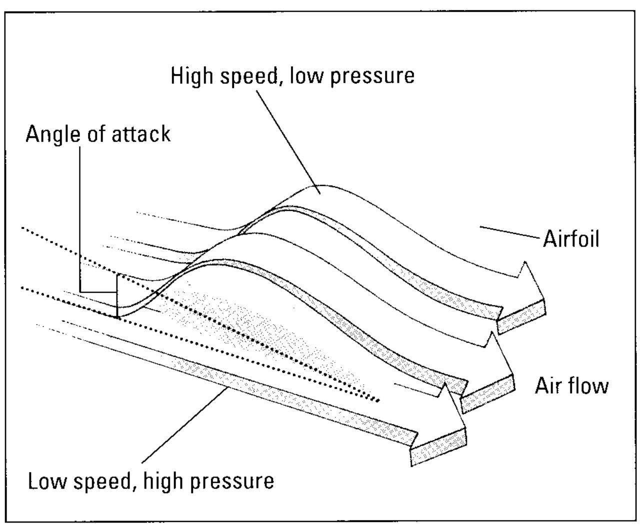
Most air-cushion vehicles are used for traveling over water. They can move very fast, and some have a top speed of 90 mi. per hour [150 km per hour]. Air-cushion vehicles can travel at these high speeds because they do not move through the water. An ordinary ship travels more slowly. It is slowed down by friction between the hull and the water (see FRICTION). In an air-cushion vehicle, air is sucked in through the top of the vehicle by a large fan. The air is then blown through nozzles to the bottom of the craft. Here it forms a cushion of air.

Many air-cushion vehicles are surrounded by a "skirt" that reaches down to the water. This helps keep the air inside the cushion. This effect allows the vehicle to ride higher out of the water, above waves that are fairly high.

Air-cushion vehicles travel by means of propellers driven by engines. The propellers on the vehicles face backwards. By swiveling the propellers, an operator can steer the vehicle. Some air-cushion vehicles have large vertical tail fins and are steered by turning the fins to either side. Because of the high speed at which they can travel, air-cushion vehicles are very useful for carrying passengers and freight between ports. They are only used for fairly short distances, since they cannot, as yet, travel in rough seas. Air-cushion vehicles are also very useful for traveling over swamps.

PROJECT 49

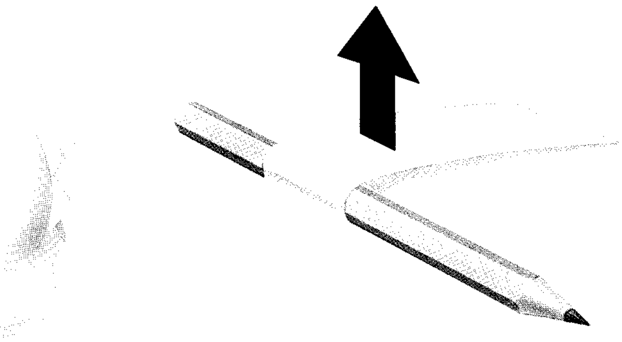
**AIRFOIL** An airfoil is a body, such as an airplane wing, that interacts with airflow to produce a desired effect. For example, as an airplane moves through the air, the air divides to pass above and below its wings. Each wing has a curved upper surface and a flatter bottom surface. This design causes the air moving above the wing to move faster than air moving below. Fast-moving air exerts less pressure than slow-moving air (see BERNOULLI EFFECT). Because there is less pressure above and more below, the airplane is lifted. The




**AIRFOIL**

An airfoil is shaped to force air traveling over it to speed up, thereby reducing its pressure.

**ACTIVITY** *Make an airfoil*



Curve a piece of paper around a pencil and glue the ends together. Bend the glued end downward. Next, blow over the airfoil; watch it rise like an airplane wing.

lifting force can be increased by increasing the angle of attack, which is the angle at which the wing is attached to the airplane's fuselage.

*See also* AERODYNAMICS. PROJECT 38

**AIR MASS** An air mass is a huge body of air. It often extends 1,000 mi. [1,600 km] or more across a given area. The higher parts of an air mass are colder than the lower parts. The temperature of air decreases with height. On the same level, the air in one part of the air mass is about the same temperature as the air in other parts of the same mass.

There are four main types of air masses: continental polar, continental tropical, maritime polar, and maritime tropical. Continental air masses form over land, while maritime air masses form over the sea. Continental polar air masses are cold and dry. Continental tropical air masses are warm and dry. Maritime polar air masses are cool and moist. Maritime tropical air masses are warm and moist.

A cold air mass is colder than the ground surface over which it moves, and a warm air mass is warmer than the ground surface. Cold air weighs more than warm air. Therefore, a cold air mass exerts greater pressure on the earth than a warm air mass does. Cooler air tends to move toward the warmer air because of the difference in pressure between the two air masses.

When a cold air mass meets a warm one, the cold air tends to run under the warm air instead of mixing with it. The line along which this occurs is called a cold front (see COLD FRONT). As the warm air is pushed up, it expands and cools. This causes cloud formations and precipitation, such as rain or snow. Precipitation occurs because warm air holds more water vapor than cool air does. As the warm air grows cooler, the water vapor leaves the air (see CONDENSATION). It falls to the earth in the form of rain, sleet, snow, or a combination of the three. If wind movements cause a warm air mass to overtake a cold air mass, the warm air, weighing less, slides up over the cold. Clouds and precipitation are formed. This is called a warm front (see WARM FRONT).

When an air mass is moving very slowly, its moisture content and temperature are affected by the surface below it. For example, an air mass may take on the coldness of a polar region or the heat of the tropics. The region where an air mass takes on its temperature and moisture is called its source region. The depth to which an air mass is changed by its source region depends upon the length of time the air stays in the source region. It also depends upon the difference between the temperature of the air and that of the underlying surface.

Weather maps use symbols, such as *cP* for continental polar, *cT* for continental tropical, *mP* for maritime polar, and *mT* for maritime tropical, to identify air masses. Such symbols explain where the air mass began, the direction it is taking, and the type of surface over which it is moving. As an air mass moves from one surface to another, it can change from a warm air mass (*w*) to a cold air mass (*k*).

Across the United States, the general movement of air masses is from west to east. A cold air mass moves faster than a warm one. A cold air mass may average 500 to 700 mi. [800 to 1,120 km] in a day. The weather depends on the type of air mass and on the action between two or more air masses. With just one air mass, the weather is about the same throughout the area it covers. Differences are caused by changes in the surfaces below, such as lakes, mountains, and valleys.

*See also* WEATHER.

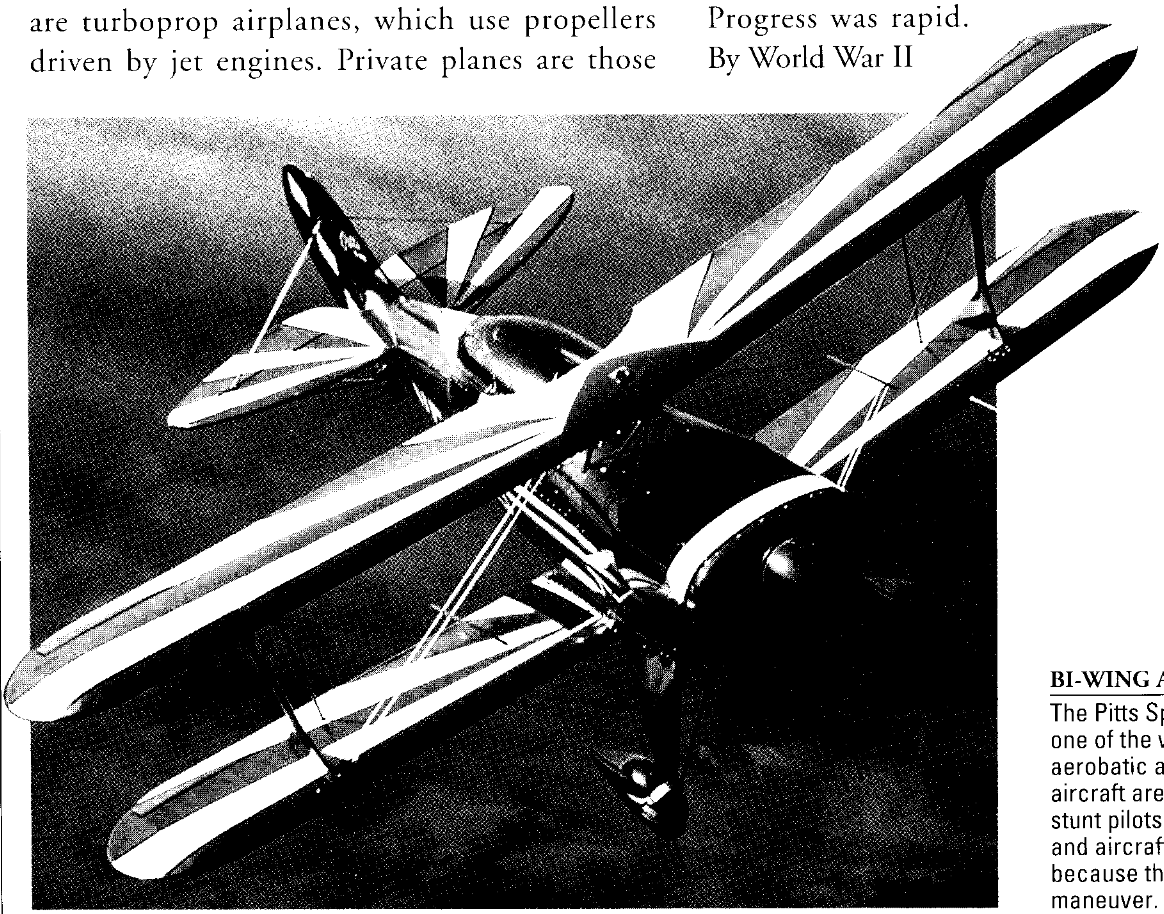
# AIRPLANE

An airplane is a heavier-than-air vehicle with fixed wings that flies. Before an airplane can fly, a force acting upwards greater than its own weight must be created. This force is called lift. An airplane obtains lift from the design of its wings (see AIRFOIL). There are airplanes with and without engines. The engines provide forward motion by a force called thrust (see AERODYNAMICS). Unpowered airplanes have to be brought into the air by tow before they can glide to earth.

There are three main categories of airplanes: military, commercial, and private. Military planes include fighters, bombers, transports, and trainers. Most are powered by gas turbine jet engines (see ENGINE; JET PROPULSION; TURBINE). Commercial planes include passenger and cargo planes used by airlines, as well as planes developed for special uses. Most large commercial planes are powered by jet engines. Some planes, especially small private aircraft, still have piston engines with propellers. Between these two types are turboprop airplanes, which use propellers driven by jet engines. Private planes are those owned by individuals and companies. They are usually small, carrying from one to six people. Most are powered by one or two piston engines or jet engines.

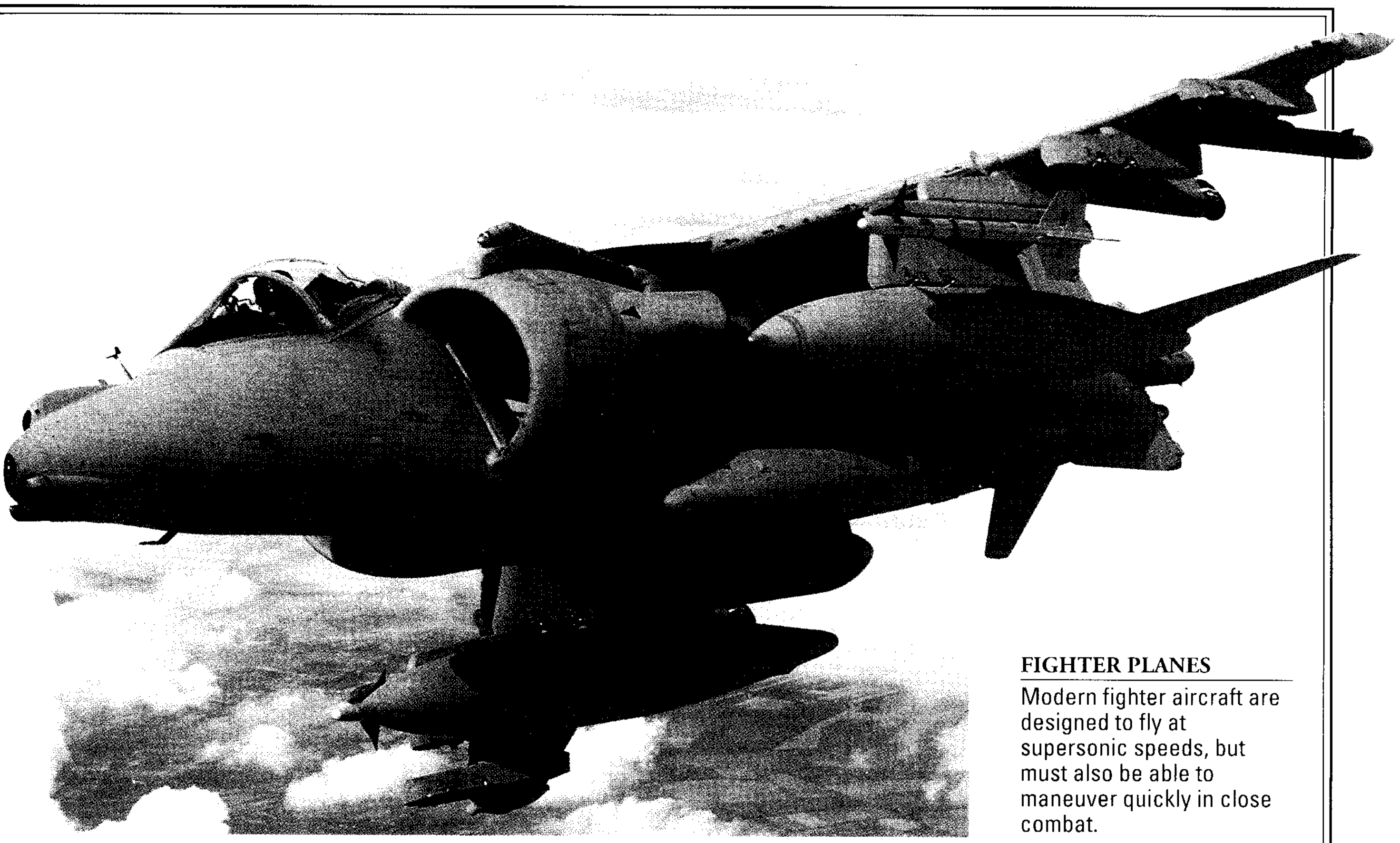
**History** The first attempts to fly were made with balloons (see BALLOON). The Montgolfier brothers succeeded in making the first balloon flight in 1783, in France, using heated air. Starting one hundred years later, Otto Lilienthal of Germany made two thousand flights in gliders over a twenty-year period. A glider is an airplane without an engine. Gliders are towed aloft by a winch and cable, or by a powered airplane. Then they are released. They depend upon rising and shifting air currents for lift. In 1903 Orville Wright of the United States made the world's first powered flight at Kitty Hawk, North Carolina (see WRIGHT BROTHERS).

The need for military planes in World War I (1914–1918) speeded up airplane development. Progress was rapid. By World War II



**BI-WING AIRCRAFT**

The Pitts Special (left) is one of the world's leading aerobatic aircraft. Bi-wing aircraft are popular with stunt pilots, crop dusters, and aircraft hobbyists because they are easy to maneuver.



**FIGHTER PLANES**

Modern fighter aircraft are designed to fly at supersonic speeds, but must also be able to maneuver quickly in close combat.

(1939–1945), the airplane had become a major weapon. Air speeds in the 300 to 400 m.p.h. [480 to 640 kph] range were common. Jet-powered planes were introduced in the 1940s. They have since come into wide use. Some military and commercial jet planes now fly at supersonic speeds (faster than the speed of sound, which is 743 m.p.h. or 1,200 kph at sea level, and is called Mach 1). The French *Concorde* passenger plane flies at Mach 2.2 (2.2 times the speed of sound, 1,450 m.p.h. or 2,333 kph) (see MACH; SUPERSONIC FLIGHT).

Other recent developments in airplane design have been VTOL and STOL planes. VTOL (vertical takeoff and landing) planes lift straight up off the ground in a horizontal position, like helicopters, before flying forward. STOL (short takeoff and landing) planes have powerful engines and high-lift wings that enable them to take off and land on very short runways.

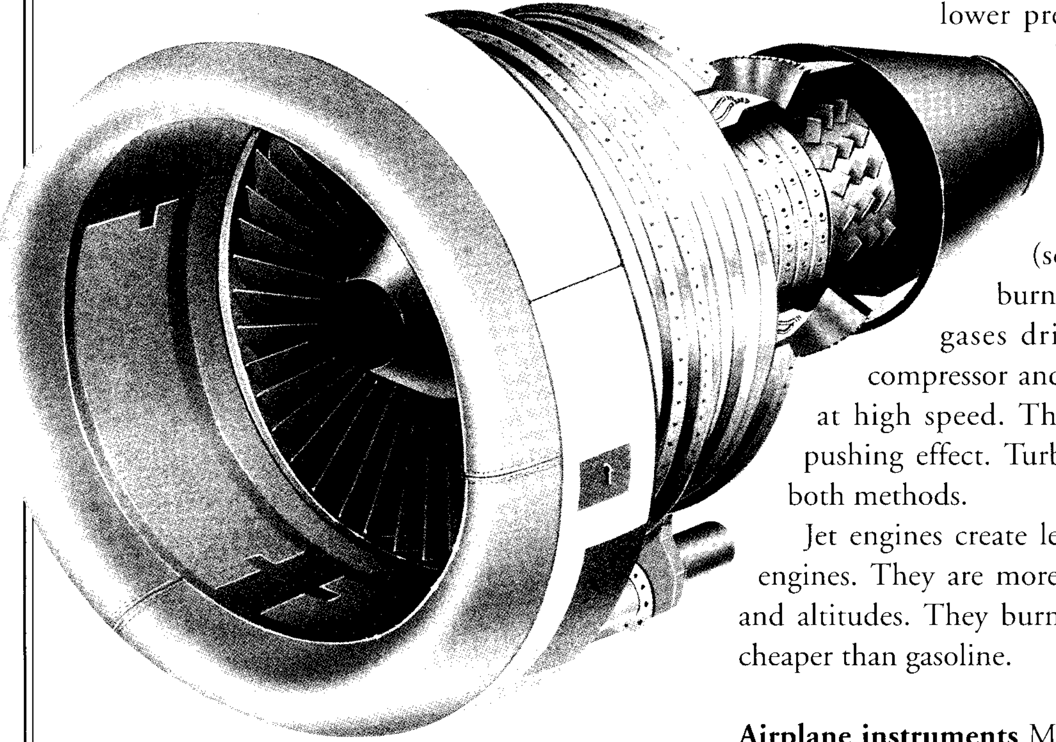
**Airplane parts** The body of an airplane, which contains the pilot cockpit and the passenger compartment, is called the fuselage. The wings and tail are attached to it. The engine, or engines, may be mounted on the fuselage or wings. Sometimes they are attached beneath the wings on finlike devices called pylons. The landing gear consists of heavy wheels with shock-absorbing supports. The landing gear is folded up into the plane during flight to reduce air resistance, which would slow the plane. Small private planes often have landing gear that cannot be moved.

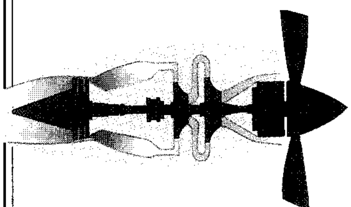
The tail surfaces at the rear of the plane and the wings have movable parts that control the forces on the airplane and the direction of flight. The vertical part of the tail is called the tailfin, and the movable part of the tailfin is called the rudder. The horizontal parts, which are like small wings, are called the tailplanes. The movable parts of the tailplanes are called elevators. Movable parts on the wings include the ailerons. Flaps can be lowered to reduce speed and to increase lift. Spoilers, airbrakes, and lift dumpers, on top of the wings, help reduce lift if required. All the movable parts are controlled by the pilot from the control center, or flight deck, of the plane.

Wing design varies. Low-speed planes need large, thick wings to achieve sufficient lift. High-speed planes require only small, thin wings. Wings project out at right angles to the fuselage in low-speed planes. They are swept back in a V shape in high-speed planes to reduce drag.

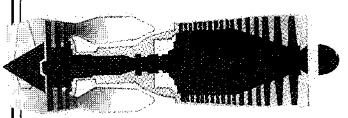
Large passenger planes contain seats for the passengers, kitchens for serving food, and toilets.

**ENGINES**
Airliners are powered by turbofan engines (below) because they are most efficient at high subsonic speeds.

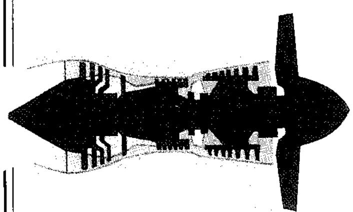




**TURBOPROP**
A turboprop is a gas turbine (jet engine) used to drive a propeller.



**TURBOJET**
The earliest jet engines were simple turbojets. They were noisy and inefficient at low flying speeds.



**TURBOFAN**
Turbofans accelerate some air rapidly through the hot core and the rest slowly around the outside.

Baggage is usually stored in spaces below the passenger cabin. The cabin and flight deck areas are pressurized (that is, the air pressure inside the aircraft is higher than it is outside) to allow people to breathe at the altitudes where planes fly (see AIR).

**Airplane engines** Gas turbine jet engines and piston engines that turn propellers are the two main sources of power for airplanes. Some jet engines also turn propellers. These are called turboprops. The propeller spins at high speed and creates a lower pressure in front of itself. This sucks the airplane forward. Gas turbine jet engines take in air at the front end, mix it with fuel, and compress (squeeze) it. The mixture burns, and the hot, expanded gases drive the turbine for the compressor and come out the back end at high speed. This provides thrust, or a pushing effect. Turboprop engines combine both methods.

Jet engines create less vibration than piston engines. They are more efficient at high speeds and altitudes. They burn kerosene, a fuel that is cheaper than gasoline.

**Airplane instruments** Modern airplanes are complicated machines. Pilots need many gauges and electronic aids to help fly them. The flight deck of a large passenger plane contains many indicator dials and warning lights. One of the most important instruments is the altimeter (see ALTIMETER). This tells the pilot how high the plane is off the ground. The air speed indicator measures the plane's speed. The artificial horizon shows the position of the plane relative to the horizon. The turn-and-bank indicator shows how much the plane is turning and tilting. In dense clouds and fog, a pilot would not always know which way the plane is heading if not for this instrument. A gyrocompass and various radio devices are necessary for navigation (see GYROSCOPE; NAVIGATION).

Most large planes also have an automatic pilot.

FLIGHT SIMULATORS

Flight simulators are an important training aid, since they can reproduce all the conditions of a real flight.

This is a device operated by a computer. It will fly the plane without the pilot's touching the controls. These autopilots can even control takeoffs and landings. The flight deck also contains many gauges and meters that tell the pilot whether the many pieces of equipment on the plane are operating properly. They measure fuel level, oil pressure, temperatures, thrust, cabin pressure, and electric current. Indicators show whether the landing gear is up or down. The radio equipment allows the pilot to talk to ground controllers and to receive navigation signals.

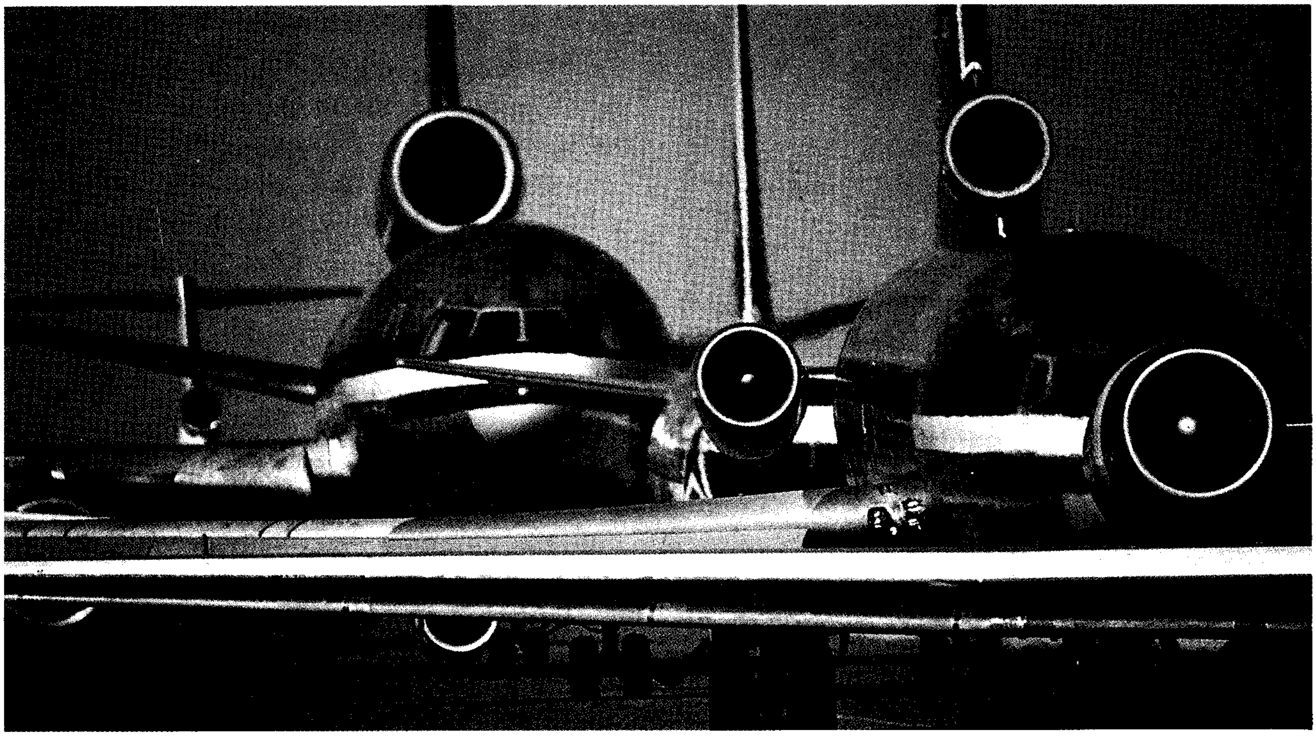
**Airplane construction** Early airplanes were made of wood frames covered by fabric and held in shape by wire. After World War I, airplane designers started to use lightweight metals such as aluminum, titanium, and magnesium alloys. A thin skin of metal was riveted into place over metal ribs. Strong epoxy glues are now used for some joints, instead of rivets. As planes grew in size, they became heavier. More powerful engines were developed in order to fly the heavier planes.

The use of metals brings with it a problem called metal fatigue. Stress and vibration in flight can cause metal parts eventually to break up. Airplanes must be constantly checked for signs of this trouble. Defective parts must be replaced by aircraft maintenance people. Designers test scale models in wind tunnels, before the full-sized planes are built. Reactions of the models to high-speed air streams give good indications how full-sized planes will react in flight. Computers are also used to predict how a plane will behave in flight. This approach helps save a great deal of money, and also helps make airplanes safer.

PROJECT 38

AIRCRAFT MANUFACTURE

The manufacture of today's advanced high-performance aircraft is complex and precise.



AIRPORT—Jets
Large jets taxi out to the runway at Dallas-Fort Worth International Airport.

**AIRPORT** An airport is a place where airplanes arrive and depart. Passengers leave and arrive on the airplanes, and cargo is loaded and unloaded. Large, jet-powered airplanes require long runways for takeoffs and landings. Big terminal buildings are necessary to handle thousands of passengers and their baggage. The largest airports cover thousands of acres. Hundreds of planes arrive and depart daily. All this traffic must be carefully controlled to avoid delays and accidents. This is done from the control tower. The tower stands high above the ground. Air-traffic controllers, inside the tower, must be able to guide airplanes through their takeoffs and landings.

Large airports are often like small cities. Many have post offices, banks, hotels, restaurants, offices, and many kinds of shops. Airports also have their own fire and police departments, fuel storage tanks, repair workshops, and storage hangars. Some companies even have their shipping warehouses located at airports.

O'Hare International Airport, in Chicago, Illinois, is the busiest airport in the world. It handles more than 800,000 takeoffs and landings and more than 60 million passengers a year.

Small airports that are used only by private airplanes usually cover 50 to 100 acres [20 to 40 hectares]. They do not need all the buildings and services of a large airport. The control tower may be just a small room in a building at ground level.

**Runways** Today's big jet planes weigh hundreds of tons. They move along runways at speeds of over 125 m.p.h. [200 kph]. When they land, they hit the runways hard. The runways take a great deal of pounding and must be made of concrete or asphalt. They must have a solid foundation and a surface that prevents skidding.

Airplanes take off into the wind in order to get better lift. They also land into the wind in order to have better control as they slow down (see AERODYNAMICS). Most airports have runways pointing in different directions. This means that there are always runways on which airplanes can face into the wind during takeoff and landing.

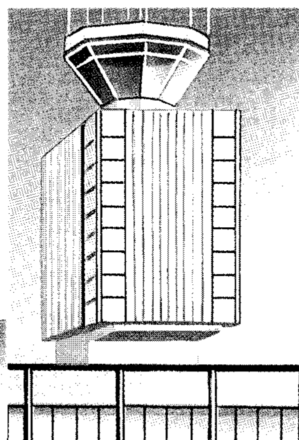
Runways at some large airports are longer than 10,000 ft. [3,000 m]. At night, lights lining the runways shine brightly so that pilots can find them easily. A system of guide lights is set up beyond the runway to help pilots land safely.

**Control towers** People called air-traffic controllers direct the movements of all planes on the ground and in the air by keeping track of them on large radar screens. Air-traffic controllers tell a pilot, by radio, when and where to taxi or pilot the plane down the runway. At busy hours, when many planes have to take off, as many as fifteen jets may have to wait in line to take their turn.

Electronic equipment is used to guide airplanes. Long-range radar is used to keep track of planes far away from the airport. This radar is called Ground-Controlled Approach (GCA). When the airplane gets within a few miles of the runway, the air-traffic controller begins to use Precision Approach Radar (PAR). This allows the controller to guide the airplane to within 0.25 miles [0.4 km] of the runway. At that point, the pilot completes the landing. Another electronic aid used in bad weather is the Instrument Landing System (ILS). In this system, radio transmitters located near the runway send guidance signals to the airplane. These tell the pilot how to steer the plane for the final approach to the runway. Today, there are also electronic microwave landing systems (MLS) that can land the plane fully automatically.

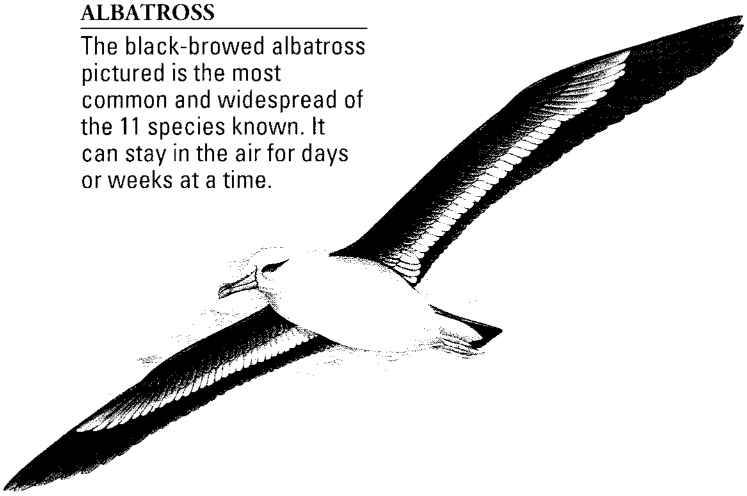
**Terminal buildings** Terminal buildings vary in size and shape. Most are quite large. Every passenger must pass through terminals. Long, covered walkways lead from the center of some terminals to the gates where airplanes are boarded. At some airports, buses are used to transport passengers to their airplanes. Passengers arriving from another country must pass through customs and passport control. Customs officials check the incoming baggage for taxable items. They also check to be sure no forbidden items are brought into the country. Passport officials check the passports of passengers for personal identification.

Passengers are forbidden to bring guns, knives, or other weapons onto a passenger airplane. Before boarding, they must walk through a detector that triggers a signal if they are carrying anything made of metal. Luggage is also examined for weapons.



**AIRPORT—Control tower**
The glass-walled visual control tower gives controllers a good view of aircraft movements at the airport (inset left).

**AIRPORT—Monitoring aircraft**
Aircraft movements are monitored from a room at the top of a control tower (below).



ALBATROSS
The black-browed albatross pictured is the most common and widespread of the 11 species known. It can stay in the air for days or weeks at a time.

**ALBATROSS** Albatrosses are large seabirds that belong to the family Diomedeidae. They are found mainly south of the equator. Albatrosses have a long, heavy beak and long, narrow wings that allow them to soar on the wind, seemingly without effort, for hours. The largest species is the wandering albatross, which has a wingspan of more than 11 ft. [3.4 m] and a body 4 ft. [1.2 m] long. Albatrosses have difficulty beginning each flight. They need wind and must run along the ground or paddle with their webbed feet across the water before they are able to stay in the air.

**ALBINO** (ăl bī′nō) An albino is an animal or plant that is unable to produce pigment (coloring matter) in its cells. Albinism is an inherited condition (see GENE; HEREDITY). Because many animals rely on pigment for protection from the sun and for protective coloration, albino animals are at a definite disadvantage in the wild (see PROTECTIVE COLORATION). Albino animals rarely survive long enough to reproduce.

There are albinos in almost every race of human beings. Many albinos are complete (or true) albinos. They have pinkish-white skin and white hair. Their eyes appear pink because of the color of the blood vessels at the back of the eyes. In a person with normal coloring, the pigment of the iris (usually brown or blue) blocks out the color of the blood vessels (see EYE AND VISION). Because other, light-absorbing pigments are also lacking in the skin, an albino is extremely sensitive to bright light, such as sunlight.

Some people are partial albinos and lack pigment in some, but not all, tissues and organs. Some animals are also partial albinos. Some, though not all, plants with white flowers are partial albinos. A complete albino plant lacks even the green pigment chlorophyll. As a result, it is unable to photosynthesize, and dies shortly after food supplies in the seed are used up (see CHLOROPHYLL; PHOTOSYNTHESIS).
*See also* GENETICS; METABOLISM; PIGMENTATION.

ALBINO
An albino animal cannot produce pigment in its cells. This albino rabbit has white fur, white skin, and pink eyes.

**ALCHEMY** (ăl′kə mē) Alchemy was an early form of chemistry. It was widely practiced during the Middle Ages. It developed from the ideas of ancient philosophers, such as Aristotle.

An alchemist used chemicals to try to change one thing into another. Alchemists thought that some metals were more "perfect" than others. They considered gold to be the most perfect metal of all. They tried to discover a substance that would make metals more and more perfect. They hoped that the metal would then turn into gold. They called the substance that would do this the philosopher's stone. They thought that if they took the philosopher's stone themselves, they would become better people. They also tried to discover the elixir of life. This was a medicine that was supposed to make people live forever.

Alchemy was related to religion, magic, and astrology (see ASTROLOGY). The sun, moon, and planets were linked with different metals. For example, alchemists linked gold with the sun and silver with the moon. People lost faith in alchemy in the 1600s. It is now thought to be unscientific. However, the alchemist's methods of heating and mixing substances led to modern chemistry.

**ALCOHOL** Alcohol in its most common form is a clear, colorless liquid. It burns and evaporates easily. It has a burning taste. Alcohols are made from chemicals found in living things. They all have hydroxyl (OH) groups that are connected to carbon atoms.

The simplest alcohol is methanol, or methyl alcohol. This poisonous substance is commonly called wood alcohol. It once was produced from wood but now is produced mostly from methane (see METHANE). Its molecules consist of a methyl group ($CH_3$) connected to a hydroxyl group (OH). Its formula is $CH_3OH$. Ethanol, or ethyl alcohol, is commonly called grain alcohol. Its formula is $C_2H_5OH$.

Ethyl alcohol is used in alcoholic beverages, such as beer, wine, and liquor. The alcohol used in such beverages is produced by fermenting grains, such as barley, corn, and rye; fruit such as grapes; or vegetables such as potatoes. Ethyl alcohol is also used in stains, lacquers, and varnishes; as a solvent; and as a source of other chemicals. Sometimes, ethyl alcohol is combined with gasoline to make a fuel called gasohol. Methyl alcohol also may be used to make gasohol (see GASOLINE). Most methyl alcohol is converted to formaldehyde, a chemical used in making plastics. Methyl alcohol is also used as an antifreeze and in the making of paints and varnishes. It is used in combination with other chemicals as well.

Other kinds of alcohols include isopropyl, glycol, and glycerol. Isopropyl alcohol is used in producing acetone (an industrial solvent), in the making of cosmetics, and also as a rubbing alcohol. Glycol is used as antifreeze. Glycerol, or glycerin, is used as a softener in foods. It is also used in cosmetics, in medicines, and in nitroglycerin, an explosive used in making gunpowder and dynamite.

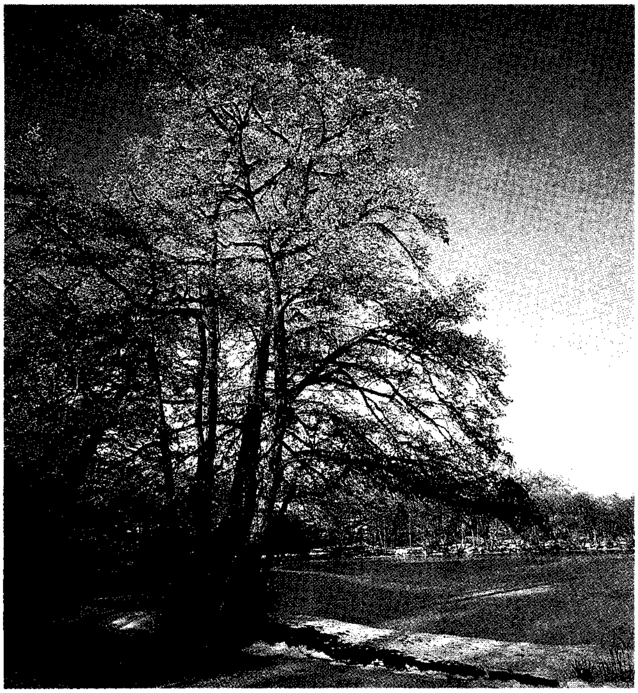
**ALCOHOLISM** Alcoholism is often viewed as a disease having to do with the overuse of alcoholic drinks. Such drinks include whiskey, gin, rum, vodka, bourbon, wine, and beer.

Some people can drink alcoholic beverages without serious harm. Other people become addicted to them. These people are called alcoholics. They depend on alcohol to help them ignore problems they cannot solve. They use alcohol in order to relax. If they do not have alcohol regularly, they may experience withdrawal symptoms. Withdrawal symptoms occur because, over time, the alcohol becomes necessary for the body's chemical processes to work. Withdrawal symptoms vary. Alcoholics may feel weak and tired. They may shake and perspire freely. Sometimes they vomit, run a fever, or hallucinate, seeing things that do not really exist. There are more than ten million alcoholics in the United States, making alcoholism one of the major diseases in the country. Alcoholism can help lead to diseases of the circulatory system, nervous system, liver, pancreas, stomach, and immune system. Many alcoholics are undernourished. Pregnant women who use too much alcohol may give birth to babies who have birth defects.

Alcohol acts as a depressant. A depressant dulls the parts of the brain that control speech, the emotions, judgment, and bodily movement. Because alcohol can blur the vision and slow the reflexes, people who have been drinking should not drive. The National Safety Council says that about half the drivers involved in accidents in which people are killed have been drinking.

One organization that has been set up to help alcoholics is called Alcoholics Anonymous, or A.A. People at an A.A. meeting discuss their drinking problems with each other. They give each other support in trying to overcome the disease. Sometimes, a drug such as Antabuse is used to help a person stop drinking. Antabuse reacts to alcohol in such a way that a person taking a drink with alcohol in it feels very uncomfortable. That person's discomfort helps him or her refuse any more alcoholic drinks.

*See also* ADDICTION.



ALDER
The alder provides food and cover for many small animals that live near streams and rivers.

**ALDER** Alders are trees or bushes belonging to the birch family, Betulaceae. They have oval, toothed leaves. Most alders are found in the Northern Hemisphere, but a few species grow in South America. The best-known species is the black alder of Europe.

The wood of the alder, which is soft, is used in making furniture. Alders commonly grow along stream banks. They are valuable in preventing erosion and for providing food and cover for wildlife.
*See also* BIRCH.

**ALEWIFE** The alewife is a silvery fish belonging to the herring family, Clupeidae. Alewives are found along the east coast of North America, from Florida to Quebec. These fish are usually anadromous. This means that they live their adult lives in the oceans but return to freshwater rivers to spawn, or lay eggs. Many die after this spawning. Alewives also live in the Great Lakes. Anadromous alewives are 10 to 12 in. [25 to 30 cm] long, while freshwater alewives are only 3 to 6 in. [8 to 15 cm] long. Both kinds have a thin body with a deeply forked tail.

Alewives have not always been found in the Great Lakes. When canals were built connecting the lakes with the St. Lawrence and Hudson rivers, alewives entered the lakes and were unable to return to the sea.

Alewives are caught in nets and are used as bait, fertilizer, and pet food. They also are salted, pickled, or smoked to be eaten by people.

**ALFALFA** Alfalfa, also known as lucerne, is a plant that is a member of the pea family, Leguminosae (see PEA FAMILY). It grows from 1 to 3 ft. [0.3 to 0.9 m] tall and has purple flowers. Like other legumes, alfalfa is able to absorb nitrogen from the air and put it into the soil. It is able to do this because of a bacterium that grows on its roots. Called nitrogen fixation, this process is important because nitrogen is a valuable plant nutrient that is quickly taken from the soil by other crops. Farmers plant alfalfa in fields to restore nitrogen to the soil. This helps reduce the amount of nitrogen-containing fertilizer needed.

Alfalfa is high in protein and vitamins, making it an excellent food for animals. It tolerates heat, cold, and drought. Alfalfa originally came from Asia but is now planted around the world.
*See also* NITROGEN CYCLE; NITROGEN FIXATION.

ALFALFA
Alfalfa roots contain bacteria that take nitrogen from the air and attach it to other elements in the soil. The nitrates that result are easier for other plants to use than pure nitrogen.

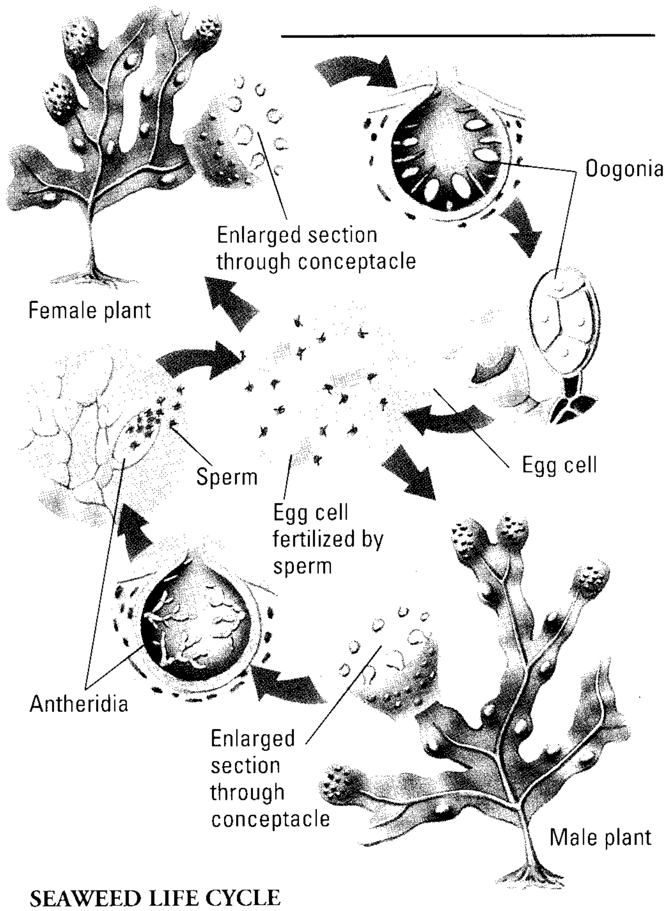
Algae (ăl′ jē) are simple organisms. Most algae belong to kingdom Protista. Blue-green algae belong to kingdom Monera. The illustration (see page 58) shows the major algae groups. Although many of the algae are one-celled organisms, others are made up of many cells and have rootlike structures. Such algae may grow over 200 ft. [60 m] long. Algae produce food by photosynthesis (see PHOTOSYNTHESIS). They reproduce in different ways: asexually and sexually. The one-celled algae reproduce asexually by dividing into two identical cells. Sexual reproduction involves sex cells (see REPRODUCTION).

Most algae live in the water in oceans, rivers, lakes, and ponds. Some can live in moist places on land. Algae are found on the ice in polar regions. Some are found in the hot springs at Yellowstone National Park in the western United States. These springs are nearly 187°F [88°C]. The best-known kinds of algae are probably the seaweeds found at beaches.

Algae are important because they are the beginning of some food chains that provide food for animals. Many fish depend directly or indirectly on algae for their food. People eat the fish. People also use algae directly. Many people, especially in Asia, eat certain kinds of algae, such as dulse, nori, and Irish moss. In addition, algae are used in making certain cosmetic products and such foods as ice cream, puddings, and gelatin. Diatomite, a material produced from fossilized diatom deposits, is used in such items as swimming pool filters, insulation, and scouring powder. In sewage-treatment plants, algae are used to help break down sewage into harmless chemicals.

Algae can be harmful to people when the organisms are present in great numbers. Several species of red dinoflagellates produce a poison that can paralyze a person. When a clam eats the algae, it collects this poison in its tissues. If a person then eats the clam, he or she will be poisoned. The red algae sometimes grow in large colonies. These colonies turn the water red.

*See also* AGAR; DIATOM; MONERA; PROTISTA; SEAWEED.




**SEAWEED LIFE CYCLE**

Algae such as bladderwrack have separate male and female plants. The sperm and eggs are produced in structures called conceptacles. Fertilization produces a zygote, from which a new plant develops.

**ALGAL BLOOM**

The millions of microscopic algae in this lake have given the water its green, soupy appearance.

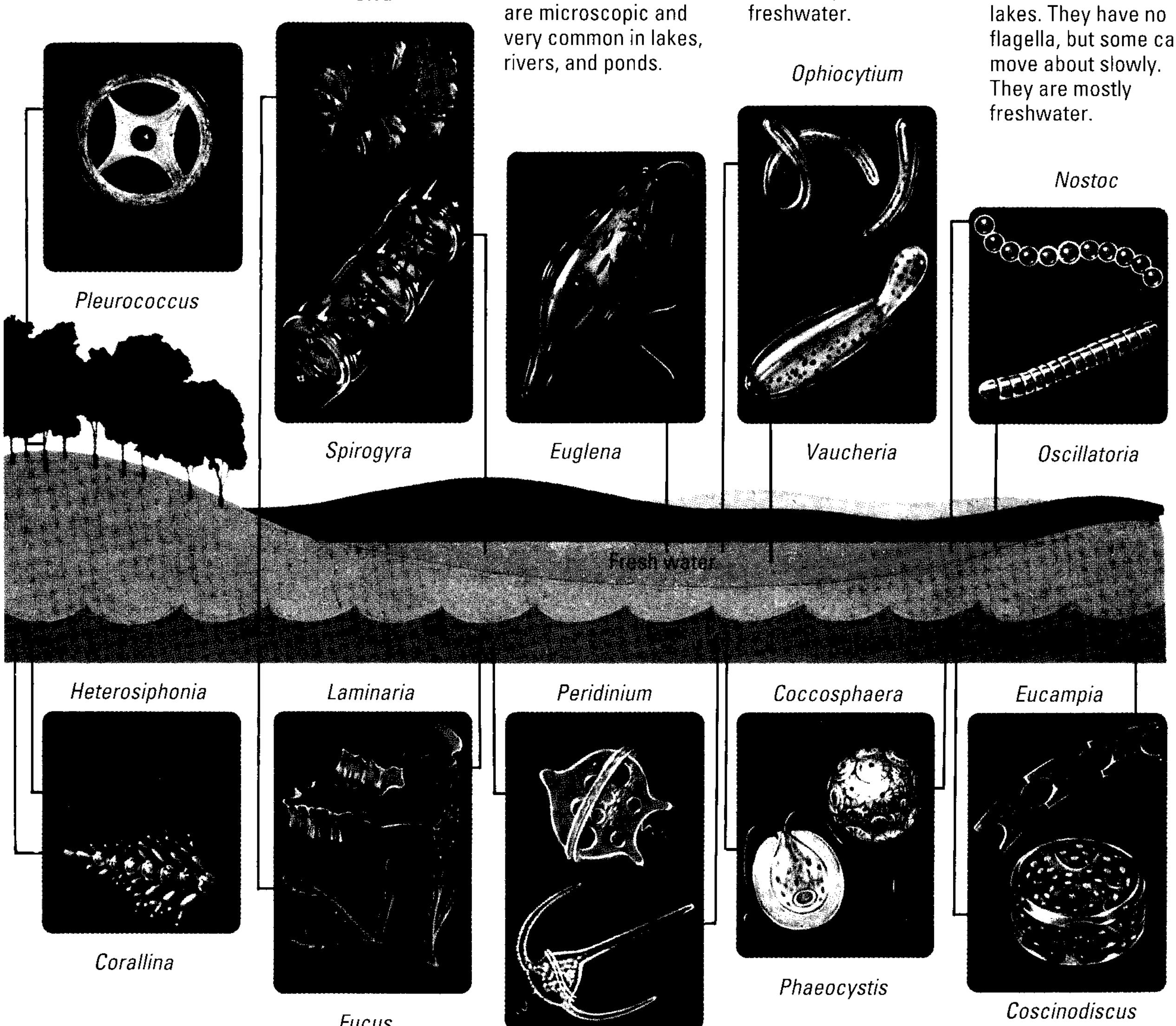
## THE MAIN GROUPS OF ALGAE AND WHERE THEY ARE FOUND

**Green algae** *(Chlorophyta)*
are a varied group that commonly cause scums on ponds. Nearly all the alga forms occur. The examples shown include a single-cell, *Pleurococcus*, which grows on tree trunks; a filament (series of cells arranged in a threadlike way), *Spirogyra*, which is a freshwater alga; and a multicelled flat sheet, *Ulva*, which is a seashore alga, a few inches long. Most green algae are freshwater and microscopic.

**Euglenoids**
*(Euglenophyta)*
are single-celled forms only. They have a flagellum (taillike structure), rooted in a front pocket, and lack a cell wall, which distinguishes them from green algae. All are microscopic and very common in lakes, rivers, and ponds.

**Yellow-green algae**
*(Xanthophyta)*
do not store starch in their cells, which distinguishes them from green algae. Single-celled and tube forms occur, which are mostly microscopic and freshwater.

**Blue-green algae**
*(Cyanophyta)*
are more closely related to the bacteria than to other algae. There are single-celled and filament forms. They are all microscopic but can be seen as "blooms" on lakes. They have no flagella, but some can move about slowly. They are mostly freshwater.




**Red seaweeds**
*(Rhodophyta)*
Often a foot or more in length, most red algae are many-celled and branched or blade shaped. Their sex cells, unlike those of the brown seaweed, have no flagella. They have a pigment (coloring substance) that allows them to grow at deeper levels than other algae. Most live in the sea.

**Brown seaweeds**
*(Phaeophyta)*
These include the largest algae—some are over 200 ft. [60 m] long. Adults are made up of millions of cells, but the sex cells are microscopic and flagellated, like the adult cells of some other algae. Most live in the sea.

**Dinoflagellates**
*(Pyrrophyta)*
These often cause phosphorescence in seawater. All are microscopic, single-celled or colonial, with two flagella. Most live in the sea.

**Golden Algae**
*(Chrysophyta)*
A rather mixed group of microscopic, very delicate algae. Single-celled, colonial, and filament forms are found in plankton and in cold fresh water. The very tiny Coccolithophores are marine algae covered with round chalky plates. Many chalk cliffs are made from their bodies.

**Diatoms**
*(Bacillariophyta)*
Diatoms have hard, sculptured cell walls containing silica. All are microscopic and single-celled or colonial. They have no flagella but can move about slowly. They are common in the sea and in fresh water.

# ALGEBRA

Algebra is a branch of mathematics that uses symbols such as letters to stand for numbers, sets of numbers, and values of many kinds. Algebra uses equations in solving problems. The word *algebra* comes from the Arabic word *al-jebr*. The Arab mathematician al–Khowarizmi named one of his books *Al-jebr* in the ninth century. The word referred to topics dealing with equations.

One of the rules in arithmetic is $2 + 3 = 3 + 2$. This is an example of the general fact that when any two numbers are added together in any order, the answer is the same. This same statement in algebra could be written $x + y = y + x$. The letters $x$ and $y$ stand for any two numbers.

For addition and subtraction in algebra, the signs + and - are used. To show that one number is to be multiplied by another, the sign X is used, or the two numbers or symbols are written next to each other. Sometimes a dot is written between the numbers or symbols. $2x$ means 2 multiplied by $x$ (or $x$ multiplied by 2). A simple way of showing $x$ multiplied by $x$ is to use an exponent. For example, $xx$ is written $x^2$. The number 2 above and to the right of the $x$ is called the exponent. Exponents are used to show that a number is multiplied by itself many times. $5^6$ means $5 \times 5 \times 5 \times 5 \times 5 \times 5$.

Using the above rules, symbols can be combined to form algebraic expressions. The expression $x^2 + 3x - 5$ may have different values, depending on the value of $x$. If $x$ equals 2 this algebraic expression can be simplified as:

$$2^2 + (3 \times 2) - 5$$

The parts of this expression have these values:

$$2^2 = 2 \times 2 = 4$$
$$3 \times 2 = 6$$

So the whole expression has the value

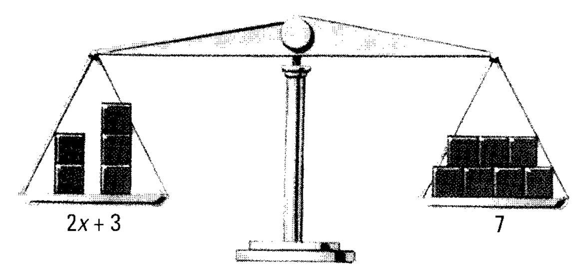
$$4 + 6 - 5$$

Therefore, the expression means $4 + 6 - 5$ and the answer is 5. It makes no difference if 4 is added to 6 before or after subtracting 5. The calculation may be $10 - 5$ or $4 + 1$. The answer is still 5.

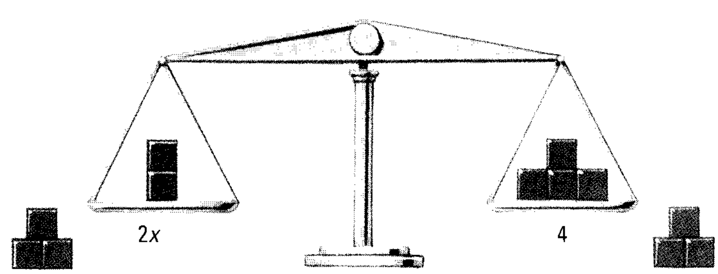
Algebraic expressions are used to solve many kinds of problems. For example, the statement "the sum of two numbers is ten" may be written $x + y = 10$. The letters $x$ and $y$ stand for any two numbers.

Once you have an equation, the next step is to find out when it is true. An equation is usually true only for certain values of the unknown quantity. For example, the equation $2x = 10$ is a true statement only if $x = 5$. The value of $x$ for which the statement is true is called the solution of the equation.

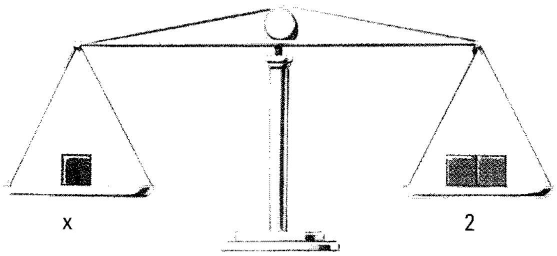
To find the solutions of some equations, the equation should be thought of as a balance. Whatever is done to one side of the equation must be done to the other side. To solve the equation $2x + 3 = 7$, the diagram shows the $2x + 3$ in the left-hand pan balanced by the 7 in the right-hand pan.




Subtracting 3 from both sides of the equation, the equation becomes $2x = 4$. The pans still balance.



Dividing both sides of the equation by 2, the equation becomes $x = 2$. The solution of the equation is $x = 2$.




Equations with two unknown quantities are more difficult problems. For instance, an equation might need two numbers that add up to 10. If the two numbers are written as $x$ and $y$, we can write the expression as $x + y = 10$. If $x = y$, then there is only one solution: $x$ and $y$ must each equal 5. If $x$ is not equal to $y$ (this is written as $x \neq y$), there are many solutions for $x + y = 10$. Some solutions could be $x = 1$, $y = 9$; or $x = 2$, $y = 8$; or $x = 3$, $y = 7$. This type of equation is called indeterminate.

Another equation might be $x - y = 2$. This equation has many possible solutions, such as $x = 4, y = 2$; or $x = 7, y = 5$; and so on. If the equations $x + y = 10$ and $x - y = 2$ are put together, there is only one set of values of $x$ and $y$ that can satisfy both of them. The solution is $x = 6$ and $y = 4$.

Using a graph is one way to find the solution. The values of $x$ are shown on the numbered line going from left to right across the page. This is called the $x$-axis. The values of $y$ go up and down on the other numbered line. This is the $y$-axis. Some of the solutions of the equation $x + y = 10$ are:

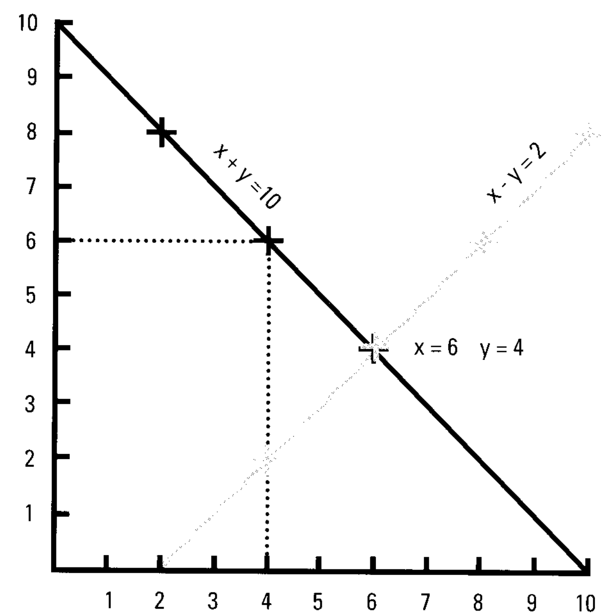
$$x = 0, y = 10$$
$$x = 2, y = 8$$
$$x = 4, y = 6.$$

These solutions are marked by the points in red. For example, the point showing the solution $x = 4, y = 6$, is found by moving 4 units across the $x$-axis and then by moving 6 units up the $y$-axis.

Some solutions of the equation $x - y = 2$ are:

$$x = 10, y = 8$$
$$x = 8, y = 6$$
$$x = 6, y = 4.$$

These solutions are marked by the green points. By connecting the two sets of points, you get two straight lines. These lines are the graphs of the two equations. (The word *graph* is also often used to mean the whole diagram, including the lines, the $x$-axis and $y$-axis, and the area around them.) The point at which the lines cross marks the solution of both equations, $x + y = 10$ and $x - y = 2$.



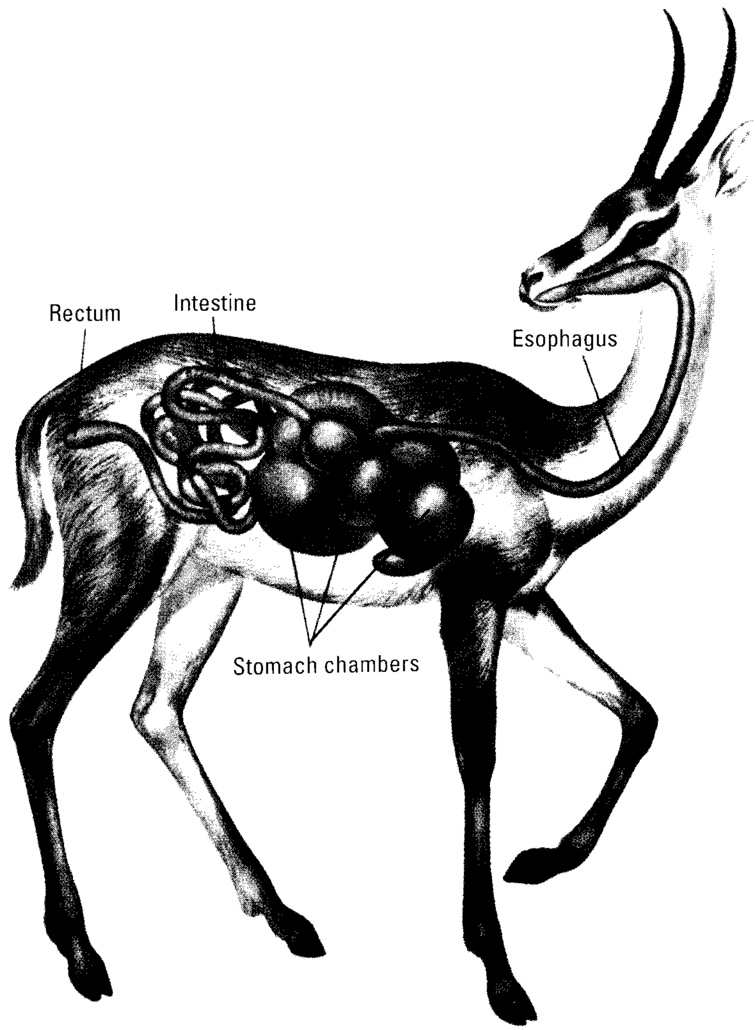

The solutions of equations do not always have graphs that are straight lines. Equations can be written that produce circles, squares, and more complicated shapes. Graphs are a useful aid to thinking about algebra, but for accurate work, mathematicians prefer to use the equations themselves.

Computers and pocket calculators can do ordinary arithmetic extremely fast and accurately. Some calculators, and any computer that is running a suitable program, can solve equations as well.

Mathematics includes many different kinds of algebra to solve different kinds of problems. Algebra is used to solve problems in chemistry, physics, and engineering.

ALIMENTARY CANAL

The alimentary canal of an animal is the long tube through which food passes and in which food is digested. All higher animals have an alimentary canal that consists of at least an esophagus, a stomach, an intestine, and a rectum. Animals that eat only plants, which contain a great deal of cellulose, need extra stomach compartments to digest this material. The plant-eating gazelle (pictured) has multiple stomach chambers. Some of these chambers contain bacteria that assist in the digestion of cellulose.




**ALIMENTARY CANAL** The alimentary canal is also called the digestive or gastrointestinal tract. It is a long tube within the body of an animal. It usually begins at the mouth and ends at the anus. Some simple animals, such as the Cnidarians, have only one opening.

Food passes through the alimentary canal to be digested and absorbed into the body tissues. Undigested food and wastes are expelled through the anus.

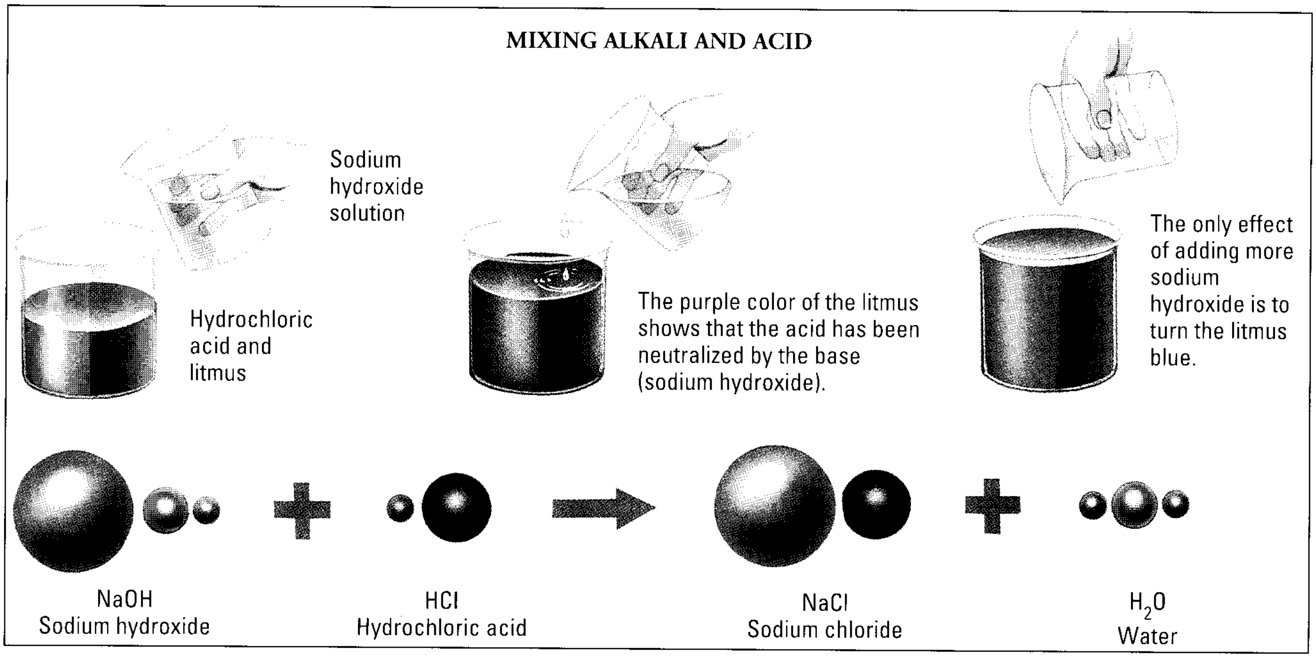
*See also* ANUS; DIGESTIVE SYSTEM; ESOPHAGUS; INTESTINE; STOMACH.

**ALKALI** (ăl′kə lī′) An alkali is a base that dissolves easily in water. A solution of a strong alkali has a soapy feeling and a bitter taste. The solution can corrode other substances. It must always be handled extremely carefully to avoid burning.

Using an indicator is one way of telling whether a solution is alkaline. Red litmus paper will turn blue in an alkali solution.

If an acid and an alkali are mixed in water, a salt is formed. When dry, solid acids and dry alkalis are mixed, no neutralizing chemical change occurs. Ordinary baking powder is a mixture of dry acid and dry, alkaline salt.

Strong alkalis are used as cleaning substances. They are also used in the making of soap. The best known strong alkalis are sodium hydroxide ($NaOH$), also called caustic soda, and potassium hydroxide ($KOH$), known as caustic potash. Potassium hydroxide is used mainly in the making of soap and in medicine. Sodium hydroxide is used in the manufacture of other chemicals,




**ALKALI**

The diagram above shows what happens when an alkali and acid interact chemically. Sodium hydroxide is a strong alkali. When a water solution of sodium hydroxide is mixed with hydrochloric acid, a neutral salt, sodium chloride, is formed. The litmus indicator is red in acid and blue in alkali.

rayon, film, and soap. It is also used in medicine.

*See also* ACID; BASE.

PROJECT 1

**ALKALI METAL** The alkali metals are a group of six elements: lithium (Li), sodium (Na), potassium (K), rubidium (Rb), cesium (Cs), and francium (Fr). These metals are so reactive that they are not found in nature. They are found only as ions in different chemicals (see IONS AND IONIZATION).

Alkali metals have a silvery shine. Each is a good conductor of electricity and heat, and is easily molded or shaped. These metals are soft. They can be cut with a knife. The alkali metals are difficult to handle and store because of the chemical reactivity. They are often stored under kerosene or some other liquid. They react violently with water, giving off hydrogen gas and forming bases. All the alkali metals have a valence of one. This means that they gain or share one electron in bonding with other atoms.

*See also* ALKALI; BASE; ELEMENT; VALENCE.

**ALKALINE EARTH METAL** The alkaline earth metals are a group of six elements: beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), barium (Ba), and radium (Ra). They are usually found in the earth. The alkaline earth metals are harder and have higher melting points and boiling points than the alkali metals (see ALKALI METAL). The alkaline earth metals react with water, giving off hydrogen gas and forming bases. They do not react as rapidly as the alkali metals. All the alkaline earth metals have a valence of two. This means that they gain or share two electrons in bonding with other atoms.

*See also* ALKALI; BASE; ELEMENT; VALENCE.

**ALKALOID** An alkaloid is an organic compound containing carbon (C), hydrogen (H), and nitrogen (N). Alkaloids are made by plants as waste products. They possibly help plants to deter grazing and browsing animals. Alkaloids are solids that appear as crystals, except for coniine, found in hemlock, and nicotine, found in tobacco. Both of these alkaloids are liquids. Alkaloids dissolve in alcohol, but not in water. Alkaloids often have harsh effects on animals, including humans.

Some alkaloids, such as coniine, are deadly poisons. Strychnine, which comes from various trees, causes muscles to shake and tighten. Curare, a mixture of alkaloids, also comes from trees. Curare was first used by natives in South America. They dipped their arrowheads in it so that animals died when wounded. Also known as arrow poison, curare relaxes muscles. It is sometimes used in surgery for this purpose.

Alkaloids have been used to kill insects. Small doses of belladonna were once used by women to improve their beauty. The drug makes the pupils of the eyes larger. Morphine, from the opium plant, and cocaine, from the coca plant, were once widely used as anesthetics. They are now seldom used for this purpose because they are addictive. Quinine, from the bark of the cinchona, was used to fight the disease malaria. Caffeine is an alkaloid in coffee, tea, and other substances. Theobromine occurs in cocoa.

**ALLELE** (ə lēl′) Alleles are alternative versions of the same gene. In most human cells there are two sets of matching chromosomes, one set originating from each parent. On any corresponding pair of chromosomes, the alleles of a particular gene are always found in the same place, or locus. Each allele can have a different effect on the appearance of the individual. For example, in the gene locus that controls eye color, one allele may produce blue eyes and one may produce brown. In most cases, only one of the alleles on a matching pair of chromosomes has an effect on the individual's characteristics. It is said to be dominant over the other allele, which is described as recessive. The recessive allele only shows itself when it is partnered by another recessive allele at the same locus on the matching chromosome.
*See also* CHROMOSOME; GENETICS.

**ALLERGY** An allergy is an abnormal sensitivity of the body to certain substances. For most people, these substances are harmless. Some things to which a person may be allergic are fur, feathers, dust, pollen from plants, certain foods, some medicines, and bee stings. Substances to which people are allergic are called allergens. One person may be allergic to feathers, but another person may not be. Feathers are an allergen only to the first person.

When an allergic person comes near an allergen, he or she may react by sneezing, coughing, or even vomiting. His or her eyes may water or redden.

ALLERGY
Many people are allergic to ragweed. Contact with pollen in the air can cause sneezing, itching, and watering eyes.

The person may break out in a rash or hives, which are spots of fluid in the skin. Some people have serious allergic reactions in which they have trouble breathing. Some allergic reactions last for a few hours. Some last several days. Several common disorders, partly or wholly caused by allergens, are asthma, eczema, and hay fever. Sensitivity to allergens may be inherited.

During an allergic reaction, several parts of the body's immune system are activated by and help attack the allergen. Immune cells called lymphocytes produce large numbers of proteins called antibodies. Antibodies combine with the allergen to cause the release of certain substances from the body cells into the blood and other body fluids. These substances, called H-substances, bring about various reactions. These reactions include attracting additional immune cells (more lymphocytes as well as other cells), causing blood vessels to dilate (widen), and causing fluid to build up in the area. Some of the lymphocytes attack the allergen directly without making antibodies. The result of all these actions is the so-called inflammatory response, which is responsible for the symptoms—such as sneezing or a rash—mentioned above.

The main H-substance is called histamine. Antihistamines are drugs that reduce the effects of histamines. For example, antihistamines can reduce sneezing and help control the itching of a rash. Another helpful treatment is desensitization, in which increasing amounts of the allergen are injected over a considerable time, until the sufferer no longer experiences the allergic reaction.

Some people have antibodies that react to penicillin, a drug that is helpful to most people. The reaction to a dose of penicillin may be fatal to a person with an allergy to it. Such a reaction is called anaphylactic shock.

*See also* ANTIBODY; ANTIHISTAMINE; ASTHMA; ECZEMA; IMMUNITY.

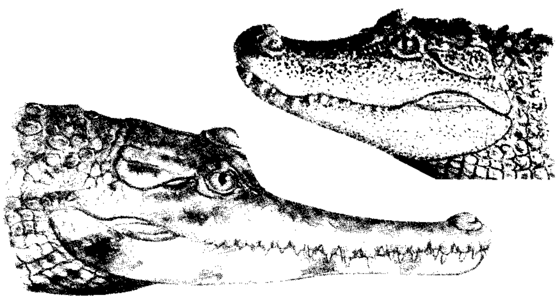
**ALLIGATOR** Alligators are reptiles that are related to crocodiles (see CROCODILE). The largest species is the American alligator, which grows to 19 ft. [5.7 m] long. It is found only in the southeastern United States. A smaller species, the Chinese alligator, grows to 6 ft. [1.8 m] long and is found along the Chang Jiang (Yangtse River) in China. All species of alligators live in warm climates.

Alligators live near water where they eat fish, frogs, birds, and other animals. Very large adults can eat a deer, or, very rarely, a human. Alligators have large mouths and many sharp teeth. They make nests at the edge of water and lay twenty to seventy eggs during the summer.

Alligator meat has become increasingly popular for human consumption, especially in such states as Louisiana and Florida. The meat comes primarily from the alligator's tail.

Alligators are very similar to crocodiles. Crocodiles have pointed noses, while alligators have blunt noses.

*See also* REPTILE.

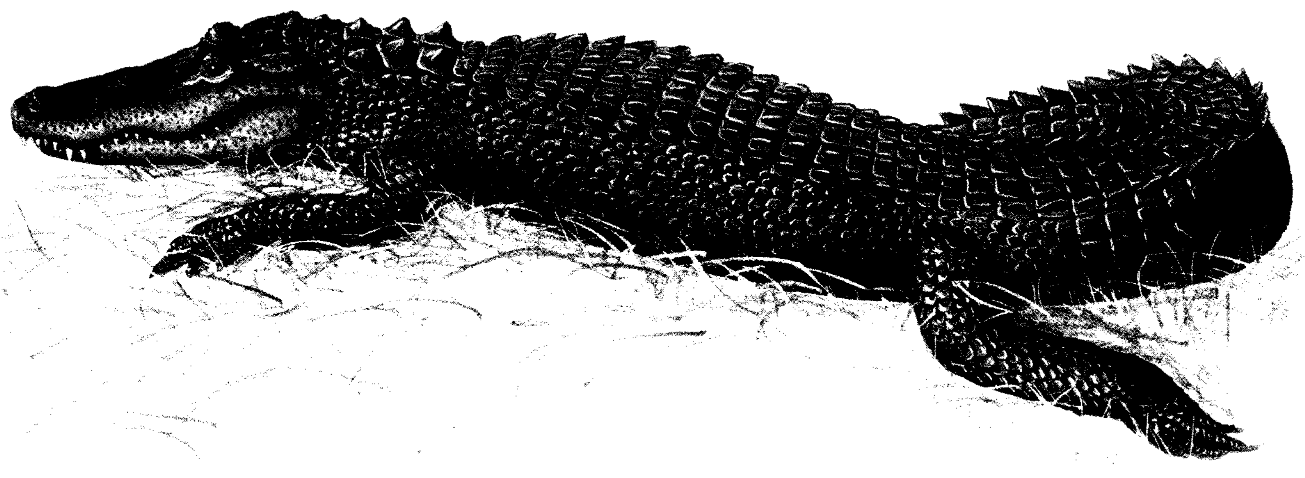


**ALLIGATOR**

Alligators (top) have blunt noses, whereas crocodiles (above) have pointed noses. The American alligator (below) occurs in wet habitats in the southeastern United States.

**ALLOY** Most alloys are a mixture of two or more metals. The metals are combined by heating them until they become liquid. An alloy is made when the metals remain evenly mixed after cooling and become solid.

Metals in their pure form are often too weak for most uses. They can be improved by mixing one or more other metals with them to form alloys. For example, pure aluminum is light, but weak. When copper and magnesium are added to it, the aluminum alloy becomes stronger. Copper and tin are soft and weak. Mixed together in an alloy, they form the harder, stronger bronze. Brass, a mixture of copper and zinc, is another strong

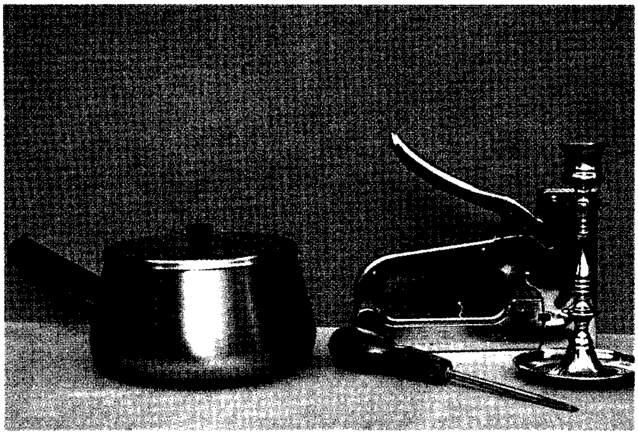


## SOME IMPORTANT ALLOYS

| Ferrous alloys (mainly iron) | Major properties | Major uses | Typical amounts of elements other than iron |
|---|---|---|---|
| High-alloy steels and stainless steels | Very hard, strong steels, often resistant to corrosion. | Tools to cut and drill other metals, and high-strength metal parts. Stainless steels are often used for cutlery. | 0.1-2.0% carbon, up to 27% chromium or 20% tungsten or 15% nickel, and lesser amounts of vanadium, cobalt, molybdenum, zirconium, or tantalum. |
| Mild steels | Hard, strong, workable steels, more resistant to corrosion than pure iron. | Steel constructions other than those above. Widely used for automobiles and ships. | 0.1-1.5% carbon, very small amounts of other elements. |
| Cast iron | Hard but brittle. | Widely used in early industrial times. | 2-3% carbon, a few percent silicon and other elements. |

| Nonferrous alloys (little or no iron) | Major properties | Major uses | Typical amounts of elements |
|---|---|---|---|
| Aluminum alloys | Fairly hard and strong, very light alloys, often with good corrosion resistance and good electrical conductivity. | Tubes for boilers, automobile bodies, buildings, food equipment, foil kitchenware, electric cables, nuts, bolts, ships' tubes and sheets. Widely used when lightness plus strength is required. | 85-98% aluminum, alloyed with varying amounts of chromium, copper, magnesium, manganese, or silicon. |
| Aluminum bronze | Tough, but workable, and resistant to corrosion by seawater. | Nuts, bolts, ships' tubes and sheets. | 92% copper, 8% aluminum. |
| Manganese bronze | Very good resistance to wear. | Automobile clutch disks, valves. | 58.5% copper, 39% zinc, 1.5% iron, 1% tin. |
| Phosphor bronze | Strong, fairly corrosion resistant, good electrical conductivity. | Chemical equipment, electric motor brushes. | 95% copper, 5% tin, trace level of phosphorus. |
| Bronze | Resistant to corrosion by seawater. | Superstructure and other parts on ships. | 90% copper, 10% zinc. |
| Naval brass | Fairly strong and workable. Attractive yellow color. | Portholes and other parts on ships. | 60% copper, 39% zinc, 0.75% tin, 0.25% lead. |
| Red brass | Workable, fairly resistant to corrosion. | Plumbing for houses (but plastics often replace it). | 85% copper, 15% zinc. |
| Copper-nickel alloys | Hard, heat and corrosion resistant. | Chemical equipment. | Up to 85% copper, up to 30% nickel, sometimes with small amounts of iron and manganese. |
| Nickel-copper alloys | Hard, resistant to many acids and bases. | Chemical equipment. | About 31% copper, 64% nickel, small amounts of carbon, iron, manganese, and silicon. |
| Nickel-chromium alloys | Very resistant to heat. Good resistance to corrosion. | Airplane exhausts, food and dairy equipment. | About 68% nickel, 15% chromium, 9% iron, small amounts of carbon, copper, manganese, silicon, and tellurium. |
| Nickel-molybdenum alloys | Extremely good heat resistance. Good resistance to corrosion. | Jet airplane engines, missiles, furnaces. | Molybdenum with up to 70% nickel, or up to 30% copper, sometimes with small amounts of other elements. |
| Lead alloys | Soft, but antimony lead is harder. Good acid resistance (not oxidizing acids). | House roofs and acid equipment. Antimony lead is used for storage battery grids. | 94-99.7% lead, up to 6% antimony. |
| Pewter | Attractive shiny gray color. | Drinking mugs and ornamental objects. | 91% lead, 7% antimony, 2% copper. |
| White metal | A fairly soft alloy. | Bearings for motors. | 92% tin, 8% antimony. |
| Magnesium alloys | Very light, fairly hard. Not very resistant to corrosion. | Small parts for engines, where lightness is very important. | About 90% magnesium, 7% aluminum, 1.5% zinc, and some manganese. |
| *Titanium alloys | Lightweight, very strong, resistant to corrosion. | Jet airplane, missile, and ship engines, and chemical equipment. | Mostly titanium, with up to 13% vanadium, 11% chromium, 8% manganese, 6% aluminum, and some other metals. |
| Noble metal alloys | Generally rather soft and workable. Resist corrosion well. Often very heat resistant. | Expensive alloys used in jewelry. Harder types, such as osmiridium, are used in fountain pen tips. | Alloys containing platinum, rhodium, osmium, iridium, ruthenium, palladium, and gold or silver. |

* Although used only recently, titanium is the ninth most common element in the earth's crust.



**ALLOY**

The stainless steel saucepan, hardened steel screwdriver, chromium-plated staple gun, and brass candlestick are all examples of alloys.

and useful alloy. Copper is often used in making alloys. It is used in cupronickel, from which some coins are made.

Alloys can also be made by adding a non-metal, such as carbon or silicon, to a metal. Steel is made of carbon, iron, and traces of other metals. Iron by itself is very weak and soft compared with steel. Only a small amount of carbon is needed to make the change to steel. Ordinary steel contains less than 0.25 percent carbon.

Alloys do more than just make a metal harder and stronger. Each type of element mixed has a certain effect on the total mass of metal. If chromium, nickel, and molybdenum are added to steel, the rust-free alloy called stainless steel is produced. Stainless steel, also stronger than ordinary steel, is only one of many alloy steels used in industry.

Most metals dissolve in one another in certain proportions. However, copper and nickel can mix together, no matter how much of either element is used. They are said to be totally miscible. A few pairs of metals, such as lead and aluminum, are immiscible. They cannot be mixed together at all.

Alloys usually have cooling rates different from those of pure metals. Pure metals turn solid at a specific temperature. Above that temperature, they are liquid. Below it, they are solid. Most alloys have a range. This means an alloy may turn solid anywhere between many degrees of temperature. An equal mixture of the copper-nickel alloy, for instance, has a range from 2,394°F [1,312°C] to 2,278°F [1,248°C].

A few alloys behave like pure metals, melting at certain temperatures. In all these alloys, the amount of each metal used is such that the lowest possible melting point is obtained. Wood's metal is one example. An alloy of bismuth, lead, tin, and cadmium, it melts at 158°F [70°C]. It is used in valves of sprinkler systems in public buildings. There, if a fire starts, the heat melts the Wood's metal seal. This releases the water to put out the fire. Such alloys, and their melting temperatures, are called eutectic.

**ALLUVIUM** (ə lo͞o′vē əm) Alluvium is gravel, sand, silt, or mud that has been deposited by water. Alluvium is found at the banks and mouths of rivers or alongside lakes and oceans. It is also found where rivers, lakes, or oceans once existed but have since dried up.

Erosion washes soil into streams. The streams carry the soil downstream. When the speed of the water slows, the water cannot carry the heavier objects that are in it. These objects are dropped and left behind. Also, when a stream

**ALLUVIUM**

Alluvium that has been deposited along the shore of the Potomac River in Virginia is shown in the photograph. Alluvium consists of gravel, sand, silt, or mud.

enters a larger stream or body of water such as a lake, it will drop its load of soil. Gravel is deposited first because it is the heaviest. Silt and mud are light. They remain suspended in the water until the stream that carries them reaches the mouth of the river. Deltas are alluvial deposits, usually consisting of silt and mud, found at the mouths of some rivers. Alluvial plains are found in flat valleys where the river has flooded and deposited mud. Alluvial plains are among the most fertile and densely populated regions in the world.
*See also* SOIL.

**ALMOND** The almond tree belongs to the rose family, Rosaceae. Its nutlike fruit is called an almond. The almond is not really a nut. It is a hard seed from a fleshy fruit similar to a peach. The tree is small, only growing to 20 ft. [6 m]. It is very attractive. It resembles a peach tree, to which it is related. The almond tree is originally from southwest Asia. It now grows in warm climates around the world. In the United States, almonds are grown in California.

There are two types of almonds. One is bitter, and one is sweet. The sweet almond is eaten and used in food. The bitter almond contains small amounts of the deadly poison hydrocyanic acid.

ALMOND

The sweet almond and the bitter almond are both varieties of the wild almond shown here in bloom.

**ALOE** The aloes are a group of succulent plants belonging to the lily family, Liliaceae (see LILY FAMILY). They grow rosettes, which are spiral-shaped bunches of fleshy leaves. A tall spike of flowers grows up from the center. Aloes are found in the dry regions of Africa and Asia. They are similar to the agaves of the Americas (see AGAVE). Aloes are grown for decoration and are used in medicine for the treatment of burns.

ALOE

Aloe plants are members of the lily family. Their fleshy leaves grow in spiral-shaped bunches.

**ALPHA CENTAURI** Alpha Centauri is the name of the star system that is closest to Earth. It is the third brightest object in the sky. Alpha Centauri is a member of the constellation Centaurus. This constellation is in the southern hemisphere of the sky. Alpha Centauri is about

4.3 light-years away from Earth. Traveling at the speed of light (186,282 mi. per second or 299,792 km per second), it would take an object four years and four months to get to Alpha Centauri from Earth.

Scientists once believed that Alpha Centauri was a single star. It is now known that it is a triple star. One of its stars, Proxima Centauri, is the nearest star to our sun.

*See also* ASTRONOMY; CONSTELLATION; STAR.

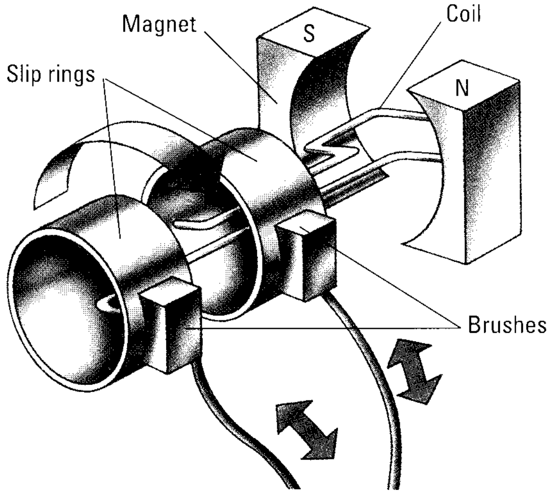
**ALPHA PARTICLE** Alpha particles are positively charged particles given off by the nuclei of certain radioactive atoms (see RADIOACTIVITY). Alpha particles are made up of two neutrons and two protons bound together. Alpha particles are identical to the nuclei of helium atoms. They were discovered by Ernest Rutherford in 1899 (see ATOM; RUTHERFORD, ERNEST).

Radioactive elements such as uranium and radium give off alpha and beta particles and gamma rays. Alpha particles are the least dangerous of the three because they can be stopped by a piece of paper or by a few centimeters of air. Alpha particles are not harmful to humans unless they actually enter the body.

Alpha particles can be detected by a Geiger counter. They will also leave tracks on photographic film or make a flash of light on a fluorescent screen.

*See also* BETA PARTICLE; GAMMA RAY; GEIGER COUNTER.

**ALTERNATING CURRENT** An alternating current is an electrical current that changes direction regularly. It can be produced by an electrical generator (see GENERATOR, ELECTRICAL). A generator has a coil of wire spinning between the poles of a magnet. The magnet causes a current to flow in the coil as it spins. The direction of the current changes twice in every spin. During the first quarter of the spin, the current builds up to a maximum in one direction. Then it goes back to zero at the end of half of the spin. At this point, the current changes direction. It then builds up to a maximum in the other direction and reduces to zero after it has completed the spin. This is called a cycle. At the end of the cycle, the current changes direction to start a new cycle. There can be 50 or more cycles in every second.



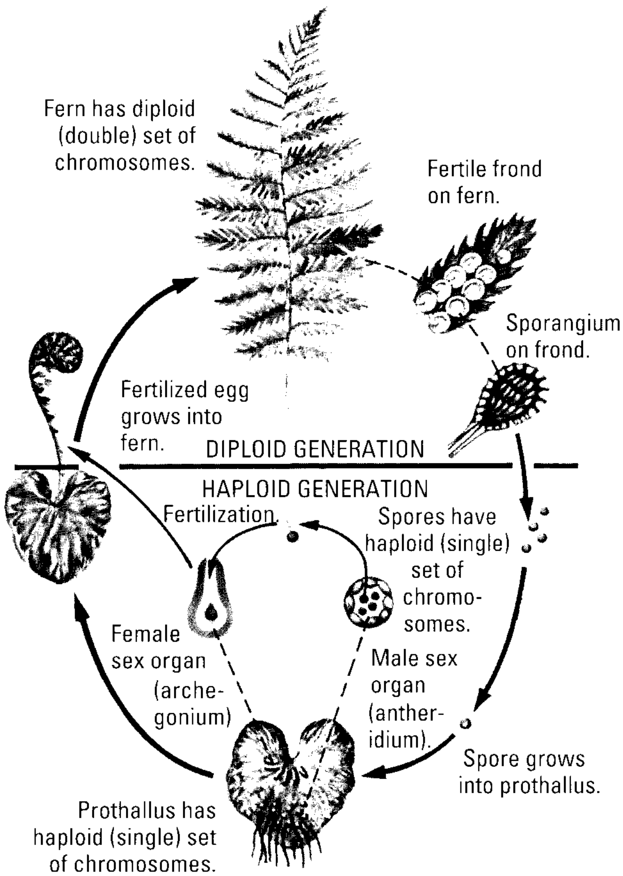

ALTERNATING CURRENT
An alternating, or two-way, current can be made to flow by a generator like the one shown in the simplified diagram above. A loop of wire, called the coil, is made to rotate rapidly (large arrow) between the poles of a horseshoe magnet. The slip rings mounted on the coil make contact with the "brushes," through which current flows to and from the outside circuit (small two-way arrows).

This is the most common way of producing an alternating current. Another way of producing an alternating current is to spin the magnet around inside the coil of wire.

*See also* ELECTROMAGNETISM.

**ALTERNATION OF GENERATIONS** Alternation of generations is the alternation of two distinct stages in an organism's life cycle. It is characteristic of some lower animals, such as jellyfish and flatworms, as well as some protozoans. Also, many plants, including mosses, ferns, and seed-bearing plants—and fungi—experience alternation of generations.

In alternation of generations, the gametophyte (gamete-producing) generation alternates with the sporophyte (spore-producing) generation. The gametophyte, or haploid, generation is the sexually reproductive stage in an organism's life cycle. It produces male gametes (sperm) and female gametes (eggs), which combine to form a zygote (see GAMETE; ZYGOTE). The zygote develops into a new organism, the sporophyte. The sporophyte,




**ALTERNATION OF GENERATIONS**

Alternation of generations is clearly shown by the fern plant. The fern (top) is the diploid generation, having a double set of chromosomes. The smaller prothallus plant (bottom) is the haploid generation, having a single set of chromosomes.

or diploid, generation is the asexually reproductive stage in an organism's life cycle. The sporophyte produces spores, which develop into new organisms (see SPORE).

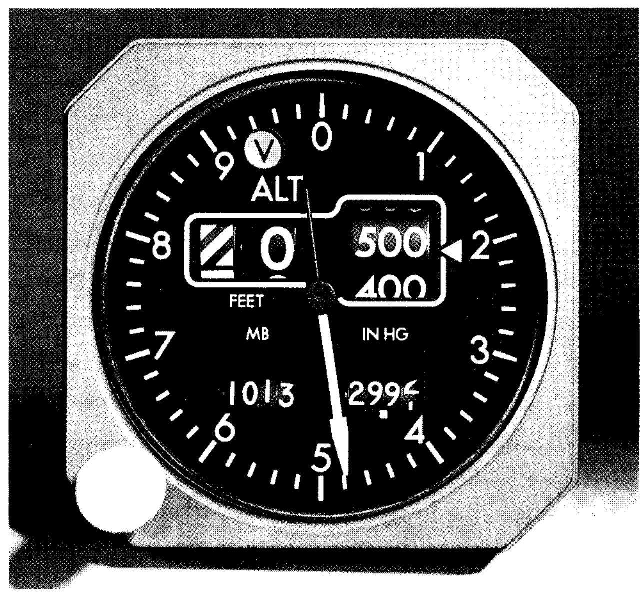
Although alternation of generations is common in many organisms, one of the two stages may be difficult to observe. This may be due to the fact that it is very small or short-lived. Frequently, one generation of an organism looks totally different from the other generation, even though it is the same species.

*See also* ASEXUAL REPRODUCTION; REPRODUCTION; SEX.

**ALTIMETER** (ăl tĭm′ĭ tər) An altimeter is an instrument in an airplane that shows how high the plane is above the earth. The barometric or aneroid altimeter, used in many small planes, shows the height above sea level. It measures the decrease in air pressure as the altitude increases. Because air pressure on the ground varies as part of the changing weather, this type of altimeter must be adjusted to the air pressure on the ground before each flight.

Most large planes carry altimeters that are more accurate than the barometric type. Radio or absolute altimeters bounce electronic signals off the earth's surface, much like radar. The time it takes for the echoes to return is calculated into a precise measurement of the altitude. The sonic altimeter bounces sound signals off the earth's surface. It times the echoes to determine the altitude.

*See also* ATMOSPHERE; BAROMETER.




**ALTIMETER**

An altimeter records an aircraft's height above the earth by a needle on a dial and also in figures.

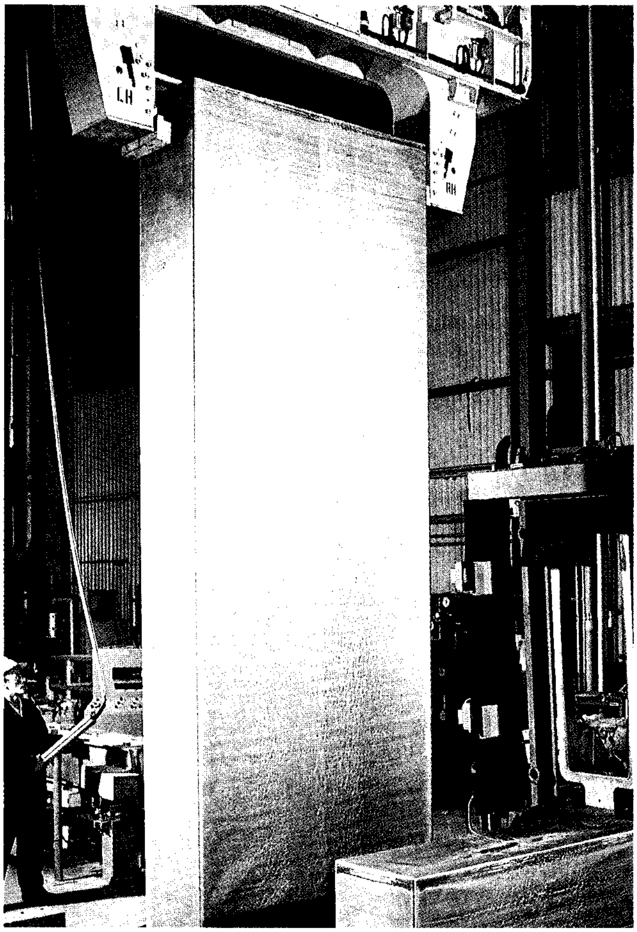
**ALTITUDE** Altitude is the height of an object from a given level. For example, the altitude of an airplane in flight is measured from the ground. The altitude of a geographical feature such as a mountain is measured from the surface of the ocean (sea level). The altitude of the sun, moon, stars, and planets is measured from the earth's horizon and is given in an angle of degrees, minutes, and seconds.

Airplanes carry instruments called altimeters that measure in feet or meters the altitude at which an airplane flies (see ALTIMETER). The altitudes of mountains are called elevations. Mt. Everest, the highest mountain on Earth, has an elevation of 29,078 ft. [8,863 m]. Many maps show altitudes of land with contour lines. These are lines connecting points which are at the same altitude.

**ALUM** Alum is the name for any of a group of hydrated (water-containing) double salts. One common alum is potassium aluminum sulfate, also called potash alum. It forms colorless eight-sided crystals, known as octahedrons. Alum is produced by evaporation of a water solution that contains aluminum sulfate and potassium sulfate, and its chemical formula is $KAl(SO_4)_2 \cdot 12H_2O$. Potash alum is used in dyeing leather, paper, and fabrics. It is also used in medicine to stop small cuts from bleeding. Alums are also used to purify water. Must alums are manufactured from the ore known as bauxite.
*See also* BAUXITE; HYDRATE; SALTS; SULFATE.

**ALUMINUM** Aluminum is a silvery white metallic element with the symbol Al. It was discovered by Friedrich Wohler, a German chemist, in 1827. Aluminum is the most abundant metal in the earth's crust, making up eight percent of the crust. However, for many years, producing aluminum was an expensive process. Then, in 1886, an inexpensive way of producing pure aluminum was developed. It is now a widely used metal. The atomic number of aluminum is 13, and its relative atomic mass is 26.98. It melts at 1,200°F [660°C] and boils at 4,472°F [2,467°C].

**Extraction** Most aluminum comes from a mineral called bauxite (see BAUXITE). Bauxite contains aluminum oxide, often called alumina. The alumina is obtained from the bauxite by washing and refining. Then it is mixed with cryolite, another mineral that contains aluminum. A powerful electric current is passed through the mixture in an electrolytic cell (see ELECTROLYSIS). The current generates a temperature of about 1,832°F [1,000°C]. The aluminum melts and falls to the bottom of the cell, where it is collected. This

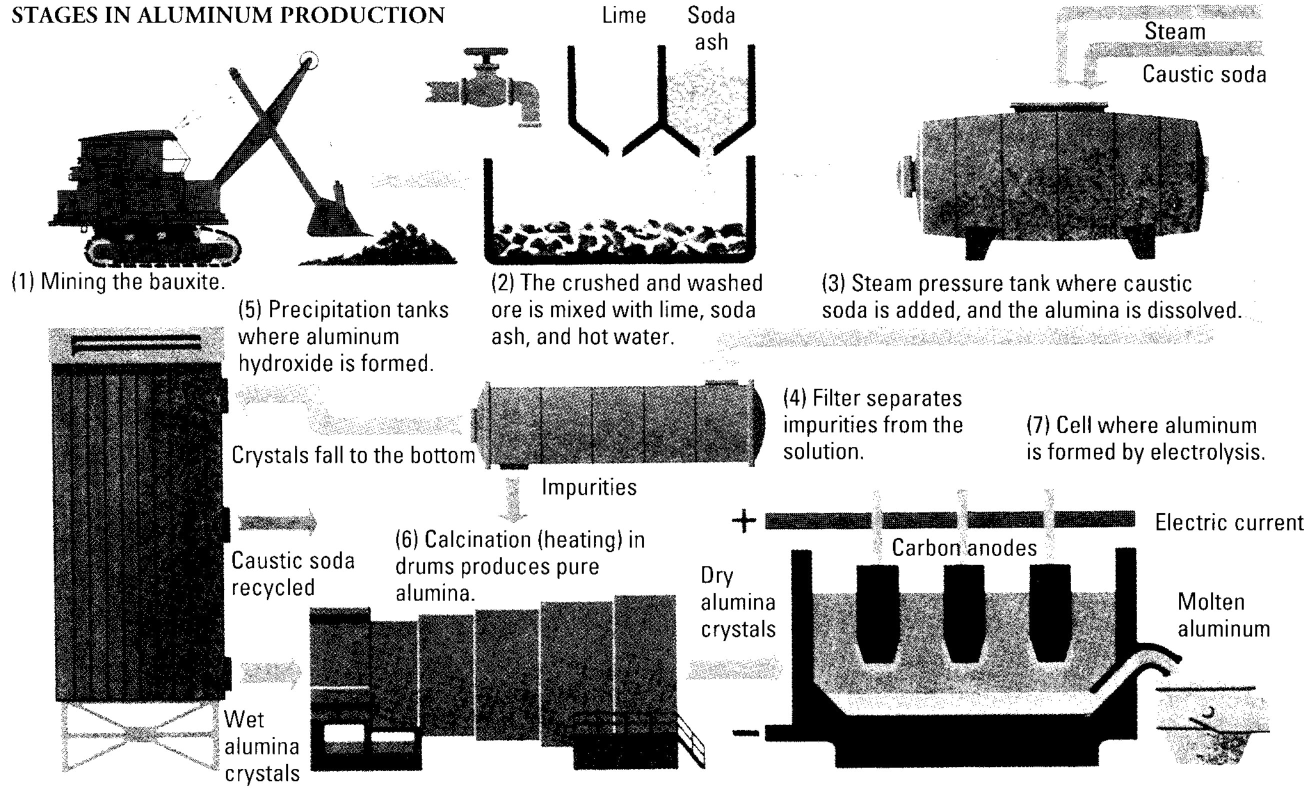


ALUMINUM
This aluminum ingot (above) was recycled from over one million used drink cans. Aluminum is produced in two main stages (opposite). Alumina is extracted from bauxite ore, and then smelted to produce pure aluminum.

process, called the Hall-Héroult process, requires large amounts of electricity. About 10 kilowatt hours of electricity are needed to make 2.2 lb. [1.0 kg] of aluminum. Because of this, most aluminum is extracted in areas where hydroelectric power is plentiful and therefore inexpensive.

**Uses of aluminum** Aluminum is a very light, yet strong, metal with many different uses. It is used for making pots and pans because it is a good conductor of heat. Aluminum also conducts electricity well and is used to make electrical wires. Aluminum is used to make cans for various beverages and other liquids. It can be pressed into a thin foil that is used both commercially and in homes for such purposes as wrapping foods for storage. Because aluminum is light but strong, it is widely used in airplanes and spacecraft. It can

STAGES IN ALUMINUM PRODUCTION




be made even stronger by mixing it with other metals to form alloys (see ALLOY). Duralumin is such an alloy. It is used as the outer surface of many airplanes. The bodies and parts of some automobiles, trucks, boats, and trains are made from aluminum alloys.

Seawater corrodes pure aluminum (see CORROSION). Alloys of aluminum have been developed that do not corrode. Aluminum is not corroded by fresh water or by the atmosphere. This is because aluminum forms a thin coating of its oxide on its surface. This is called anodizing. Manufacturers anodize such products as window frames, screen doors, and drainpipes.

*See also* ANODIZING; OXIDE.

**ALVAREZ, LUIS** (1911–1988) Luis Alvarez was an American physicist and Nobel-prize winner. Alvarez is best known for his discoveries of atomic particles in the 1950s and 1960s. Alvarez discovered these particles using a device he invented, called a bubble chamber (see ACCELERATORS, PARTICLE).

Alvarez was born in San Francisco, California. He entered the University of Chicago, where he studied physics, in 1929. While in Chicago, he met the physicist Ernest Lawrence (see LAWRENCE, ERNEST). Lawrence invited Alvarez to work at the Lawrence Radiation Laboratory at the University of California at Berkeley. There, Alvarez worked with other scientists using a device called a cyclotron to study atoms. A cyclotron is a particle accelerator shaped in a circle. In World War II (1939–1945), Alvarez directed the development of a radar system called Ground-Controlled Approach (GCA). GCA uses radio waves to guide planes through fog or darkness to a safe landing (see RADAR).

Alvarez also worked on the development of the atomic bomb. When the atomic bomb was dropped on Hiroshima, Japan, in 1945, Alvarez flew in a plane that accompanied the bomber. He measured the blast of the bomb using instruments he had designed (see NUCLEAR WEAPONS).

Alvarez and his son Walter also are known for their theory about the extinction of the dinosaurs. Their theory says that a large body from space crashed into the earth about 65 million years ago. The smoke and dust from the crash blocked out the sun's light. Without sunlight, plants died. The animals that fed on the plants, including the dinosaurs, starved and froze to death (see DINOSAUR).

**ALZHEIMER'S DISEASE** Alzheimer's disease is a disorder affecting certain parts of the brain. It causes a weakening of the mind and body, including the immune system (see IMMUNITY). Alzheimer's disease usually affects elderly people. Only a small number of people have Alzheimer's disease before age sixty-five.

Symptoms of Alzheimer's disease include memory loss; difficulty learning and remembering new information; difficulty speaking and coordinating muscles; and sometimes loss of the sense of smell. As the disease progresses, the symptoms worsen. A person with Alzheimer's may forget how to eat, use the toilet, or bathe. As the person's body becomes weaker, so does his or her immune system. Usually, death results from infection.

Researchers believe that almost three quarters of Alzheimer's disease cases may be linked to a gene that is abnormal. Scientists believe that the exact location of the gene is on chromosome 21 (see CHROMOSOME; GENE). By further studying the gene, scientists hope to develop treatments to cure or even prevent Alzheimer's disease.

Today, doctors diagnose Alzheimer's by ruling out other disorders. Medical tests involving radiation often help diagnose Alzheimer's disease in its early stages. These tests show a slowing of activity in certain parts of the brain. Other tests, such as brain scanning and imaging, brain fluid or blood flow analysis, and skin tests may help doctors understand more about this disease. Early diagnosis, when possible, can help the patient and family cope with the symptoms. For example, the patient and family can receive help from support groups. Some doctors believe there is a link between the amount of aluminum in food and water and whether people go on to develop Alzheimer's disease.
*See also* BRAIN.

**AMALGAM** An amalgam is an alloy of a metal with mercury (see ALLOY). Mercury is normally a liquid, and so an amalgam is often a liquid. An amalgam may also be a solid, depending on how much metal is used in relation to the amount of mercury.

Precious metals, such as gold and silver, can be dissolved out of their ores with the use of mercury. The gold or silver is then removed from the amalgam by boiling off the mercury. Dentists use silver and other amalgams for the fillings they put in teeth. Some dentists believe that such fillings may result in a harmful accumulation of mercury in a person's body. There is disagreement over this issue.
*See also* MERCURY.

**AMARANTH FAMILY** (ăm'ə rănth') About 800 species of herbaceous, dicotyledon plants make up the amaranth family, Amaranthaceae (see DICOTYLEDON; HERBACEOUS PLANT). These plants are found in warm regions, including the southern and southwestern United States. Many of the plants are considered troublesome weeds, such as the tumbleweed. Others have long-lasting green or red flowers, such as the popular garden plant called love-lies-bleeding. One variety of amaranth was cultivated as a grain by the ancient Aztecs of Mexico. It has recently become recognized again as a food crop. Its seeds have higher-quality protein than wheat.

**AMARANTH FAMILY**
Love-lies-bleeding, a popular garden plant, is a member of the amaranth family.

AMARYLLIS FAMILY
Daffodils are members of the amaryllis family.

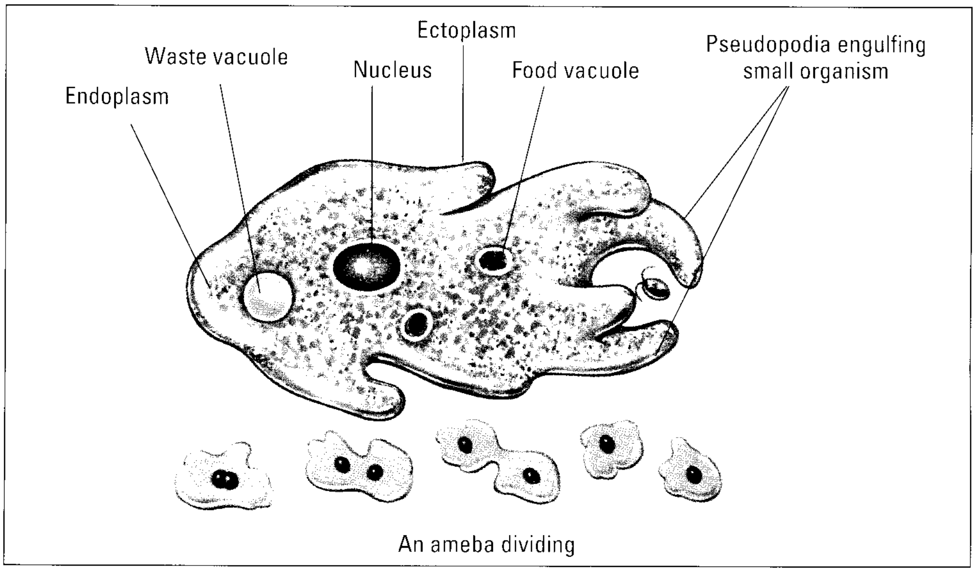
**AMARYLLIS FAMILY** There are more than 1,100 species in the amaryllis family, Amaryllidaceae. These plants are monocotyledons and closely resemble members of the lily family (see MONOCOTYLEDON; LILY FAMILY). Most amaryllis species are tropical or subtropical. Many grow in dry regions. There are about forty species in North America, including the daffodil and snowdrop. The plants in this family have stems up to 3 ft. [90 cm] long; numerous narrow leaves; and large, sweet-smelling flowers.

**AMBER** Amber is pine tree sap that dripped out of the trees millions of years ago and was buried. During the time it was buried, it hardened into a yellow or brown stone that looks like glass. Sometimes, insects fell into the sticky sap, which is also called resin. They became fossils inside the amber. Amber is now used for jewelry.

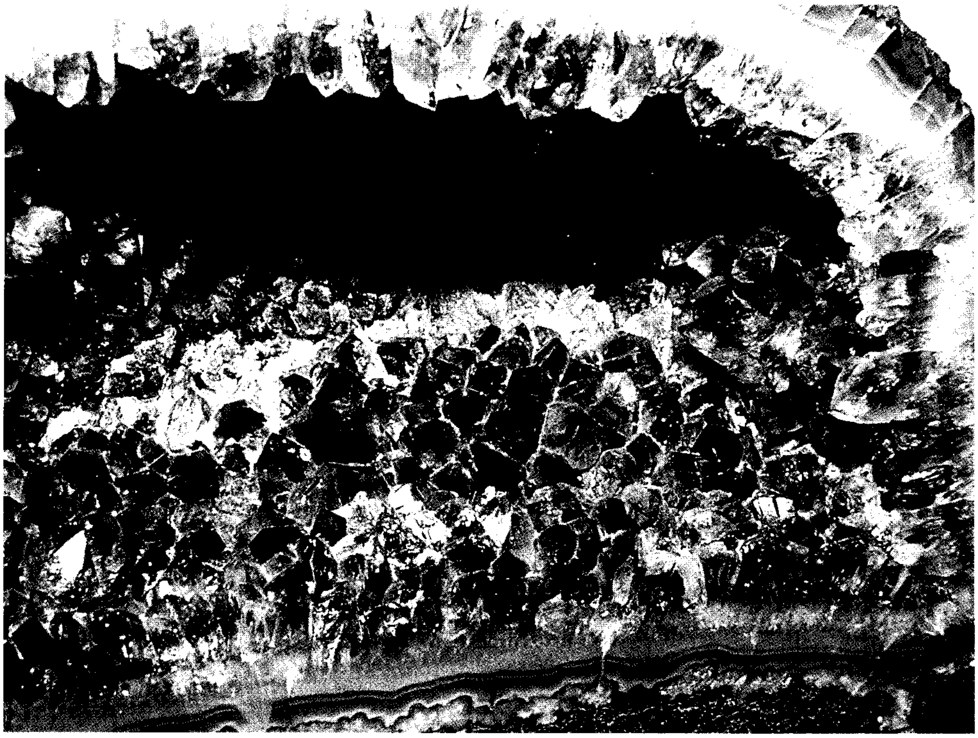
**AMEBA** An ameba is an organism having only one cell. It is a protozoan in the kingdom Protista (see PROTOZOA). Most amebas can be seen only with a microscope. They live in water or in places that are moist, such as under wet leaves. The ameba is one of the most common organisms on Earth. Amebas can even be found inside the intestinal tracts of human beings.

Everything the ameba needs is in its one cell. Its nucleus acts as its control center, and its vacuoles store foods and waste. The ameba's cell is filled with a substance called cytoplasm (see CELL; CYTOPLASM; VACUOLE).

An ameba feeds on bacteria. Its soft body wraps around a bacterium (singular of *bacteria*) and surrounds it. The bacterium is then enclosed in a food vacuole and digested. The ameba moves by slowly projecting a part of its body forward and letting the rest of its body ooze up to it. The part of the body projected is called a *pseudopodium*, which means "false foot." The ameba reproduces by cell division to form two identical cells (see REPRODUCTION).




AMEBA
Amebas feed by engulfing their food and then bringing it into their bodies. Amebas reproduce by simple fission. The nucleus divides, splitting the cell in two.



**AMETHYST**
Amethyst is a form of quartz. Its beautiful purple color makes it a popular semiprecious stone.

**AMETHYST** Amethyst is a variety of quartz, found in the form of six-sided, pointed crystals. These bluish-violet or purple crystals are frequently found in lumps of rock called geodes. Amethyst has a hardness of 7 on the Mohs scale (see CRYSTAL; GEODE; HARDNESS; QUARTZ). When heated, amethyst turns to brilliant yellow or light brown.

Amethyst is used in jewelry. It is the birthstone for February. The most prized amethysts are transparent, with a deep, even color. The color is caused by iron and manganese oxides (see OXIDE). Oriental amethyst, which has the same bluish-violet or purple color as true amethyst, is a form of corundum (see CORUNDUM).

**AMINE** An amine is a chemical compound. It is a base that reacts with an acid to form a salt. It is usually formed from ammonia ($NH_3$) (see AMMONIA). To form amines, the hydrogen atoms in ammonia are replaced with radicals containing carbon atoms (see RADICAL). If an amine contains one of these carbon radicals, it is called a primary amine. If it contains two of the radicals, it is called a secondary amine. If it contains three, it is called a tertiary amine. Most amines have a fishy or musty smell to them. They are used in making dyes.

**AMINO ACID** An amino acid is an organic (carbon-containing) compound possessing both acidic and basic characteristics (see ACID; BASE). Most amino acids have the following general chemical structure:

$$\begin{array}{c} \quad\quad NH_2 \\ \quad\quad | \\ R{\equiv}C{-}COOH \\ \quad\quad | \\ \quad\quad H \end{array}$$

$NH_2$ is called the amino group, COOH is the carboxyl acid group, and R represents the rest of the molecule. The differences in R make one amino acid different from another.

Amino acids are the building blocks of proteins (see PROTEIN). Proteins are made of long, complex chains of amino acids. These chains contain as few as four or as many as several hundred amino acids. Most proteins found in plants, animals, and microorganisms are made of different combinations of twenty-two of these amino acids. Genes code the sequence of amino acids in a protein, and it is the sequence that dictates the protein's function (see GENE). Plants and some microorganisms are able to produce all the amino acids they need. Human beings and most other higher animals, however, cannot produce all the necessary amino acids. The eight amino acids that are not made by the body are called the essential amino acids. They must be supplied by food in the diet (see DIET). The essential amino acids are found in a variety of foods from animal and plant sources.

During digestion, certain types of enzymes called proteases break proteins into amino acids. These amino acids are small enough to be absorbed into the blood. They then travel to the tissues, where they are rebuilt into the new proteins that the body needs. Extra amino acids are not built into proteins, but are broken down again and converted into urea. Urea is then excreted as part of urine (see EXCRETION; UREA; URINE).
*See also* DIGESTIVE SYSTEM; ENZYME.

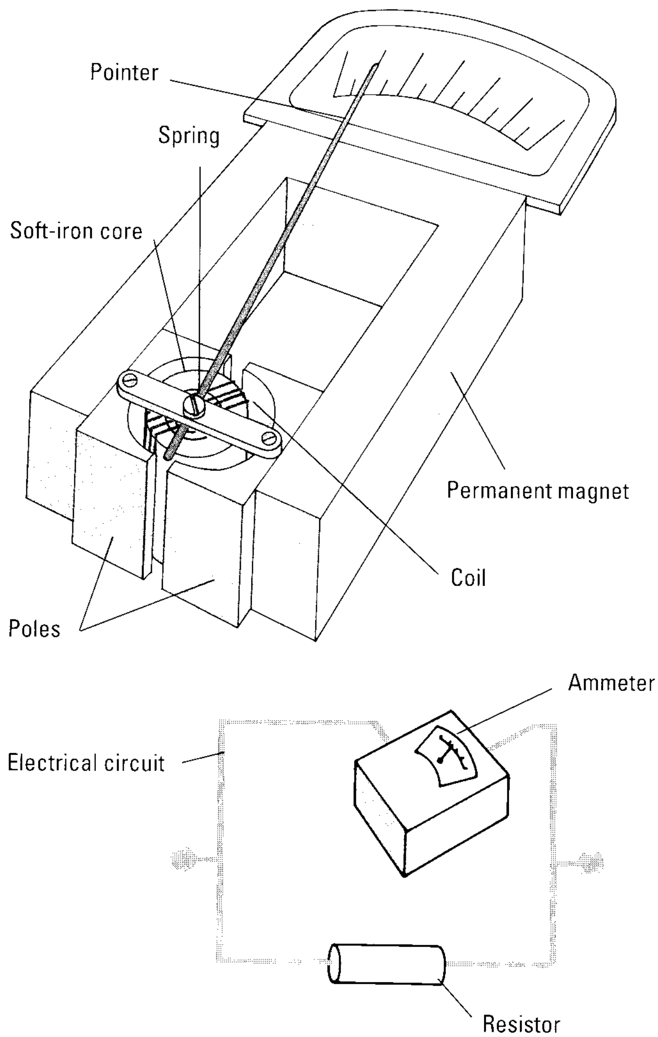
**AMMETER** An ammeter is an instrument for measuring electric current. The measurement is usually in amperes (see AMPERE). There are three main kinds of ammeters.

The moving-coil ammeter is like a galvanometer (see GALVANOMETER). It has a coil of wire between the poles of a permanent magnet. As electric current passes through the coil, it creates a magnetic field around the coil. The field of the coil and the field of the magnet make the coil move. A needle attached to the coil moves to show the amount the coil has moved. The distance it moves depends on how much current passes through the coil. The moving-coil ammeter is designed for direct current, not alternating current. A rectifier is added to the moving-coil ammeter if alternating current must be measured (see RECTIFIER).

The moving-iron ammeter has two pieces of iron inside a coil. One of the iron pieces can move. The other piece cannot move. The current passing through the coil produces a magnetic field. The force of the field moves one piece of iron away from the other. A needle on a scale shows how far apart the two pieces of iron move. The moving-iron ammeter can measure direct current or alternating current. It does not need a rectifier.

A hot-wire ammeter measures the heat produced by an electric current passing through it. The electric current heats a wire, causing it to expand. A needle is attached to indicate how much the wire expands.

Ammeters usually can be found wherever electrical power is in use. They are common in automobiles and appliances as well as larger machines that use electricity.
*See also* ALTERNATING CURRENT; DIRECT CURRENT.



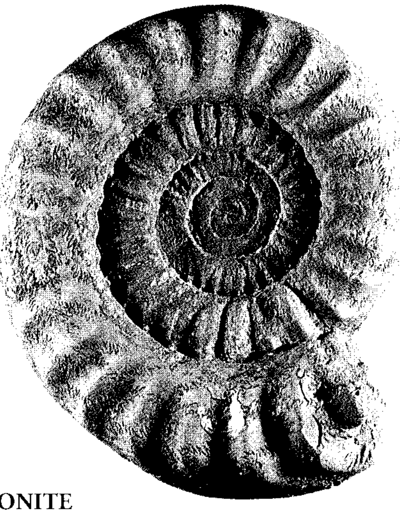

**AMMETER**
In a moving-coil ammeter (top) the current to be measured passes through the coil, temporarily turning it into an electromagnet. The magnetic fields of the coil and the permanent magnet interact, and the coil turns. This moves the pointer across the dial. The stronger the current, the more the coil turns. Moving-coil ammeters can tolerate a current of only a few milliamps flowing through the fine wire that deflects the needle, yet they may have to measure higher currents. This is achieved by connecting a resistor across the ammeter (bottom). The resistor takes most of the current, and only a small amount passes through the ammeter itself.

**AMMONIA** (ə mōn′yə) Ammonia is a gas that is a compound of nitrogen and hydrogen. Its chemical formula is $NH_3$. It has a strong odor. Ammonia can be obtained by distilling coal into coke and coal gas (see DISTILLATION). Ammonia can also be made by combining hydrogen and nitrogen with a catalyst under pressure at a high temperature. This process is called the Haber-Bosch process (see CATALYST).

The ammonia used as a household cleaner is a strong solution of gas in water. Ammonia has many industrial uses. Because it can be broken down easily into hydrogen and nitrogen, ammonia is used to transport hydrogen. Ammonia was once widely used as a refrigerant but is now outdated. Smelling salts contain chemicals that release ammonia. The shock of the smell wakes up people who have fainted.

Ammonia is also used to make ammonium compounds. It is used to make nitric acid and to dissolve certain substances. Salts of ammonia can be made by adding ammonia to an acid. These salts are called ammonium salts. The ammonia takes on a hydrogen atom to form an ammonium ion ($NH_4^+$) (see ION AND IONIZATION; SALTS). For example, ammonium chloride ($NH_4Cl$) is made by mixing ammonia ($NH_3$) and hydrochloric acid ($HCl$). The most important ammonium compound is ammonium sulfate. It is made from ammonia ($NH_3$) and sulfuric acid ($H_2SO_4$). It is used as a fertilizer because it provides nitrogen for the soil. Ammonium chloride, also called sal ammoniac, is used in the manufacture of dry cell batteries. It is also used in dyeing and printing. Ammonium nitrate is used in fertilizers, explosives, and in making nitrous oxide, sometimes called "laughing gas" (see NITROUS OXIDE).

**AMMONITE** Ammonites were members of a large group of mollusks that lived millions of years ago (see MOLLUSCA). They are now extinct. They resembled a modern mollusk, the nautilus. Most ammonites had coiled shells, so the group was named after the Egyptian god, Ammon, who had coiled horns. Ammonites are found as fossils in rocks ranging from the Lower Jurassic right up to the Upper Cretaceous in age. *See also* CEPHALOPOD; FOSSIL; GEOLOGICAL TIME SCALE.



AMMONITE

Ammonites were mollusks that lived millions of years ago. Some of them were huge, measuring more than 6 ft. [1.8 m] across. Many were only 1 in. [2.5 cm] or so across.

**AMNIOCENTESIS** (ăm′nē ō sĕn tē′sĭs) Amniocentesis is a test done on a pregnant woman by a medical doctor to find out if the fetus (unborn baby) is healthy and developing properly. Amniocentesis is not routinely done on all pregnant women. Doctors perform amniocentesis when the baby is at risk, perhaps because of the mother's advanced age or because of concern over the inheritance of certain genes.

Inside a pregnant woman's uterus, the fetus is surrounded by a thin layer of tissue called the amniotic sac. The sac contains fluid that includes cells shed by the fetus. During amniocentesis, a long, hollow needle is placed through the mother's abdomen into her uterus and the amniotic sac. A small amount of the amniotic fluid is taken out through the needle. The cells in the fluid are allowed to grow in a laboratory and are later examined. By performing the test, doctors can tell if the baby has any of more than one hundred disorders, such as Down's syndrome or hemophilia. The doctor can also tell if the fetus is a male or female.

Amniocentesis is most commonly performed late in the fourth month of pregnancy and sometimes causes cramping. Amniocentesis helps the

doctor plan treatment if necessary after the baby is born. Doctors are even beginning to inject therapeutic drugs or perform corrective surgery on some fetuses before birth. If the fetus has a condition that cannot be treated and might cause it to die, some parents choose to abort the pregnancy. Other tests have been developed that detect problems earlier than amniocentesis can. One such test is *chorionic villus sampling* (CVS). Because this test is performed earlier in the pregnancy, it helps the parents and doctor make earlier decisions about the baby if necessary.
*See also* ABORTION; GENETICS; PREGNANCY.

**AMPERE** The ampere, named after the French physicist André Ampère, is the unit of electric current (see AMPÈRE, ANDRÉ). Its symbol is A.

Electric current flows at the rate of 1 ampere when 1 coulomb flows past a section of an electric circuit in 1 second. The coulomb is an amount of electricity equal to the charge of $6.24 \times 10^{18}$ electrons. In other words, 1 ampere equals 1 coulomb per second (see COULOMB).

The difference between a coulomb and an ampere lies in the difference between quantity and rate. For instance, a container may hold ten quarts of water. This is the container's quantity. A faucet may pour out a quart of water per minute. This is the rate. There is a coulomb, or quantity, of electricity. There is also an ampere, or rate, of electricity. Electric current is measured with an ammeter (see AMMETER). A 100-watt light bulb requires about 1 ampere of current if the voltage is about 100 volts.

Physicists define amperes in terms of the magnetic force, measured in newtons, a current produces. In electrochemistry, however, the ampere is defined as the current that deposits silver at the rate of 0.001118 grams per second when passed through a solution of silver nitrate.

Some scientific instruments use currents measured in microamperes, or millionths of amperes. Some large industrial equipment uses current measured in kiloamperes, or thousands of amperes.
*See also* CURRENT, ELECTRIC; NEWTON; VOLT; WATT.

**AMPÈRE, ANDRÉ** (1775–1836) André Ampère was a French physicist and mathematician. Ampère's greatest interest was in electricity. His work was the beginning of the new science of electrodynamics. Electrodynamics is a branch of physics having to do with the way electric currents affect each other.

Ampère discovered that two parallel electrical currents moving in the same direction attract each other. Two parallel currents going in opposite directions repel, or push each other away. He also discovered that current going through a coil wound up like a spring acts like a magnet. This kind of coil is called a solenoid.

Ampère's experiments showed that electrical currents have the same effect as magnets. He invented the astatic needle. The astatic needle made it possible to discover and measure electric current.

Ampère suggested that the earth's magnetism might be caused by electrical currents going around in the earth's center. The ampere, the unit of electrical current, was named after him.
*See also* AMPERE.

**AMPHETAMINE** Amphetamines are human-made drugs. One example is the drug Benzedrine. Amphetamines are also called "speed." They are stimulants. Doctors prescribe them for treatment of mild depression, alcoholism, and sleepiness. Because amphetamines increase metabolism, doctors sometimes prescribe them to help people lose weight (see METABOLISM). These are all legal and legitimate uses of the drugs.

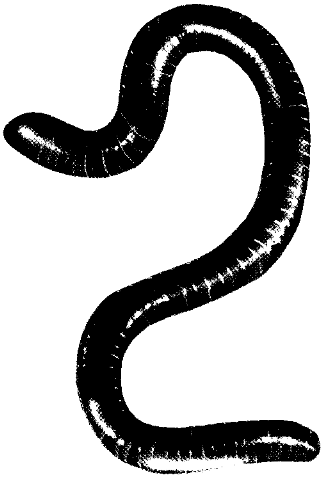
Amphetamines are, however, common drugs of abuse. They are often obtained illegally and used by people who do not need them. Such use is dangerous because amphetamines can upset the functioning of the body, leading to many serious problems.

Amphetamines may cause restlessness, lack of sleep, irritability, and nausea. They can also cause damage to the nervous system and in some cases can even lead to death. People can become addicted to amphetamines.
*See also* ADDICTION.

# AMPHIBIAN

An amphibian is a member of an ancient class of animals. The class came into existence about 370 million years ago. As a result of evolution, certain fish developed in such a way that they could breathe air and walk on land. The fins of some fish became legs. These fish evolved into amphibians. The name *amphibian* means "double life." Most early amphibians lived part of their life in water and the rest on land. After about 50 million years, some amphibians evolved into reptiles. Reptiles are a group of similar animals that can live away from water (see REPTILE). Although most amphibians disappeared, many have survived. Frogs, toads, newts, and salamanders are amphibians.

Amphibians have backbones. Most of the adults have four legs. Even though adult amphibians do not live in water, they do have to stay moist. The skin of humans prevents water from evaporating from their tissues. The skin of amphibians does not prevent evaporation. If the animal goes away from water on a hot day, it

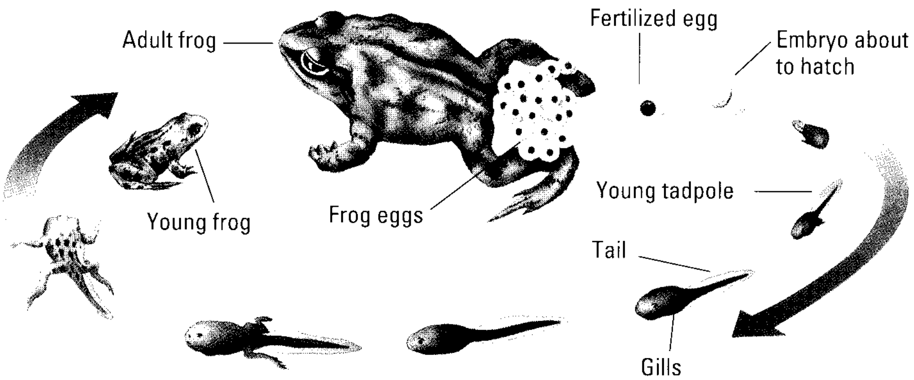


**APODANS (CAECILIANS)**

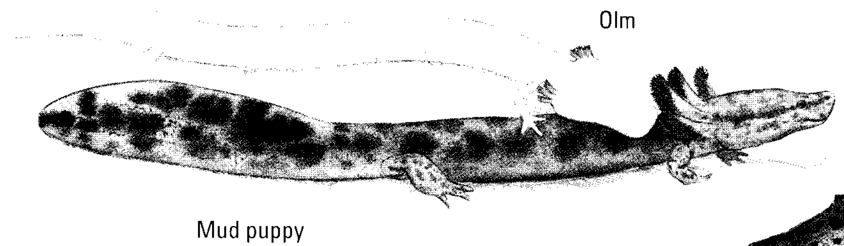
Among the most primitive of living amphibians, the apodans are mostly burrowing animals (above). They live in the tropics. They are legless and have very small eyes.

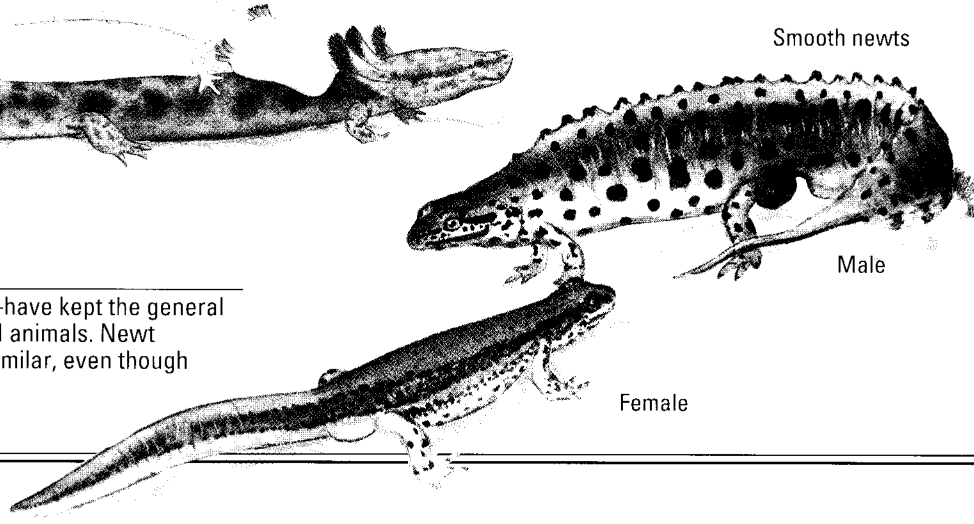
**LIFE CYCLE OF A FROG**

Most frogs return to water to mate and lay eggs. The tadpoles remain in the water until they have developed lungs. The complete life cycle takes about 16 weeks.







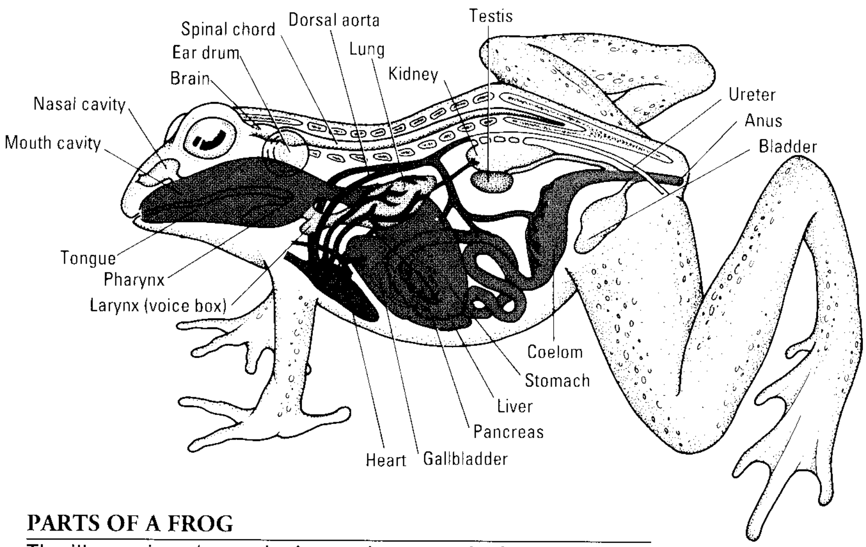




**URODELES**

Urodeles—newts and salamanders—have kept the general shape of their ancestors, the first land animals. Newt tadpoles and frog tadpoles are very similar, even though the grown animals are very different.

might dry up and die. Although most amphibians have lungs, they also breathe through gills, like fish. Amphibians lay eggs that must stay wet. Most amphibians lay eggs in water. Some of them, however, can lay their eggs in moist places such as under rotting logs and around leaves on the ground. The eggs that are laid in water hatch into tadpoles, or free-swimming larvae (see LARVA). Tadpoles live in the water and breathe through gills. When they change into adults, they can leave the water and breathe with lungs.

Amphibians are cold-blooded animals. This means that their body temperature does not remain at the same level at all times, but is about the same temperature as their surroundings.



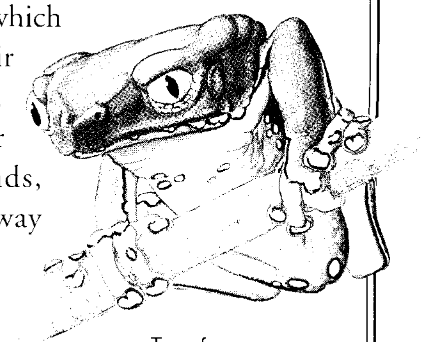

**PARTS OF A FROG**

The illustration shows the internal organs of a frog, a typical anuran.

All amphibians alive today belong to one of three groups: apodans, urodeles, and anurans. The apodans are legless, wormlike creatures found only in tropical regions. Some species live in the water, but most burrow in damp soil.

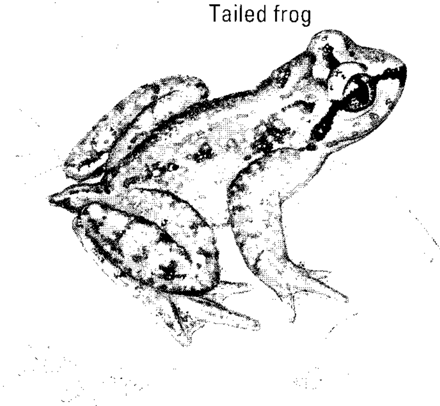
The urodeles are amphibians with tails. Salamanders and newts are urodeles. Many urodeles are completely terrestrial; they do not have to return to water. There are some salamanders that never leave the water, such as the mud puppy and the axolotl of North America. Some salamanders live in dark caves and do not have eyes. The largest amphibian is the giant salamander of Japan, which grows up to 5.5 ft. [1.65 m] long.

The anurans are the toads and frogs. They have hind legs that they use for jumping. Anurans vary in size from tiny tree frogs less than 1 in. [2.5 cm] long to the goliath frog of tropical Africa, which reaches a length of about 3.3 ft. [1 m] with its legs extended. Most anurans breed in water and lay jellylike masses or strings of eggs. Frogs and toads eat insects, which they capture with their long, sticky tongues. Most frogs stay in or near water. Most toads, however, can travel away from water.



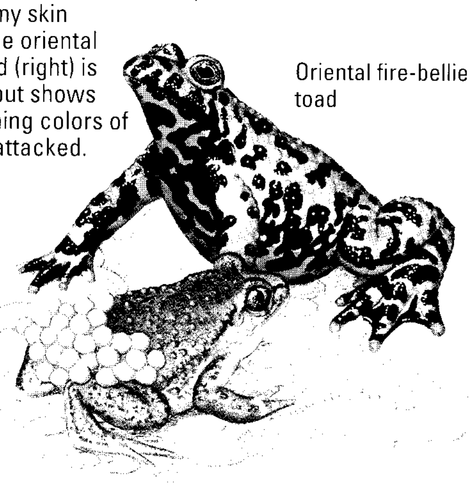
Tree frog

Tailed frog



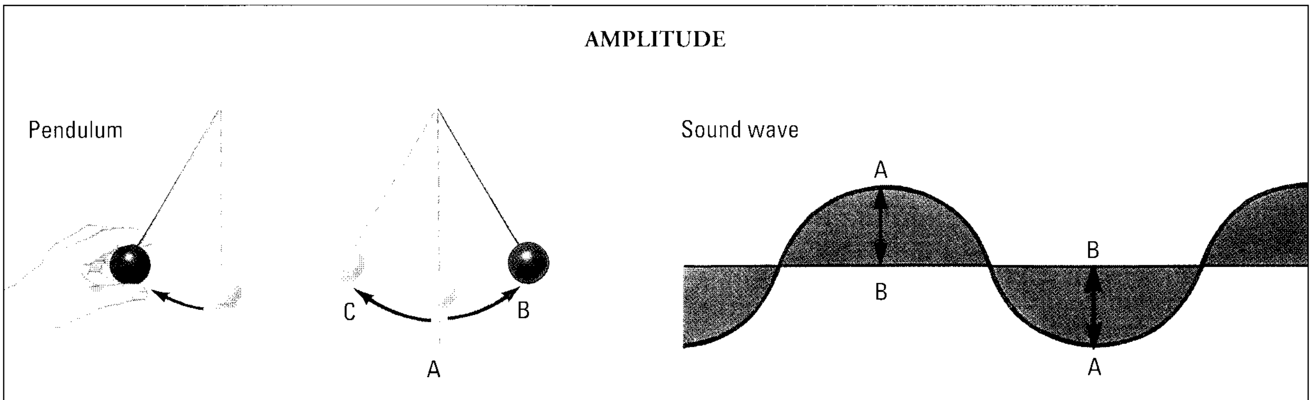
**ANURANS**

Anurans—frogs and toads—are amphibians specialized for jumping. Toads usually have warty skins, whereas frogs have smooth skins—otherwise there is little difference between them. Unlike other amphibians, anurans have voices, ranging from the high peeping of some tree frogs, to the deep croak of the bullfrog. Some anurans are protected from their enemies by slimy skin substances. The oriental fire-bellied toad (right) is camouflaged, but shows the bright warning colors of its belly when attacked.



Oriental fire-bellied toad

Iberian midwife toad




Distance AC or AB is the amplitude of this pendulum.

Distance AB is the amplitude of this sound wave.

**AMPLIFIER** An amplifier is an electronic device that increases the strength or power of a signal. Today, most amplifiers consist of integrated circuits and transistors. Vacuum tubes are used in some amplifiers when very high power is needed (see INTEGRATED CIRCUIT; TRANSISTOR; VACUUM TUBE).

Amplification occurs in stages. Each integrated circuit, tube, or transistor strengthens the signal that passes through it. Microphones, radio antennas, and the pickups in home stereo systems produce weak signals. These are usually fluctuating voltages. They may be as little as one millionth of a volt (see VOLT). Amplifiers must be used to boost the power of these signals so they can be heard. Amplifiers are particularly important in public-address systems. These systems are used when sound signals must reach many people in large rooms or outdoors. Amplifiers used to produce high-quality sound in stereo systems are often expensive, complicated devices.

*See also* ANTENNA; ELECTRONICS; RADIO.

**AMPLITUDE** The maximum distance a swinging or vibrating body moves from its place of rest, or zero point, is called its amplitude. A good example is the movement of a simple pendulum, such as a weight attached to the end of a piece of string. If the weight is pulled aside and released, it will swing to and fro, or oscillate. The greatest distance the weight travels in either direction from its central position is its amplitude.

Waves have amplitude. The amplitude of an ocean wave is the height of the wave crest above the level of the calm sea. It is the same as the depth of the wave trough below that level. The amplitude of a sound wave or of an alternating electrical current is the difference between its peak intensity and its average intensity.

*See also* ALTERNATING CURRENT; SOUND; WAVE.

**ANACONDA** The anaconda is one of the largest snakes in the world. The anaconda is a member of the Boidae family. It is found in the northern countries of South America. There are

ANACONDA

Anacondas can grow up to 28 ft. [8.5m] in length and kill their prey by squeezing them so that they die by suffocation.

two species, the giant anaconda and the yellow anaconda. The giant anaconda is dark green with alternating oval black spots. It may grow as long as 28 ft. [8.5 m] and as thick as an adult human's body. The yellow anaconda has a shorter, yellowish-green body with irregular black blotches.

The anaconda spends much of its time in water, lying in wait for its prey. Unlike poisonous snakes, it does not kill its prey by biting. It wraps its body around its prey and suffocates the animal by squeezing it. Anacondas feed mostly on small mammals and birds. Sometimes they catch and swallow a caiman, which is a relative of the alligator. After the animal is dead, the anaconda swallows it whole. Whereas other snakes lay their eggs some time before the eggs hatch, anacondas give birth to live young, up to 75 at one time.

*See also* BOA.

**ANAEROBE** An anaerobe is an organism that does not use oxygen in order to live. Many bacteria, fungi, and protozoans are anaerobic. They get their energy by breaking down either organic (carbon-containing) or inorganic compounds in a process called fermentation (see ANAEROBIC RESPIRATION; FERMENTATION). Some yeasts, for example, convert sugar into alcohol by fermentation.

Obligate anaerobes are organisms that must live in a totally oxygen-free environment. If exposed to oxygen, they will die. Facultative anaerobes can live either with or without oxygen.

*See also* AEROBE.

**ANAEROBIC RESPIRATION** Anaerobic respiration is a kind of respiration that does not involve oxygen (see RESPIRATION). Not all living things require oxygen to obtain energy. Some can break down sugar anaerobically, which means "without air." Glucose sugar—which is a substance commonly utilized during respiration—is only partly broken down during the process of anaerobic respiration, and therefore less energy is released than in aerobic respiration.

Anaerobic respiration carried out by fungi such as yeast, and by some plants, is called fermentation. During this process, cells change glucose into alcohol and carbon dioxide gas. Fermentation is used to make alcoholic drinks, such as beer, and it is also used in baking to make bread rise.

During strenuous exercise, muscles use up oxygen faster than the blood can supply it. Without oxygen, muscle cells stop making energy aerobically and start to respire anaerobically. The chemical reaction that occurs in the muscles when they work anaerobically produces lactic acid, which is poisonous to muscle cells. Lactic acid builds up in the muscles and eventually stops them from working properly. It also makes them ache—the pain is called a cramp. Only by breathing deeply can the body take in enough oxygen to break down the lactic acid into harmless waste products.

*See also* AEROBIC RESPIRATION; METABOLISM.

**ANALGESIC** (ăn′əl jē′zĭk) An analgesic is a drug that reduces pain without causing unconsciousness or complete loss of feeling. Mild analgesics, such as acetaminophen, ibuprofen, aspirin, and codeine, are used to relieve headaches, symptoms of arthritis, or other body pains. More powerful analgesics include substances derived from opium, called narcotics. Two such analgesics are morphine and heroin. These are dangerous drugs that can lead to addiction. They are used only for relieving intense pain of patients who are suffering from cancer or severe injuries. Many analgesics are also antipyretics, drugs that reduce fever.

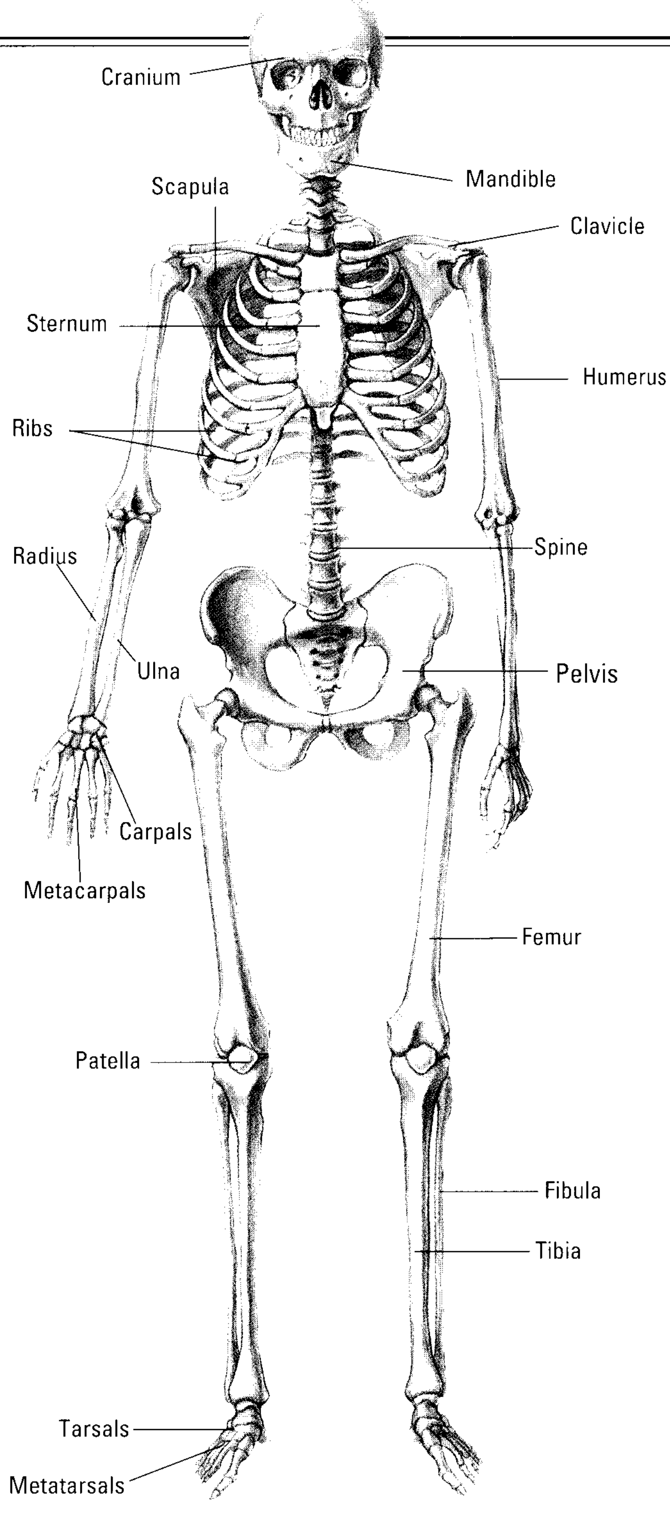
*See also* ANESTHETIC.

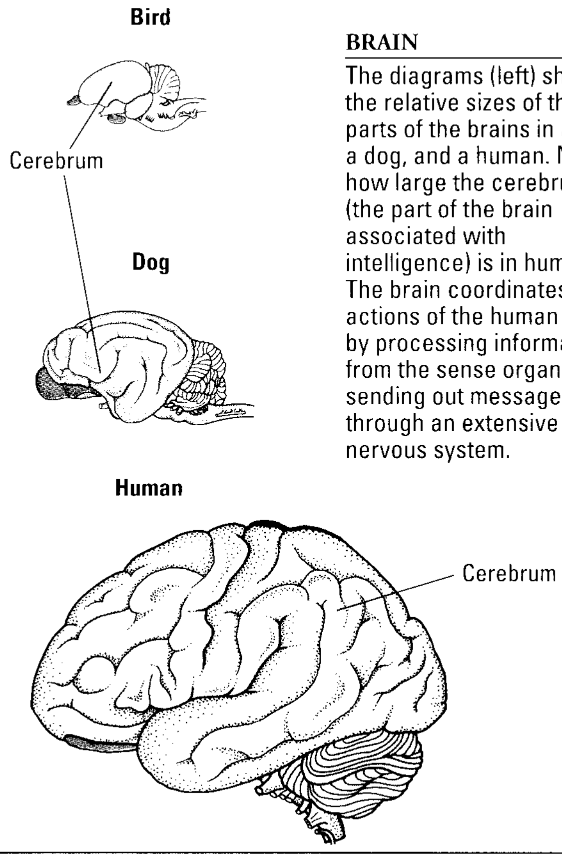
**ANALOG** An analog is a physical object or quantity, such as a pointer or a reading on a scale, that is used to measure a second quantity. The rising and falling column of mercury inside a thermometer corresponds to changes in temperature; the level of the mercury is therefore an analog of the temperature. In electronics, analog devices use the sizes of electrical signals to indicate other quantities such as length, mass, light intensity, pressure, or temperature. An analog computer processes information in the form of continuously varying electric currents or voltages. In contrast a digital computer processes information in the form of binary numbers (see COMPUTER).

# ANATOMY

Anatomy (ə năt′ə mē) is the study of how living things are built. The word *anatomy* comes from the Greek words that mean "cutting up." Most of what is known about how an organism is put together was learned by someone who cut it apart—that is, dissected it—and looked at it. Today, scientists can also study the inside of a living body with radiation and ultrasound. In the education of a doctor, a knowledge of anatomy is very important.

There are many different types of anatomy. In gross anatomy, the naked eye is used to study large parts of the body. In microscopic anatomy, microscopes are used to study very small parts of the body. Comparative anatomy is the study and comparison of similar parts of bodies in different species. A comparative anatomist may compare the heart of a fish, a frog, a snake, and a bird. Embryology is the study of embryos, which are developing unborn babies. Histology is the study of the structure of tissues. Cytology is the study of the structure of cells (see CYTOLOGY; HISTOLOGY).

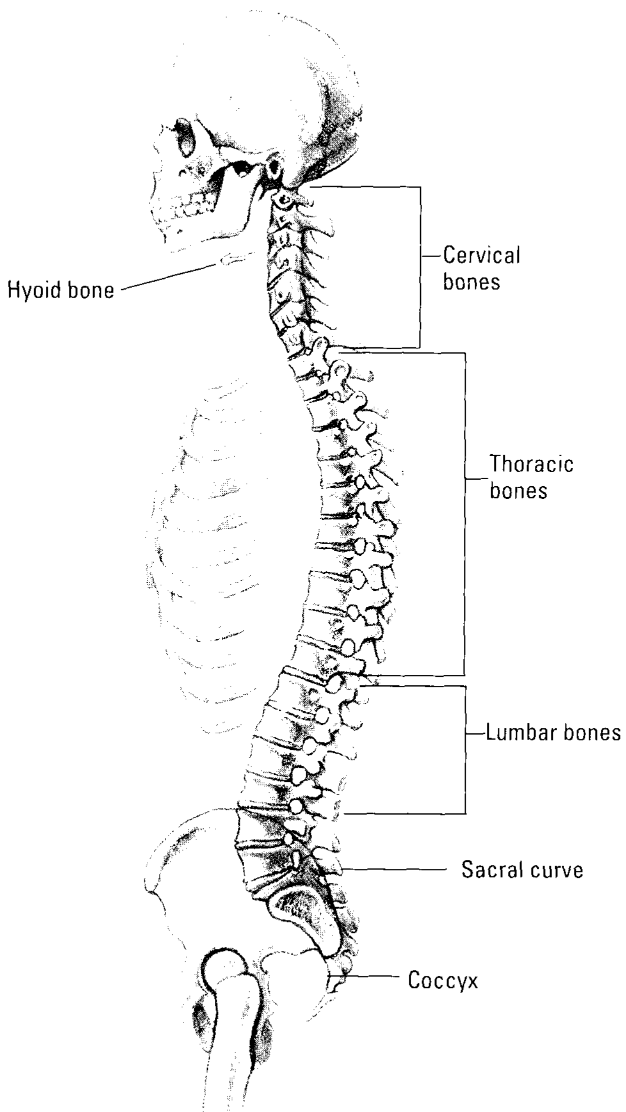



**BRAIN**

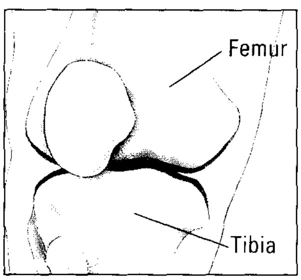
The diagrams (left) show the relative sizes of the parts of the brains in a bird, a dog, and a human. Notice how large the cerebrum (the part of the brain associated with intelligence) is in humans. The brain coordinates the actions of the human body by processing information from the sense organs and sending out messages through an extensive nervous system.

The study of the structure of the human body is called human anatomy. By understanding the parts of the human body and how they are built, doctors are able to heal injuries and cure diseases. All the parts of a body work together in a very complicated way to keep a person alive. Although doctors and scientists now know much about the human body, they still do not understand how every part works.




**SKELETON**

There are 206 bones in the human body (far left). Some bones are for protection, such as the skull; others are for support, such as the spine, or for movement, such as the femur. There are 26 bones in the spine (left) which are separated by cartilage disks that act as shock absorbers.




**KNEE JOINT**

The femur (thigh bone) meets the tibia (shin bone) at the knee joint. The joint allows easy movement because of the smooth cartilage that covers the ends of the bones and because of a natural lubricant fluid in the space between the bones.

The body is made up of nearly 50 million million cells. These are grouped together in different types of tissues, which have different functions. There are skin tissue, muscle tissue, bone tissue, and other kinds of tissue. Tissues are grouped together to form organs, such as the brain, heart, and stomach. Each cell works with other cells, and tissues and organs work together in systems to carry out jobs such as digesting food and delivering nutrients (see CELL; ORGAN; TISSUE).

The skeletal system, or skeleton, is made up of all the bones in the body. There are 206 bones in the human body. They are connected in several ways. Two bones may move over each other at a special point called a joint. For example, the knee is the joint between the upper and lower leg bones (see SKELETON). The muscular system is made up of all the muscles. They are attached to the bones. The muscles move the bones and allow a person to move about in various ways (see MUSCLE).

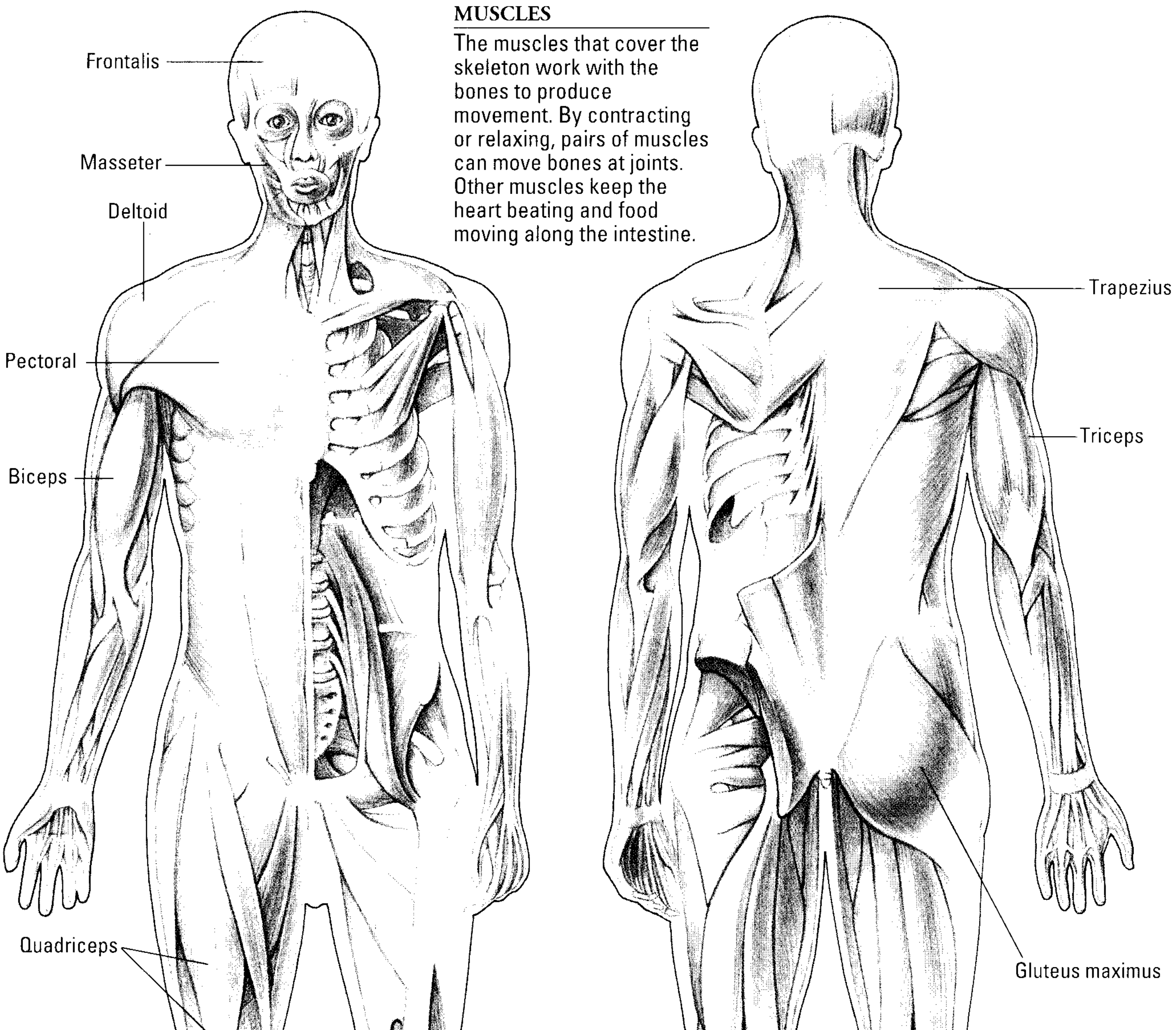
The circulatory system is made up of the heart, arteries, veins, capillaries, and blood. The blood carries nutrients and oxygen to every cell in the body. It also carries certain waste products, including carbon dioxide, away from the cells. The heart pumps the blood throughout the body. The blood leaves the heart through arteries, travels through capillaries to reach all parts of the body, and returns to the heart through veins (see CIRCULATORY SYSTEM). The lymphatic system acts in a similar way to remove other waste products from tissues (see LYMPHATIC SYSTEM).

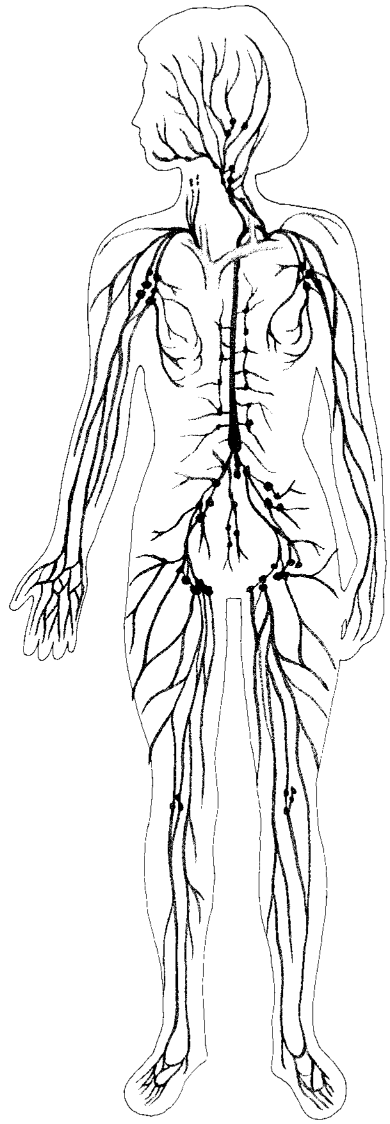
The respiratory system provides oxygen from the air for the blood. This occurs in the lungs. When a person inhales, he or she is taking in air that contains oxygen for the blood to carry to the cells. When a person exhales, he or she is releasing air that contains carbon dioxide that the blood has carried from the cells (see RESPIRATORY SYSTEM).

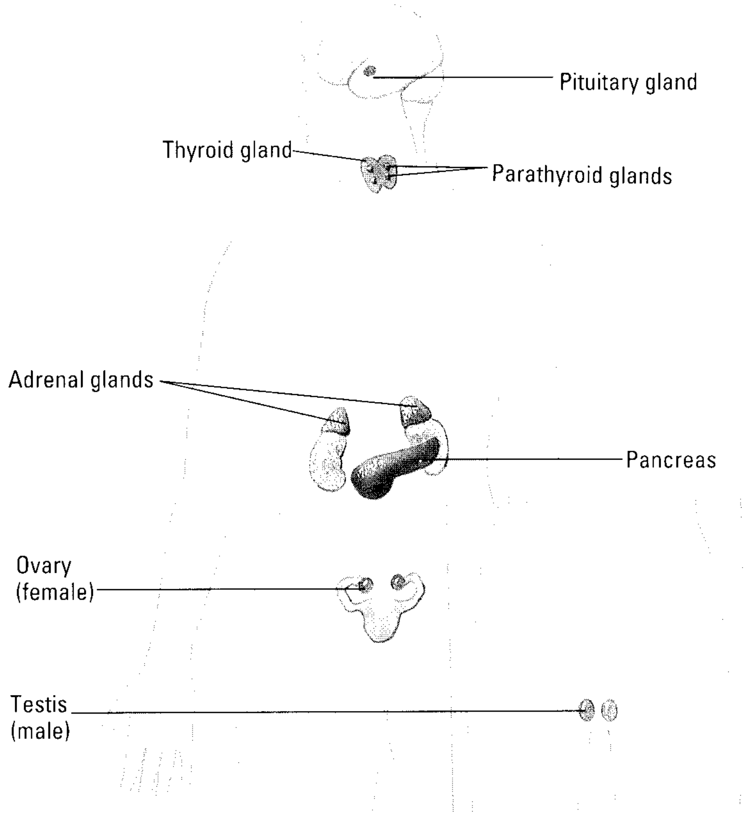
The digestive system provides nutrients for the blood to take to the cells. Food is brought into the body through the mouth and throat. In the stomach and small intestine, food is chemically changed into a form that the body can use. The blood carries the resulting nutrients from the small intestine to the cells. The unusable parts of the food are removed through the large intestine and anus (see DIGESTIVE SYSTEM). The kidneys, part of the excretory system, filter wastes and excess salts

**MUSCLES**

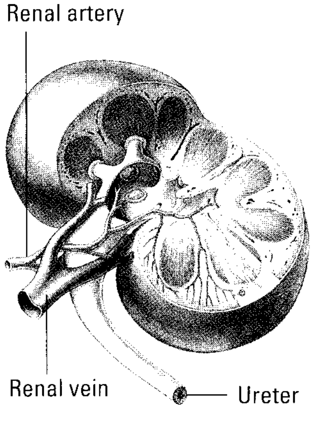
The muscles that cover the skeleton work with the bones to produce movement. By contracting or relaxing, pairs of muscles can move bones at joints. Other muscles keep the heart beating and food moving along the intestine.








**ENDOCRINE GLANDS**
The endocrine system sends chemical messengers, called hormones, to other parts of the body via the blood.




**THE LYMPH SYSTEM**
The lymph system (above) is a network of vessels that reaches almost every part of the body.

**KIDNEY**
Each kidney (left) forms part of the excretory system. They filter many waste chemicals out of the blood and pass them out of the body in the form of urine.

from the blood and store them in the bladder. When the bladder is full, its contents are passed out in the form of urine. The skin also gets rid of some wastes through sweating (see EXCRETION).

The reproductive system allows the body to produce offspring. The gonads, or sex organs, produce sex cells—eggs in the female and sperm in the male. The sex cells form a fertilized egg when they combine. The fertilized egg subsequently develops into an embryo. Each body has two gonads. A male gonad is called a testicle. A female gonad is called an ovary. The penis of the male transfers sperm into the vagina of the female. A sperm and an egg combine in one of the female's fallopian tubes (see REPRODUCTIVE SYSTEM).

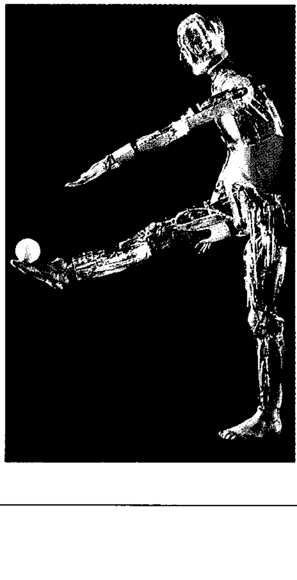
Two systems control all of the other systems to see that they work properly. The nervous system sends signals to and receives signals from parts of the body by means of impulses. These impulses are similar to electricity. The system includes the brain, spinal cord, and nerves (see NERVOUS SYSTEM). The endocrine system sends signals to parts of the body by means of chemicals in the blood (see ENDOCRINE). These chemicals are called hormones. The endocrine system includes organs such as the pituitary gland, adrenal glands, and thyroid gland.

*See also* PHYSIOLOGY.

**ANCHOVY** (ăn′chō′vē) Anchovies are small, herringlike, saltwater fish belonging to the family Engraulidae (see HERRING). There are more than one hundred species. Anchovies grow from 4 to 10 in. [10 to 25 cm] in length. They have large eyes and mouths. Anchovies are found all over the world and are especially abundant off the coasts of Peru and Chile. The fish is used to make animal feed, fish bait, and fertilizer. Some species of anchovy are filleted, salted, packed in oil, and sold as a food delicacy.

**ANDREWS, ROY CHAPMAN** (1884–1960) Roy Chapman Andrews was an American naturalist and explorer. He was born in Beloit, Wisconsin. He was an authority on whales. In 1906 he joined the staff of the Museum of Natural History in New York City, and he became its director in 1935. Andrews led six paleontological expeditions to Asia during the 1920s (paleontology is the study of fossils). Among Andrews's most important discoveries were dinosaur eggs and the remains of large land mammals thought to have lived more than 90 million years ago. His writings include *On the Trail of Ancient Man* (1926) and *Quest for the Snow Leopard* (1955).

**ANDROID** An android is a type of automation, a machine designed to carry out a limited range of actions. Automata can be made to look like birds or animals, but androids always resemble humans. Unlike a true robot, however, an android cannot be reprogrammed to perform a variety of tasks (see ROBOTICS).



ANDROID
This android is used by the Department of Energy to test protective clothing such as space suits. As well as being fully articulated, it has systems to simulate sweating and breathing.

The first androids were made hundreds of years ago in Europe. They were art objects, most often clocks with humanlike figures that rang bells.

The so-called androids in science-fiction stories are imaginary devices. Some have the characteristics of robots, whereas others, made entirely of biological materials, are meant to be indistinguishable from human beings.

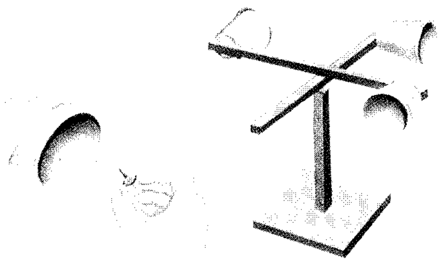
**ANEMIA** (ə nē′mē ə) Anemia is a condition in which there is a decrease in either the quantity of red blood cells or in the amount of hemoglobin in a person's blood. Red blood cells pick up oxygen in the lungs and carry the oxygen to body tissues. Hemoglobin is an iron-containing protein that is carried in the red blood cells. Hemoglobin gives blood its red color and makes it possible for the blood to carry oxygen (see BLOOD; HEMOGLOBIN).

Anemia has a number of different causes. Excessive blood loss—for example, from a wound—is one possible cause. In other cases, the bone marrow does not produce enough red blood cells because of a deficiency of a certain nutrient. If a person does not get enough iron, vitamin $B_{12}$, or folic acid in the diet—or if the body cannot absorb these nutrients properly—inadequate production of red blood cells may result. Pernicious anemia, for example, results from a deficiency of vitamin $B_{12}$. Aplastic anemias occur when the bone marrow loses its ability to produce red blood cells because of diseases such as leukemia (a form of cancer), or exposure to certain chemicals or forms of radiation, e.g., X rays.

Normally, old red blood cells are destroyed in the liver, but more slowly than new red blood cells are produced. If destruction occurs too fast, anemia may result. Too-fast destruction may be caused by hereditary diseases, such as sickle cell anemia, that produce abnormal red blood cells. Such cells are destroyed more quickly than normal red blood cells (see SICKLE CELL ANEMIA).

Some common symptoms of anemia are feeling tired all the time, being short of breath, and having abnormally pale skin. To cure anemia, doctors treat its cause. For example, a person may need to take iron or vitamin supplements.

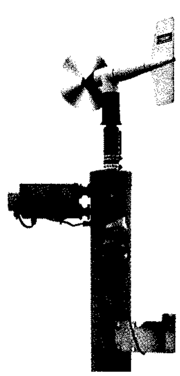
**ACTIVITY** *How to make an anemometer*



Pin four plastic cups to pieces of wood or stiff paper. Glue the wood to form a cross and make a hole in the center. Loosely pin the cross to an upright post so it will rotate in the wind.
**Caution: Handle the pins carefully.**

**ANEMOMETER** (ăn′ə mŏm′ĭ tər) An anemometer is an instrument that tells how fast the wind is blowing. The simplest anemometer, known as the Robinson's anemometer, has three or four cups attached to a vertical pipe. The wind catches the cups, spinning them around. The wind's speed is measured by how many times the cups go around in a certain period of time. Two other kinds, the hot wire anemometer and the pressure plate anemometer, give truer readings.

Airplane pilots and sailors need to know the speed of the wind. A meteorologist needs to use an anemometer when making a weather forecast.
*See also* WEATHER. PROJECT 25



ANEMOMETER
An anemometer is a device used for measuring wind speed. This anemometer has a small propeller that is turned in the wind. As the speed of the wind changes, so does the speed of rotation of the propeller. A gauge on the shaft records the number of rotations.

**ANESTHETIC** An anesthetic is a substance that causes loss of feeling in the body. A local anesthetic causes the loss of feeling in a small part of the body, such as a finger. Local anesthetics work by blocking the passage of pain messages in the nerves that connect various parts of the body to the brain. A general anesthetic causes loss of feeling throughout the entire body. General anesthetics work in the brain itself to shut off perception of all sensations. Unconsciousness usually occurs when a general anesthetic is used.

Anesthetics are used by doctors to stop pain. When a cut has to be stitched closed, a doctor will inject a local anesthetic so that the patient will not feel the pain of the stitching. The patient remains awake and alert. When more extensive surgery is necessary, such as an operation to remove an appendix, a doctor will give the patient a general anesthetic. This will stop all pain and keep the patient asleep until the operation is over. A physician called an anesthesiologist is trained to give the proper amount of anesthetic to patients.

Common general anesthetics are nitrous oxide ("laughing gas") and halothane. Common local anesthetics are lidocaine and procaine. Anesthetics were first used in 1844 by Horace Wells, a dentist.
*See also* ACUPUNCTURE; DAVY, SIR HUMPHRY; NITROUS OXIDE; PROCAINE.

**ANEURYSM** (ăn′yə rĭz′əm) An aneurysm is an enlargement of a blood vessel. Aneurysms can cause severe pain, especially if they rupture, or break. When an aneurysm ruptures, it produces a hemorrhage, or uncontrollable bleeding. If a hemorrhage occurs in the heart or aorta, the main artery leading from the heart, death can occur. Aneurysms can put pressure on organs even if they do not rupture. This is particularly serious when pressure is put on a part of the brain.

Aneurysms can have many causes. These include birth defects, certain infections, high blood pressure, and injuries. Aneurysms can be detected by X rays and treated by surgery. A small vessel with an aneurysm can be removed or tied off to prevent the flow of blood through it. A large vessel can be replaced by another vessel. The large vessel is removed, and a vessel from another part of the body is surgically implanted. A large vessel also may be repaired through grafting. In grafting, the aneurysm is cut out of the vessel, and body tissue from another part of the body is placed over the hole.
*See also* HEART.

**ANGELFISH** Angelfish are deep bodied, colorful fishes, some of which live in fresh water and some in salt water. Marine angelfish are usually found swimming among coral reefs, where their flattened shapes help them to move about the coral. They feed on tiny reef creatures which they probe from crevices. A kind of freshwater angelfish called the scalare is often kept in aquariums.

**ANGIOGRAPHY** Angiography is an X-ray procedure that examines the body's blood vessels. Angiography helps a doctor determine whether a blood vessel is blocked or diseased.

When angiography is performed, a thin, flexible tube called a catheter is inserted into a particular place on the patient's body. A substance called a contrast medium is injected through the catheter. X rays are then directed at the part of the body being studied (see X RAY). The X-ray machine is connected to a television monitor. The radiologist (physician trained in the use of radiation) watches the monitor (see RADIOLOGY). The contrast medium highlights the blood vessels in the image, making them easier to see. Sometimes, the images are videotaped for the radiologist to examine again later. The X-ray images that result from the angiographs are called angiograms. There are several different types of angiograms. For example, a cerebral angiogram is an image of the blood vessels in the head.

A newer type of angiography is called digital subtraction angiography. Digital subtraction angiography (DSA) uses a computer. Two images are made of the same organ. The first image is made before the contrast medium is injected. The second is made after it is injected. The computer subtracts the first image from the second to make a third image. This third image shows a clear picture but this time of only the blood vessels. If angiographic examination of a patient shows that certain blood vessels are blocked or diseased, the doctor may recommend angioplasty. A similar technique to angiography is ventriculography. A contrast medium is injected into the ventricles through a catheter. An X ray is then taken to see if the ventricles are pumping correctly.

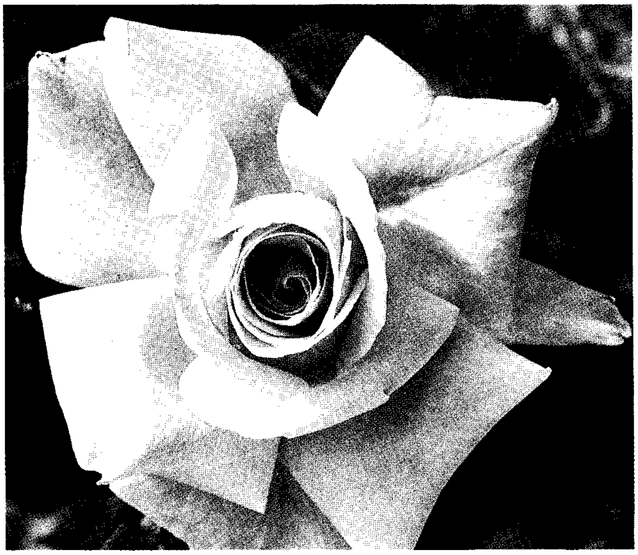
**ANGIOPLASTY** Angioplasty is a procedure used to clear arteries of the heart that are blocked by deposits called plaques (see ARTERIOSCLEROSIS). A catheter, or very narrow tube, with a tiny, collapsed balloon at the tip is inserted into an artery in the arm or the upper part of the inner thigh. The catheter is moved toward the heart and finally to the artery that is blocked. There, the balloon is inflated by a pump that is attached to the other end of the catheter. The balloon expands, compressing the blockage and clearing a wider opening through which the blood can flow. The balloon is then deflated, and the balloon and catheter are taken out of the body.

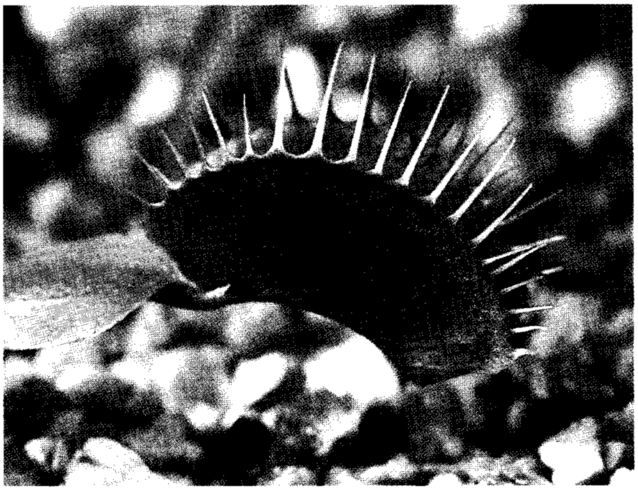
Angioplasty was introduced in 1977 by Dr. Andreas Gruntzig of the University of Zurich in Switzerland. Before then, doctors had used only open-heart bypass surgery to repair blocked arteries. In bypass surgery, a vein, usually taken from the patient's leg, is surgically implanted near the heart to route blood around the blockage. Angioplasty can be an alternative to bypass surgery for patients with certain conditions.
*See also* HEART; HEART DISEASE.

**ANGIOSPERM** An angiosperm is any plant that grows flowers. *Angiosperm* is another name for all the plants of the division Anthophyta. Not all angiosperms produce flowers that are bright and colorful like those found in gardens. For example, even the grass in a lawn grows flowers. Grass flowers are small and green, so they are rarely noticed. Grass, like other angiosperms, also bears fruit, which develops from the flowers. All of an angiosperm's seeds are found inside its fruit.

Angiosperms are the most common type of plant on Earth. There are more than 250,000 species. There are two groups of angiosperms: monocotyledons and dicotyledons. Monocotyledons have seeds with one leaf inside. They usually have long, narrow leaves and flower parts in groups of three. Dicotyledons have seeds with two leaves inside. They usually have wide leaves and flower parts in groups of four or five.
*See also* DICOTYLEDON; FLOWER; MONOCOTYLEDON; PLANT KINGDOM.

PROJECT 62





**ANGIOSPERM**

Common angiosperms, or flowering plants, include (clockwise from top left) roses, which produce colorful fragrant flowers; the nettle, which has special stinging hairs on its leaves and stem; the Venus's-flytrap, which can catch insects between its special leaves, edged with spikes; and the maple, which has a woody stem and leaves that change color in the fall.

**ANGSTROM UNIT** An angstrom unit, or angstrom, is an extremely small unit of length. It is equal to one ten-billionth of a meter. Its symbol is Å. Angstrom units are used to describe very short distances or lengths. For example, the smallest atoms are about one angstrom across, and the largest are about six angstroms across. Scientists once used the angstrom to measure wavelengths of light rays, but they now use the nanometer. The nanometer is one billionth of a meter. The angstrom unit was named for Anders Ångström, a Swedish physicist.

**ANHYDRIDE** (ăn hī'drīd') Anhydrides are chemical compounds from which water has been removed. For example, taking water ($H_2O$) out of sulfuric acid ($H_2SO_4$) makes an anhydride. It is called sulfur trioxide ($SO_3$).

There are two kinds of anhydrides. An acid anhydride is what remains after water is taken out of an acid. A basic anhydride combines with water to form bases (see ACID; BASE).

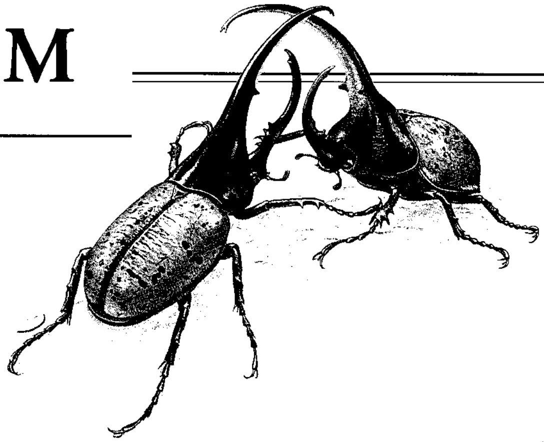
Anhydrides are important in chemistry. They are used in making other compounds. One of the most important anhydrides is acetic anhydride. It can be made into acetic acid.

*See also* ACETIC ACID.

**ANILINE** (ăn'ə lĭn) Aniline is a colorless, oily, poisonous liquid. It is made by reducing nitrobenzene (see OXIDATION AND REDUCTION). Aniline is used in the manufacture of rubber and drugs and in the making of dyes. The boiling point of aniline is 363.43°F [184.13°C]. Its freezing point is 20.7°F [-6.3°C]. Aniline has the formula $C_6H_5NH_2$.

# ANIMAL KINGDOM

All animals are said to belong to the animal kingdom. Most animals can move. Most have eyes, legs, and a head. However, some simple animals do not have eyes, or legs, or a head. Some animals that live in the ocean look like plants. The sea anemone is an example of a plantlike animal. The easiest way to tell the difference between plants and animals is to see how they obtain their food. Plants make their own food by photosynthesis (see PHOTOSYNTHESIS). Animals cannot use photosynthesis. They must get their food by eating plants or other animals. A tiny worm and a huge whale have one thing in common. They cannot make their own food. They must go out and find it and eat it.

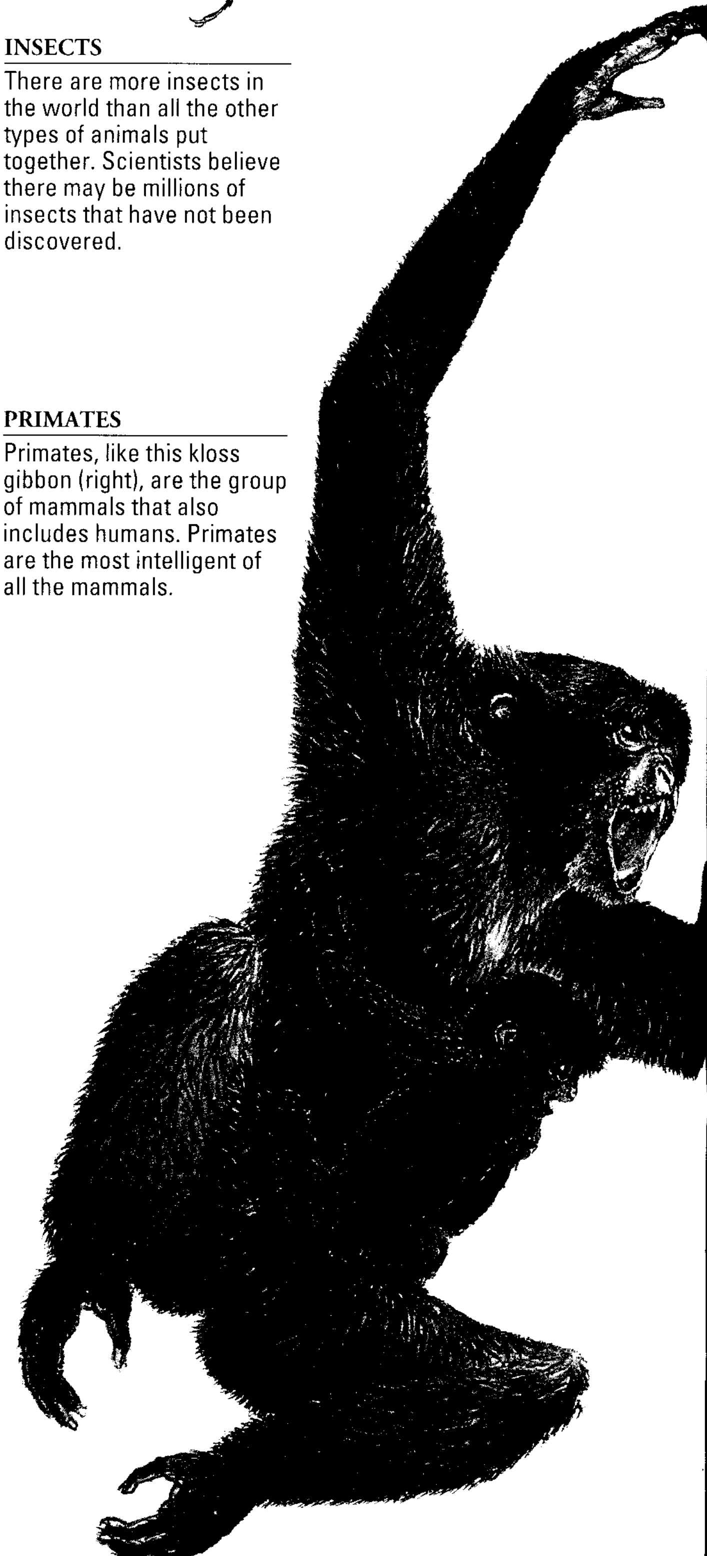


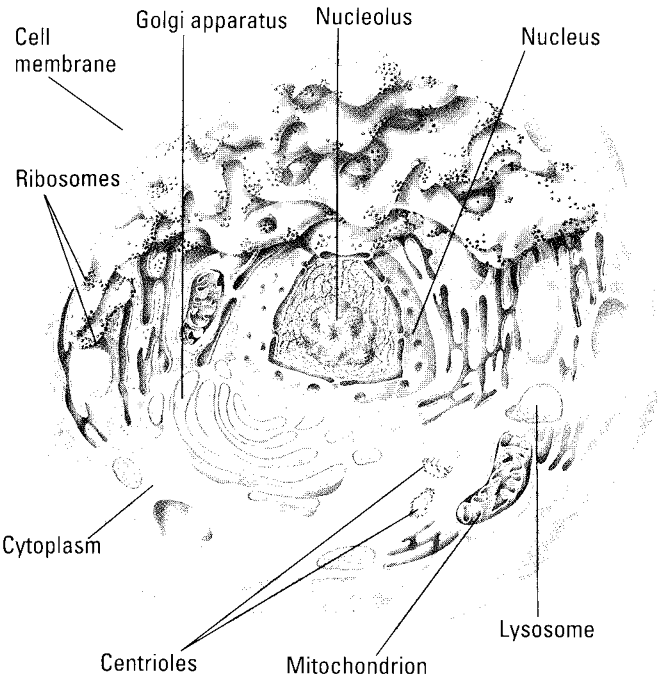
**INSECTS**

There are more insects in the world than all the other types of animals put together. Scientists believe there may be millions of insects that have not been discovered.

**PRIMATES**

Primates, like this kloss gibbon (right), are the group of mammals that also includes humans. Primates are the most intelligent of all the mammals.

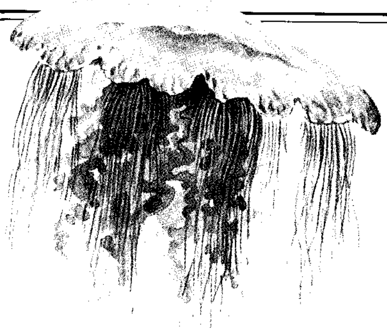




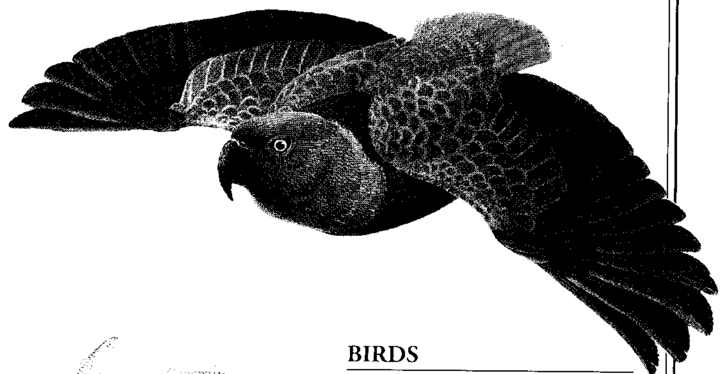

**CELL**

Every living animal is made from cells, like the one shown here. Some animals consist of only one cell, but others—like humans—are formed from millions of different cells.

There may be as many as thirty million species of animals. Only about one million are known to scientists. Some live at the bottom of oceans. Some live at the top of mountains. Animals are found at the North Pole and at the Equator. Some species have only one cell. Others have billions of cells. A sponge is a very simple animal that sits in one place. A human being is a very complex animal

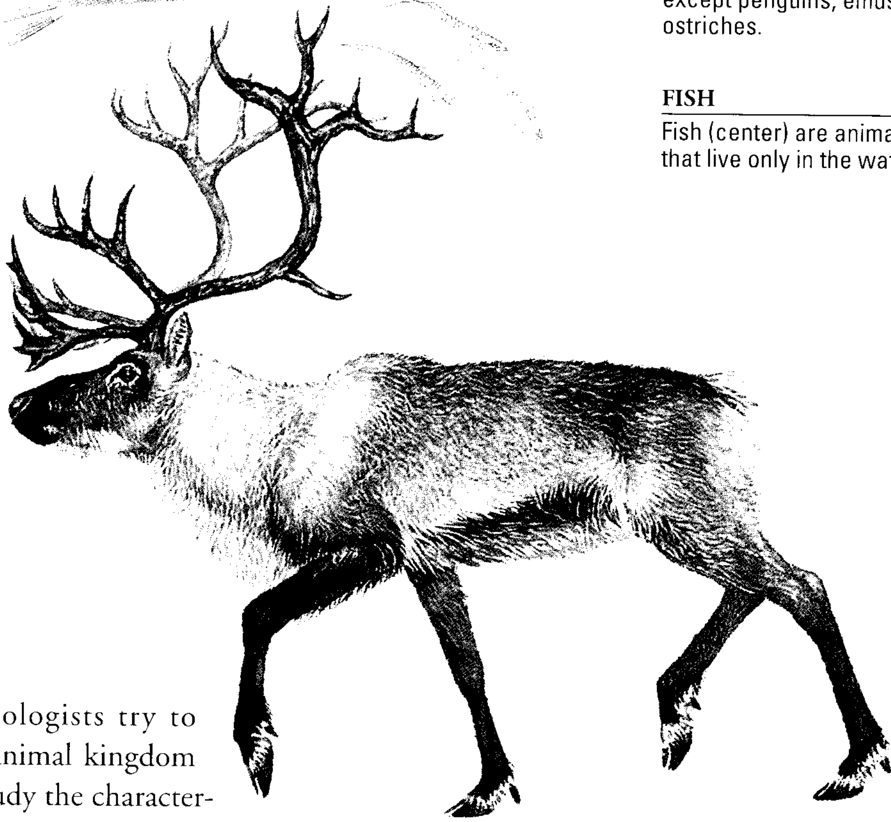


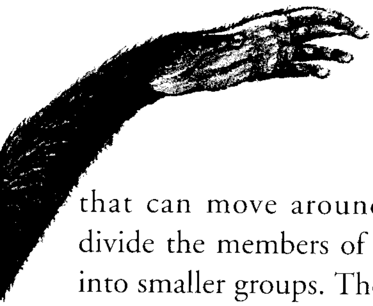
**CNIDARIANS**
Among the simplest of animals are the Cnidaria. This is the group that includes species such as the blue jellyfish (left), as well as sea anemones.



**BIRDS**
Birds are the only animals that have feathers. Almost all species of birds can fly except penguins, emus, and ostriches.

**FISH**
Fish (center) are animals that live only in the water.





that can move around. Biologists try to divide the members of the animal kingdom into smaller groups. They study the characteristics of each animal. Then they decide to which group it belongs.

Each animal in the animal kingdom belongs to a smaller group called a phylum (see CLASSIFICATION OF LIVING ORGANISMS). The following are major phyla in the animal kingdom: Porifera (sponges), Cnidaria (jellyfishes), Platyhelminthes (flatworms), Nematoda (roundworms), Mollusca (clams and octopuses), Annelida (segmented worms), Arthropoda (insects, crabs, shrimp, spiders), Echinodermata (starfish), and Chordata (all higher animals with nerve cords). Most of the familiar animals have nerve cords and backbones. They are also called vertebrates. Fish, frogs, birds, dogs, cats, and humans are all examples of vertebrates, members of the Chordata. Animals that do not have backbones are called invertebrates.

**HOOFED MAMMALS**
The reindeer is a mammal—a warm-blooded vertebrate that suckles its young. A reindeer has flat, broad hoofs that are good for walking on soft ground and snow.

The study of animals and the animal kingdom is called zoology. A scientist who studies zoology is called a zoologist.

*See also* INVERTEBRATE; KINGDOM; VERTEBRATE; ZOOLOGY.

**ANION** (ăn'ī'ən) An anion is a negatively charged ion. Anions were discovered and named in 1834 by Michael Faraday, a British physicist and chemist (see FARADAY, MICHAEL).

Anions carry a specific number of negative electric charges. For example, the chlorine ion ($Cl^-$) has an electric charge of one, meaning it is a univalent anion. The sulfate ion ($SO_4^{2-}$) has a negative electric charge of two. It is a bivalent anion.

Anions move toward the positive electrode, or anode, during electrolysis.

*See also* ELECTROLYSIS; IONS AND IONIZATION; VALENCE.

**ANNEALING** Annealing is the manufacturing process by which molten metal or glass is gradually cooled. Controlled cooling of steel, for example, softens it and makes it more ductile, or easier to work with. Cooling is done first in a furnace, then in air. Glass is cooled slowly in annealing ovens to prevent stains and bubbles caused by carbon dioxide. Slow cooling allows heat to drive off the carbon dioxide.

Quenching and tempering are two other steelmaking processes related to annealing. In quenching, the steel is heated to a critical temperature. It is then plunged into water or oil for quick cooling. This makes the steel strong, hard, and brittle. In tempering, steel is reheated to a temperature just below the critical temperature, and then cooled slowly. This softens the steel and increases its toughness.

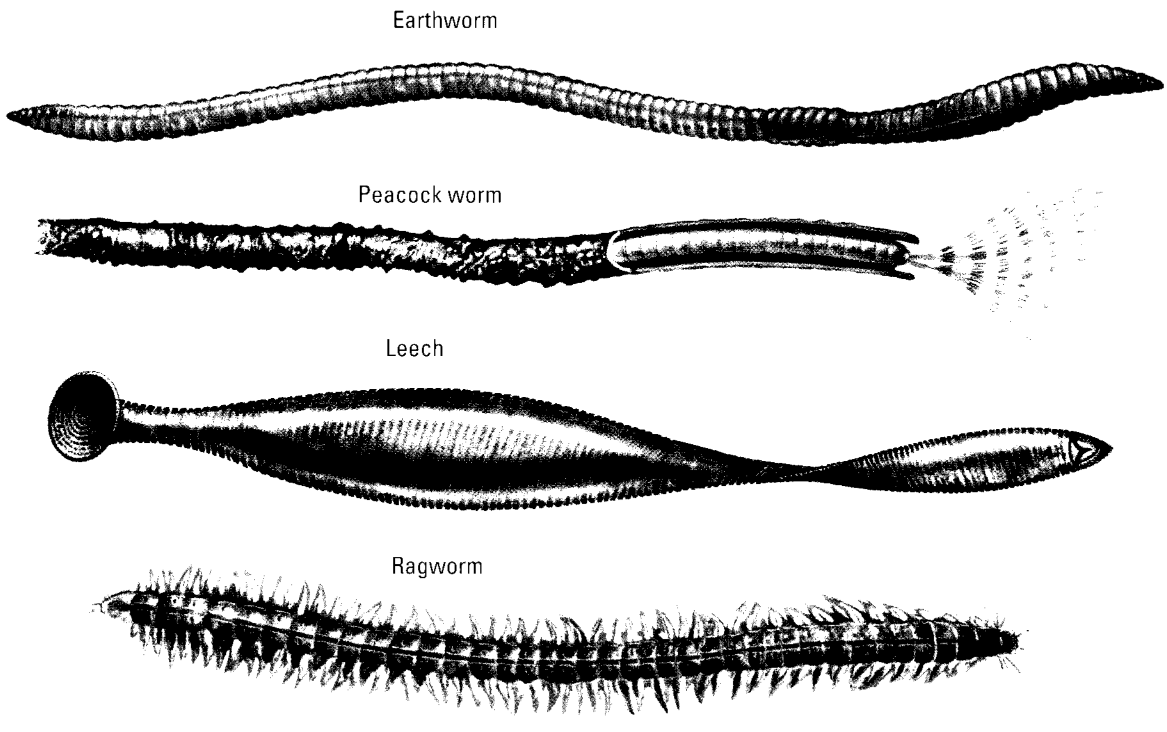
*See also* STEEL.

**ANNELIDA** (ə nĕl'ĭ də) Annelida is a phylum containing about 13,000 species of invertebrate animals. There are three classes of annelids: Polychaeta (marine worms), Oligochaeta (earthworms), and Hirudinea (leeches). Annelids, or segmented worms, are much more complex than Platyhelminthes (flatworms) and Nematoda (roundworms). Each segment has a set of muscles and there may also be flaps or bristles to help the worm to move. Their patterns of development resemble those of arthropods and mollusks. Annelids that live on land, such as the earthworm, usually develop inside an egg. The marine worms produce a free-swimming larva that eventually metamorphoses into the adult worm.

*See also* ANIMAL KINGDOM; INVERTEBRATE.

**ANNELIDA**

Of the four typical annelids shown, the earthworm is perhaps the best known. The peacock worm and the ragworm are marine forms—that is, they live in the sea. The leech feeds by sucking the blood of other animals.



ANNUAL PLANT

The sunflower can grow up to 10 ft. [3 m] in one year before it produces its seeds and dies.

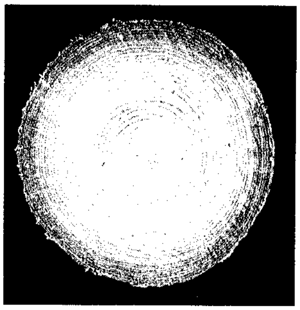
**ANNUAL PLANT** An annual plant is a plant that lives for only one growing season. It grows from a seed in the spring. It flowers in the summer. It scatters seeds and dies in the fall. The plants that appear the next spring grow from the seeds of the dead plant. Examples of annual plants are the bean, nasturtium, pea, petunia, radish, sunflower, sweet pea, and tomato.

**ANNUAL RING** A circular line in the wood of a tree that shows how it has grown is called an annual ring. As a tree gets older, it grows taller and thicker. To grow thicker, a tree adds wood underneath its bark. In tropical regions where there is no winter, trees grow year-round. In places where there is a cold winter, trees stop growing during the winter.

When growth stops in the fall, the wood cells are smaller than they are in the spring, when growth continues. If a tree is cut down and sawn straight across, the change from fall to spring growth appears as a circular line in the wood. There is one ring in the wood for each year the tree has grown. The age of a tree can be told by counting the rings on its stump after the tree has been cut down.

Scientists learn about weather conditions in the past by studying the width of annual rings. The annual ring produced in a dry year is narrow. The annual ring produced in a wet year is wide.

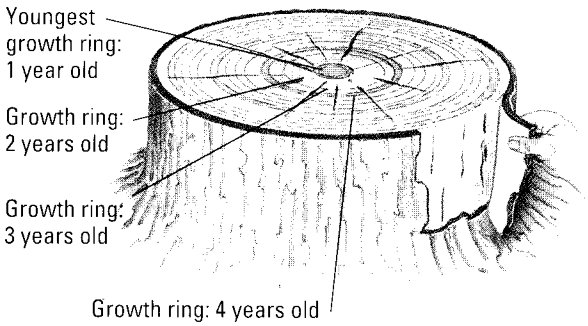
*See also* DATING.



ANNUAL RING

The cross section of a tree trunk reveals important information to scientists. Each ring of a tree represents a year's growth.

**ACTIVITY** *How to see annual rings*




Look at a log or the cut stump of a tree. Use the diagram above to help you work out how old the tree was when it was cut down. Each ring represents one year's growth.

**ANODIZING** Anodizing is a way of coating certain metals with an oxide film. This film resists corrosion. Aluminum and magnesium are the metals most often anodized. Sometimes, zinc is anodized (see CORROSION; OXIDE).

The natural oxide film on aluminum is thin. Anodizing makes a thicker oxide layer. This protects the aluminum from corrosion and makes it last longer.

In anodizing, aluminum is used as a positively charged electrode of an electrolytic cell. Electrolytes such as sulfuric acid are used (see ELECTROLYSIS). The oxide layer forms from the metal surface outward. This results in the outside layer being slightly rough and porous. It must be sealed by boiling it in water. This prevents harmful substances from attacking the metal.

Anodizing with sulfuric acid makes a clear oxide film. With chromic acid, a dull film is produced. The film may sometimes be dyed for decorative purposes. Chromic acid is also used for anodizing zinc.

**ANOREXIA NERVOSA** Anorexia nervosa is an eating disorder in which a person refuses to eat. Anorexia nervosa occurs mostly in females who are adolescents or young adults. The anorexic may seem to act normally and may even be a "model" student. Symptoms of anorexia nervosa include loss of up to fifty percent of body weight, excessive fear of being fat, distorted body image, and a preoccupation with food and exercise. Because the anorexic's body is so underweight, she may also have low blood pressure, body temperature, and heart rate, and extreme sensitivity to cold.

The anorexic is driven to lose weight because of personal stress and beliefs by society that thinness is beautiful. The anorexic starves herself and compulsively exercises to become thin, even though her weight may be normal. Anorexics also may suffer from bulimia. Bulimia is an eating disorder that involves overeating in secret, followed by self-induced vomiting (see BULIMIA).

Treatment for anorexia nervosa can involve hospitalization or psychological therapy. An anorexic may remain in the hospital for weeks or even years. While in the hospital, the patient may be fed through tubes if the condition becomes life-threatening. Therapists work with anorexics to solve problems such as depression, feelings of helplessness, low self-esteem, and guilt. Many recovered anorexics are still uncomfortable with eating and their body image. The disorder has a high relapse rate, and a small percentage of cases end in death.

**ANT** Ants are insects that belong to the order Hymenoptera. There are many thousands of species of ants. They range in size from approximately 0.08 to 1 in. [2 to 25 mm] long. Ants are found in most parts of the world. They are related to bees.

Ants are social animals. This means that they live together in large colonies, or groups. Some colonies may contain millions of ants. Most colonies make nests in the ground or in dead trees. Others do not make nests. The army ants of the tropical jungles march to a different place every day. Thousands of them march in a narrow band and eat any animal that cannot get out of their way. Army ants can eat all the flesh of an animal very quickly.

ANT
There are thousands of different species of ants. There are also different kinds of ants within a species, such as queens, soldiers, and workers (shown here).

There are different types of ants within each colony. Usually there is only one queen ant, a female that is the most important insect in the colony. The queen is the only ant that can lay eggs. When the eggs are fertilized by males, the eggs hatch into female worker ants. When the eggs are not fertilized by males, they hatch into more male ants (see PARTHENOGENESIS). Although there are thousands of worker ants in each colony, there are few male ants in a colony. Queen and male ants have wings. The queen and a male ant mate while flying in the air. Worker ants do not have wings. Worker ants collect food, feed the young ants, and build the nest. Some species of ants also have female soldier ants. They protect the nest.

Ants can do many things. They are able to travel long distances away from their nest and find their way back, because they follow their own chemical trails. Some ants can also grow food. They chew up leaves and store them in their nests. When a fungus grows on the leaves, they harvest the fungus for food. They also eat a sugary substance produced by aphids. Some species of ants keep aphids in almost the same way that humans keep cows for milk (see APHID). Ants are very strong. They can lift things that weigh fifty times as much as they do. To match this, a person weighing 200 lb. [91 kg] would have to lift 10,000 lb. [4,536 kg].

**ANTEATER** Anteaters are furry mammals (see MAMMAL). They belong to the order Edentata, which means "toothless." Anteaters have a long, sticky tongue. Their snout is long and slender. With their powerful claws, they can rip open the nests of insects. They eat ants and termites. Most anteaters are nocturnal animals. This means they come out mostly at night. The giant anteater comes out in the day. Anteaters live alone.

There are three kinds of anteaters: the giant anteater, the collared anteater, and the silky (or two-toed) anteater. The giant anteater is about 7 ft. [2.1 m] long from the end of its tail to the tip of its nose. It wanders the tropical grasslands in search of food. The collared anteater, or tamandua, is about 3.3 ft. [1 m] long. It gets its name from the coloration of fur around its shoulders, chest, and neck. The collared anteater climbs in trees and can hold onto branches with its tail. The silky anteater is 18 in. [45.7 cm] long. It also climbs trees and uses its tail for holding. All three types of anteater are found only in South America.

**ANTELOPE** Antelopes are four-legged mammals that belong to the family Bovidae. Antelopes are a type of ungulate, which is an animal with hooves (see MAMMAL; UNGULATE). Antelopes are found in Africa and Asia, usually in large herds. They are all ruminants (see RUMINANT). This means they are cud-chewers. They swallow their food without having completely chewed it. Later this food is brought back up and rechewed as cud. Then it is swallowed

ANTEATER

The giant anteater is perfectly adapted for its insect diet. It rips open ant and termite nests, and then licks up the insects using its long, sticky tongue.

again. Like most ruminants, antelopes have four-part stomachs.

Most antelopes are swift, delicate animals. They range in size, at shoulder height, from about 1 ft. [0.3 m] to about 6 ft. [2 m]. The smallest antelope is the royal antelope. The largest is the giant eland (see ELAND).

Both the male and female antelope may have horns. The horns on the female are usually smaller than those of the male.

Two of the best-known species of antelopes are the gnu and the impala (see GNU; IMPALA). Antelopes provide a major food source for the large African and Asiatic carnivores (meat eaters). People also use the flesh of the antelope for food. The hide is often used for clothing, blankets, rugs, or ornamental purposes.

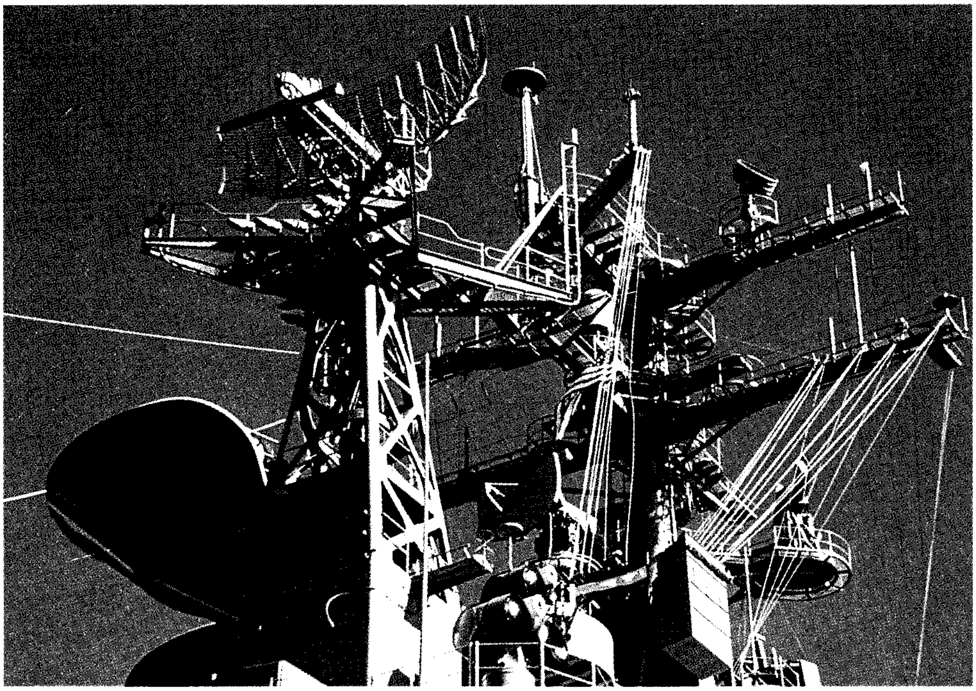
**ANTENNA** An antenna is a piece of equipment for sending and receiving electromagnetic radiation. It is a basic part of all electronic communication systems. It is used for radio, television, radar, and radio telescope operations. An antenna is also called an aerial (see RADAR; RADIO; RADIO ASTRONOMY; TELEVISION).

There are two basic kinds of antennas. A dipole antenna has two pieces of metal or wire. A monopole antenna has a single metal or wire conductor. Antennas come in many shapes and sizes. Radio transmission antennas may be tall towers. Receiving antennas for transistor radios may be no bigger than a fingernail. Locations of antennas also vary. For example, some antennas, such as those for television transmitters, must be put on the tallest building or the highest land peaks.

The kind of antenna used depends on the type of electronic signal it sends or receives. Some signals require loop, or round, antennas. Other signals require vertical or horizontal antennas. The design of an antenna must match the frequency or wavelength of its signal. AM radio antennas are used for low-frequency signals. Low-frequency signals have long wavelengths. Television antennas are used for high-frequency signals. High-frequency signals have short wavelengths. Dish-shaped radar and radio telescope antennas are used for very high-frequency signals. Very high-frequency signals have very short wavelengths called microwaves (see MICROWAVE).

The first antenna was built by Heinrich Hertz, a German physicist, in about 1887. His pioneering research work with an antenna led to the invention of radio transmission and reception by an Italian engineer named Guglielmo Marconi, in 1896.

*See also* MARCONI, GUGLIELMO; ELECTRICITY; HERTZ, HEINRICH.



**ANTENNA**

These antennas allow the ship on which they are mounted to communicate with any part of the world. Antennas are a basic part of all electronic communication systems.