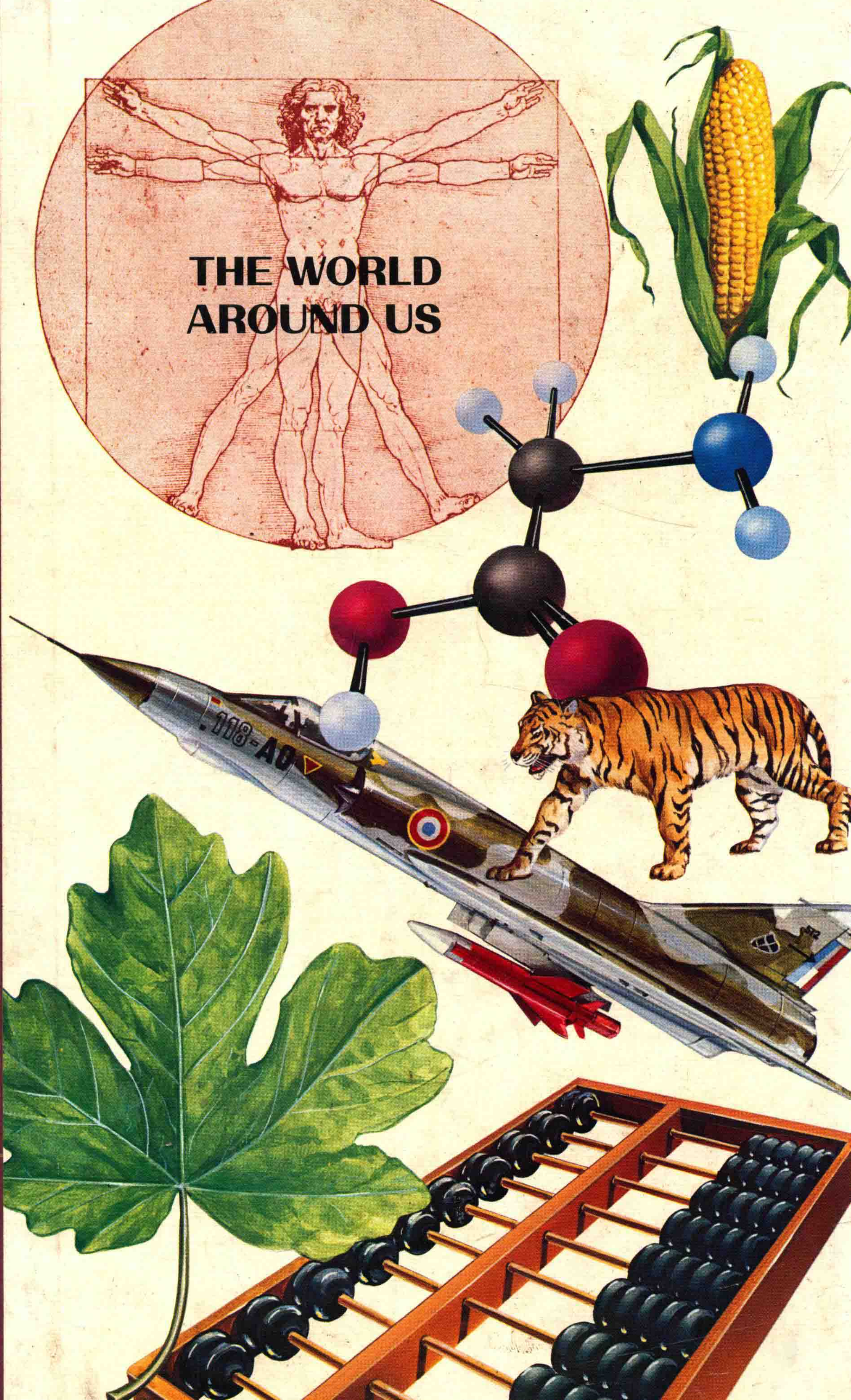
THE WORLD AROUND US

SCIENCE AND TECHNOLOGY ILLUSTRATED



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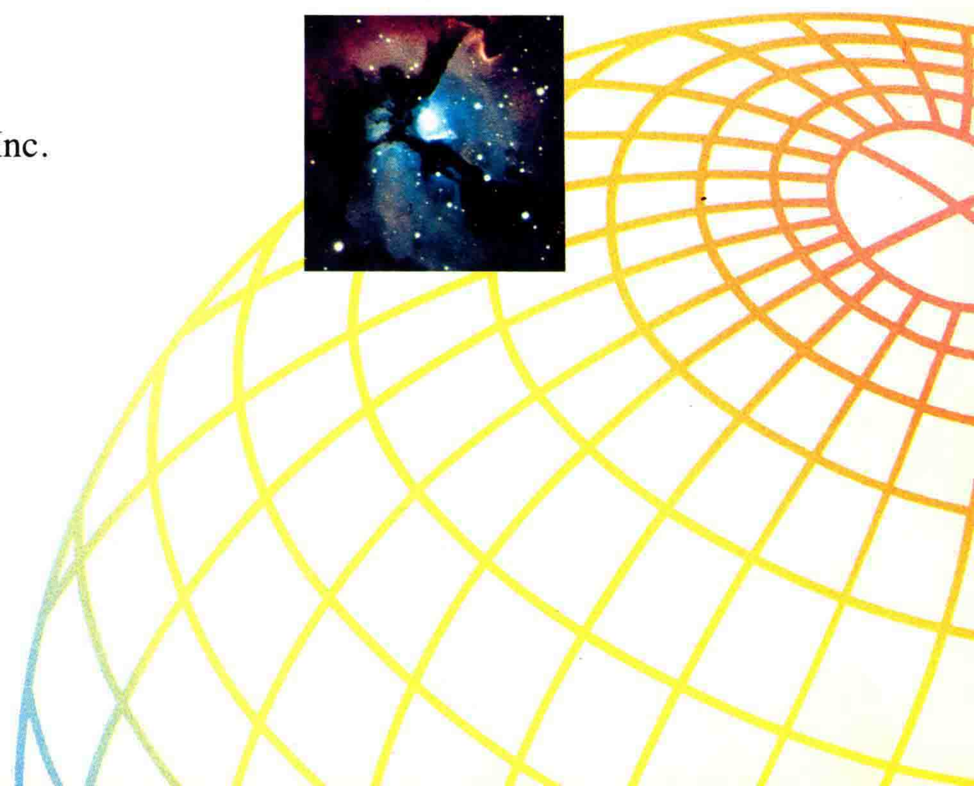

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Science and Technology Illustrated

The World Around Us

Science Technology

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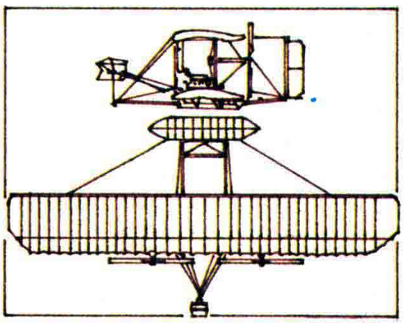

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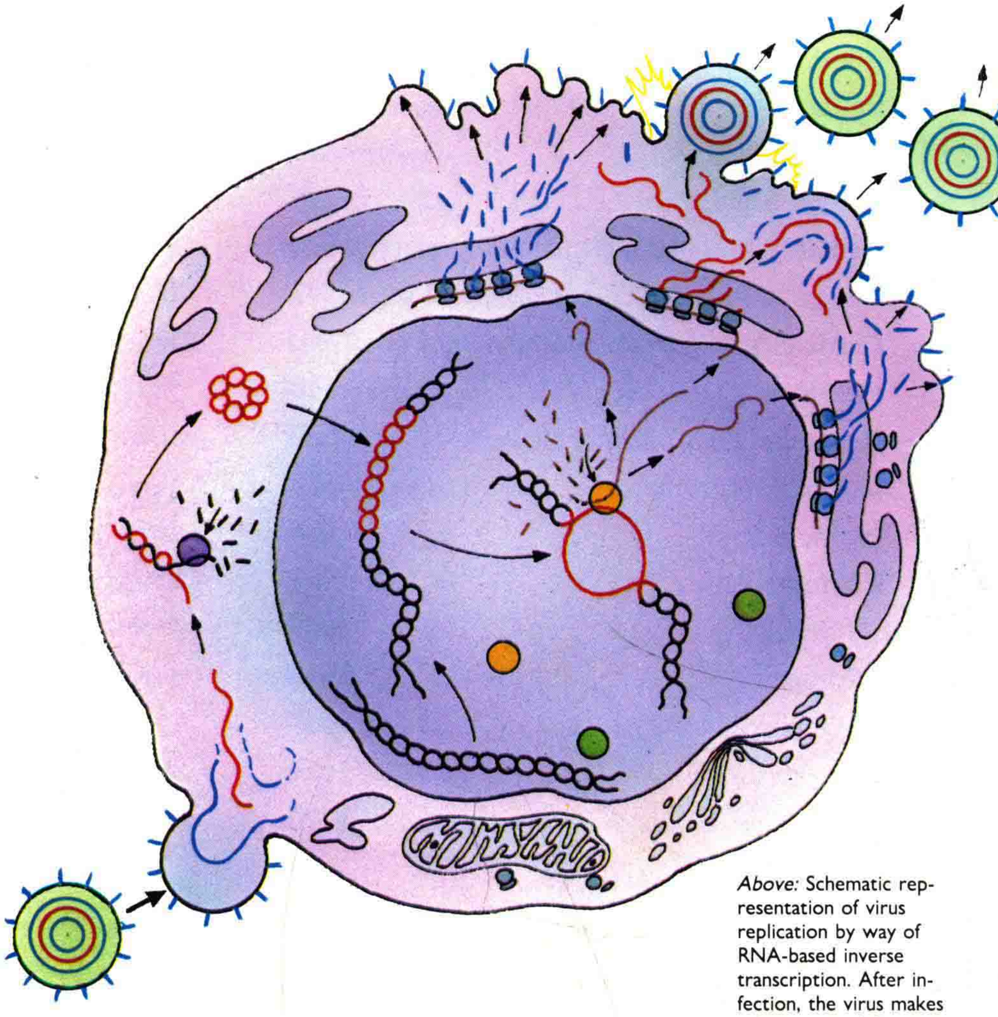
Herpes

The odds are overwhelming that nearly everyone has been exposed to at least one of the five herpesviruses that infect human beings. For example, nearly every American child gets chicken pox, an infection by the same herpesvirus. For that small percentage of people who never experience chicken pox in childhood, the odds still remain high of being infected at some point in life by a herpesvirus.

Incidence of Herpes

About 90 percent of us are infected by herpes simplex virus type 1, though only half get the cold sores and fever blisters associated with this infection. One in five American adults is affected by herpes simplex virus type 2, the genital herpes that is the most common venereal disease. By middle age, 80 percent of adults have been infected by cytomegalovirus, which produces symptoms similar to those associated with mild mononucleosis. About 85 percent of children have been infected by the Epstein-Barr virus, which may cause mononucleosis.

This alarming set of statistics indicates that the herpesviruses cause more illness in humans than any other virus group. Herpesviruses are also found in nearly every animal species. As yet, there is no cure for herpesvirus illnesses. Some consolation may be taken, however, in the knowledge that most of the viruses affect people when they are young and cause few or minor symptoms. Further, even though one may be infected, the symptoms may reveal themselves rarely or never.



Above: Schematic representation of virus replication by way of RNA-based inverse transcription. After infection, the virus makes indirect use of the genetic material of the host cell to generate other viruses.

Herpesvirus Behavior

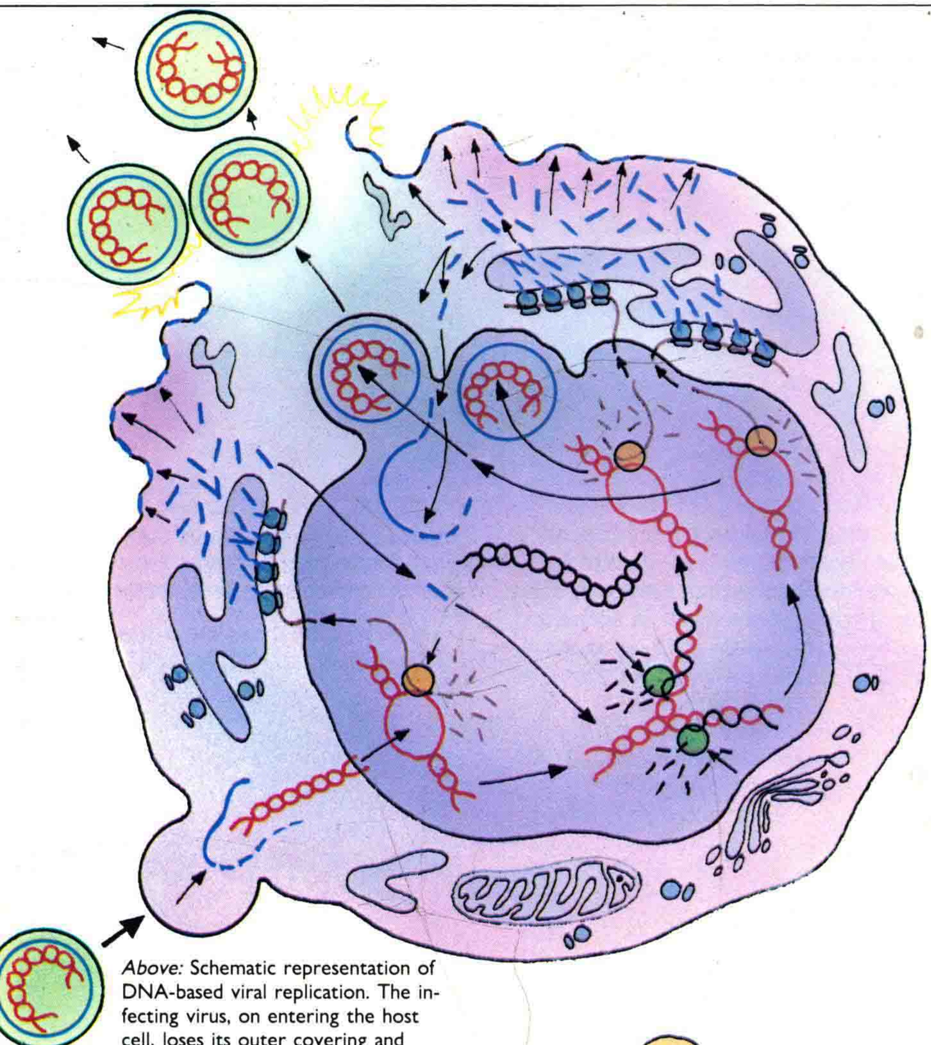
Viruses consist of a protein-coated core of nucleic acid (either DNA or RNA). These organisms can multiply only in the living cells of a host organism. Virus groups, such as the herpes family, are classified according to their origins, the effect they produce when they infect an organism, and the manner in which they travel.

One becomes exposed to the herpesviruses in a variety of ways, usually by direct contact with another person who has an active infection (as in the case of the herpes simplex) or by transmittal through the environment. The varicella-zoster herpesvirus, which causes chicken pox in children and shingles in adults, can be transmitted through the air when the infection is active.

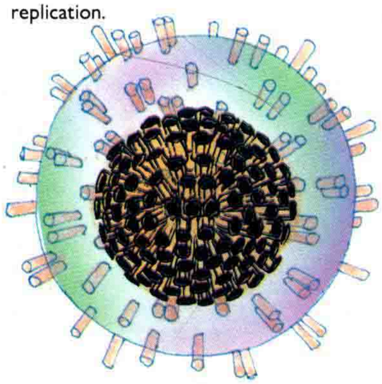
The assorted herpesviruses have widely disparate genetic structures and functions, but they work on cells similarly. When viruses attack a normal human cell, they commandeer the cell's genetic apparatus and use it to generate more viruses. The seizure of the cell by the herpesvirus usually results in the death of the cell, but the virus and the cell sometimes carry on a parasite-host relationship in which the cell harbors the virus in its inactive, or latent, stage. The herpesviruses characteristically stay in the host for life, and some, such as the cold sore and genital herpes, cause recurrent infections.

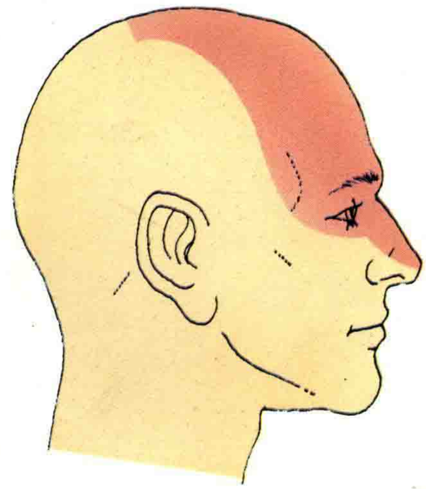
Some of the herpesviruses live in the white blood cells, others live in the epithelial tissues (tissue that lines body cavities and ducts), but much about how these viruses become active is unknown. Most of the knowledge available concerns the herpesviruses that reside in the nervous system, the herpes simplex (cold-sore and genital herpes) and the varicella-zoster herpesviruses (chicken pox and shingles). These viruses all travel along the nerve fibers until they establish residence in the ganglia (cluster of nerve cells). If the affected person is susceptible to relapses of herpes infections—in response to stress, illness, or other factors that upset the body's defenses—the dormant viruses can be awakened. When this happens, the virus will travel along the nerves to cause an infection, either the cold sores or genital blisters associated with the herpes simplex viruses, or shingles in the case of the varicella-zoster virus.

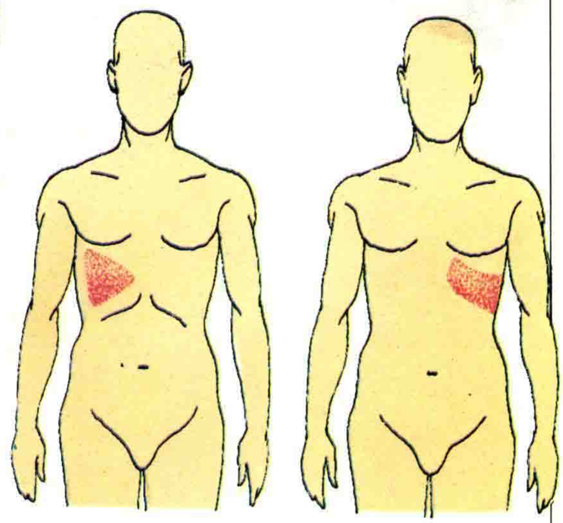
There is some evidence that herpesviruses are linked with cancer. Almost half of the women afflicted with cervical cancer show signs of herpesvirus. In laboratory research, it has been demonstrated that only a small percentage of the genetic information carried in a herpesvirus is required to make normal cells cancerous. It must be understood, however, that there is no definite proof that herpesviruses cause cancer in humans. Because of their complexity, very little definitive knowledge about the functions and ramifications of the herpesviruses and their effects on people is available.



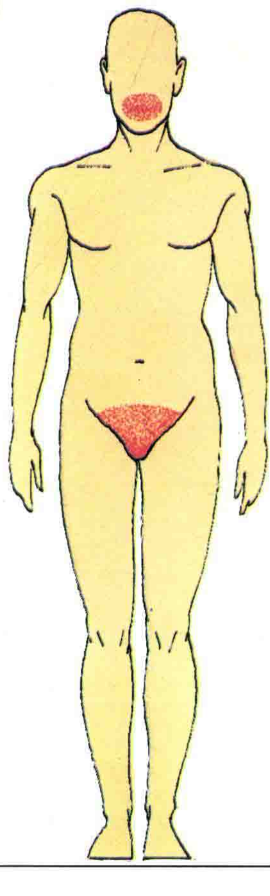
Above: Schematic representation of DNA-based viral replication. The infecting virus, on entering the host cell, loses its outer covering and penetrates the nucleus, where it uses the cell's own DNA for replication.







Above: Herpes zoster can affect facial nerve endings, leading in some cases to kerato-conjunctivitis and damage to sight. When the disease appears on the trunk, the costal nerves above the ribcage are often affected.



Right: Two types of herpes simplex virus have been identified. As shown on the human form, herpes simplex type 1 leads to lesions of oral mucous and conjunctive tissues, while type 2 attacks genital tissues.

Far right: Different factors can trigger secondary infections of herpes simplex, including excessive exposure to sunlight.

Above: Illustration of the external form of a herpes virus.

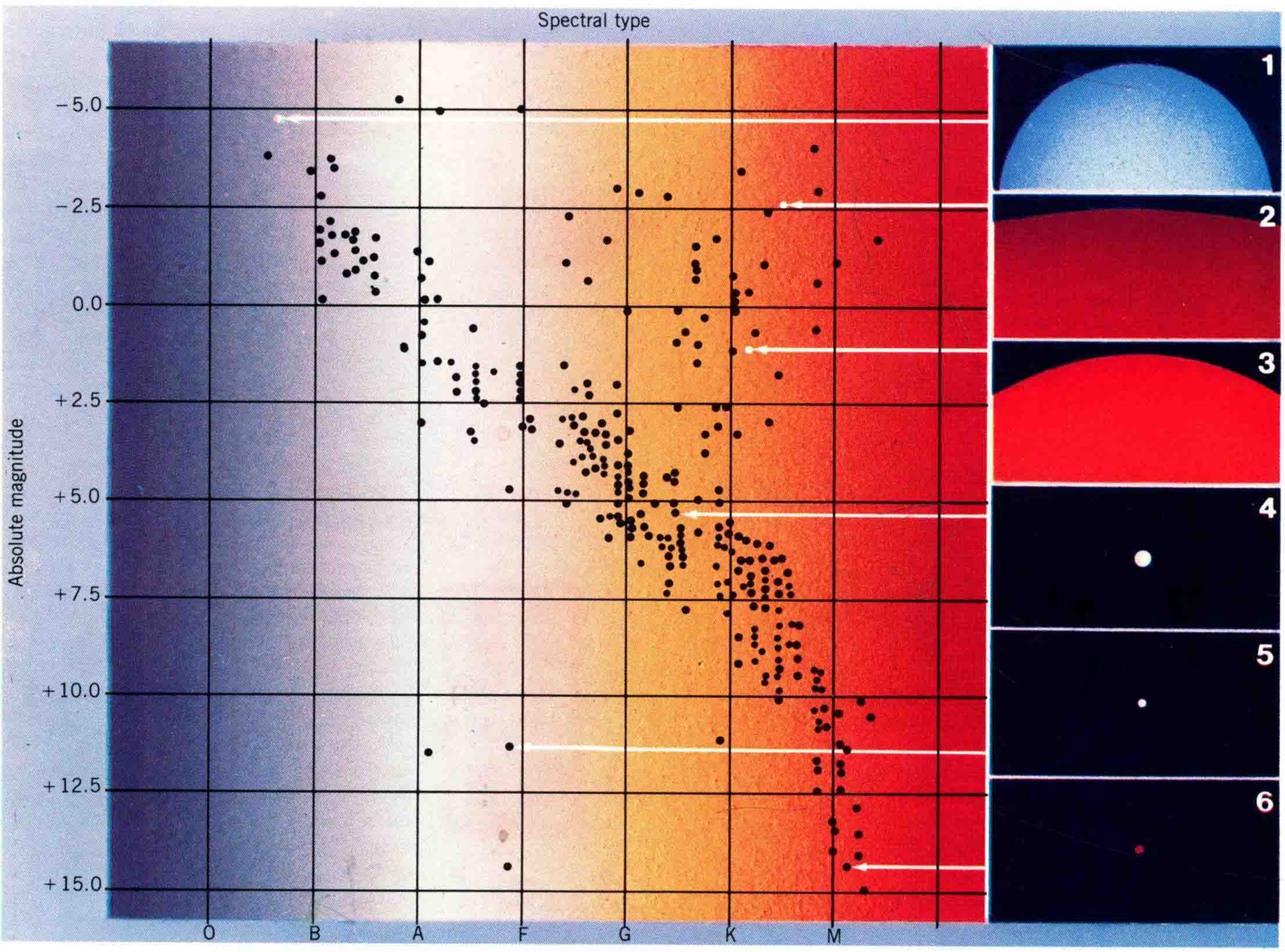
Hertzsprung-Russell Diagram

In the early 19th century, a French philosopher who was leader of the intellectual establishment at the time solemnly announced that astronomers "will never be able to study the chemical or mineralogical structure of planets and stars." Following the invention of the spectroscope 25 year later, scientists were able to describe in great detail the chemical structure of any star that could be seen through a telescope. Imagine how amazed the philosopher would have been had he been told that before a century had passed astronomers, using a simple graph, would be able to describe the evolution of all stars from their births as blazing nuclear furnaces to their deaths as invisible cinders in the sky!

The graph is known as the Hertzsprung-Russell diagram, and some astronomers have described it as simply the most fruitful single document ever produced by the men and women who watch the stars by night.

To understand how the H-R diagram (as it is usually called for short) works, you must first understand what a graph is—a diagram for illustrating statistical material (that is, information gathered in the form of numbers). One type of graph is built upon an L-shaped diagram, in which the downward stroke of the L gives one type of information, which is compared with another type shown on the sideways stroke of the L.

What the H-R diagram does is to plot the absolute magnitude (luminosity) of thousand of stars against their surface temperature. The term magnitude refers to the brightness of a star. In the 2nd century B.C., the Greek astronomer Hipparchus had worked out a system of classifying stars by their apparent magnitude—that is, how bright they appear to the naked eye. The brightest, he said, were stars of the first magnitude; dimmer ones he classified as of the second magnitude, and so on. About 160 years later, the great Egyptian astronomer Ptolemy improved Hipparchus' system, and although his method was still a very approximate one, based simply on how bright stars look to the unaided eye, it served pretty well until the middle of the last century. But astronomers are unhappy unless their measurements are as accurate as they can make them, and in 1854 a British astronomer named Norman Robert Pogson worked out a system based on his finding that the brightness of a first-magnitude star is almost exactly 100 times greater than the brightness of a six-magnitude star. Gradually, as astronomers became more skillful in making precise measurements, they



Above: When star spectral types are plotted against absolute luminosity, the resulting graph does not show random distribution but, rather, a broad diagonal band. Stars falling within this band are said to belong to the main sequence. The Sun is a main-sequence star with an absolute magnitude of around 4.8.

Numbered images to the right of the diagram compare the absolute sizes of the various kinds of known stars, ranging from white and red giants and supergiants (above) to tiny white dwarfs (below).

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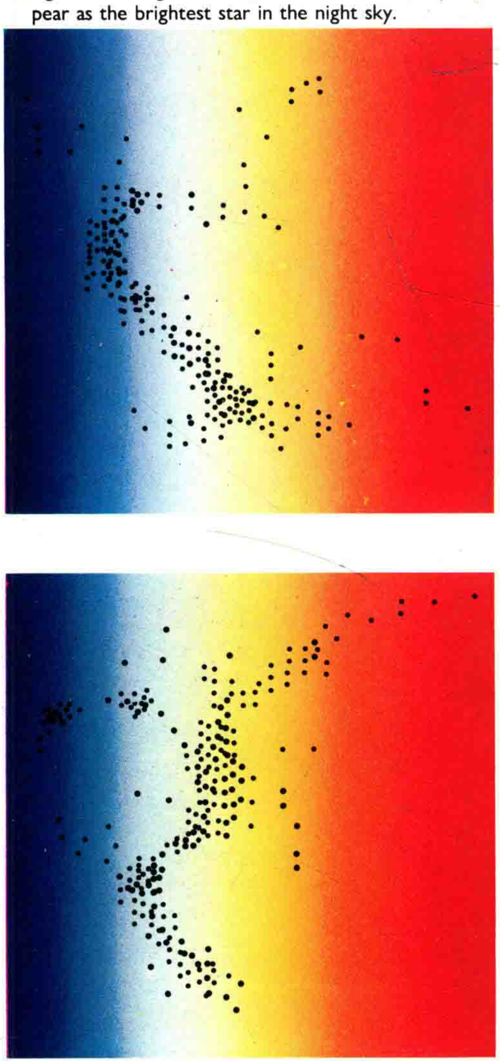
Above: The stars in these photographs, all readily visible from Earth, are of different spectral types. Betelgeuse and Aldebaran, left and center, are red giants. Sirius, the blue-white star on the right, is not a giant, but its nearness makes it appear as the brightest star in the night sky.



Above: H-R diagrams made of individual star clusters reveal characteristic patterns that vary according to the age and nature of the stars. The diagram at top shows the younger cluster. However, red giants are well represented in the H-R diagram below.

were able to develop the concept of absolute magnitude, which is an exact measurement of the amount of light radiated by a given star. Thus, the confusion is avoided by which a run-of-the-mill nearby star was classed as of greater magnitude (that is, apparent magnitude) than a far brighter but also much more distant one. By international agreement, absolute magnitude is taken to be the relative brilliancies of stars as they would appear if all stars were at a single selected distance from the observer (this distance is 10 parsecs, approximately 32.6 light-years).

Luminosity is another measure of a star's brightness, expressed as a multiple of the Sun's luminosity, which is taken as 1 on the luminosity scale. The surface temperature of a star means exactly what it says: It is a figure telling us how hot a star is at its surface, expressed in degrees above absolute zero, that is, degrees Kelvin, usually written K.

On the simplified H-R diagram above, the absolute magnitude is measured on the vertical scale, from -6 (the brightest) to $+15$ (the dimmest), with a duplicate scale expressed as luminosity telling how many times brighter or less bright than the Sun the various stars are. An astronomer, knowing that the Sun has an absolute magnitude of about 4.5 and a surface temperature of about 5,800 K, puts a dot on the diagram opposite the 4.5 mark on the vertical scale and above the 5,800 mark on the temperature scale, thus plotting magnitude against temperature.

When the Danish astronomer Ejnar Hertzsprung, in Europe, and the American Henry N. Russell, in the United States, had found the exact position for thousands of stars on their diagrams, they discovered that most stars lay in a broad swath extending in a curve from upper left (the brightest, hottest stars) to the lower right (the dimmest, coolest stars) in a principal group that they called the main sequence. Outside the main sequence, above and to the right, they found a group of enormous, bright, yet cool stars that are known as red giants, and in the lower-left corner of their diagram, they found a group of very dim, yet very hot stars that are known as white dwarfs (the terms giants and dwarfs were proposed by Hertzsprung and soon accepted by all.

Now, from extremely complex studies in many different branches of astronomy, scientists have learned a great deal about the birth, the vigorous mature life, and the death of stars. Briefly, it is known that once a star is born—that is, once it has begun to glow from the nuclear combustion of its hydrogen fuel—it soon reaches a mature stage, where it remains for most of its life (the Sun has been blazing for something more than 5,000 million years and will continue to shine for perhaps another 5,000 million years). Most of this time it will spend in the main sequence of the H-R diagram. Once it has exhausted all its hydrogen fuel, it will swell to enormous size (perhaps 200 million miles [320 million km] in diameter) and become a brilliant, relatively cool star, and then if there are any astronomers left in the Universe (for the Earth will have long since been vaporized by the swelling Sun), they will be obliged to pinpoint the Sun in the upper-right-hand section of the H-R diagram. Gradually, as the Sun gets dimmer and dimmer, but nevertheless hotter and hotter, its pinpoint will move like a falling star from the upper-right-hand corner, down across the main sequence, into the lower-left-hand corner, the final resting place of dying stars, where it may stay for a few hundred million years before dying out, a black cinder no longer visible in the night sky and detectable only by the pull of its gravitational force on other heavenly bodies.

See also SPECTROSCOPY; STAR.

The hummingbird and the grizzly bear share a remarkable biological property completely beyond the resources of humans. They are able to achieve a state of torpor—a kind of suspended animation—that conserves energy and allows them to endure adverse environmental conditions. Only one of the animals, however, is able to lower its body temperature to drastic levels, virtually shut down its metabolic processes, and still survive. That animal is the hummingbird, and the condition it achieves is called hibernation.

Many animals, from insects to reptiles, exhibit the ability to achieve a state of dormancy, but hibernation, specifically defined, refers to warm-blooded animals, such as feathered birds and furry mammals, that allow their body temperature to approach that of the environment. (The bear, by contrast, maintains a fairly high body temperature during dormancy, which is more accurately regarded as a winter sleep.)

All hibernators have the unique ability to use a thermoregulator—a kind of thermostat in the brain that monitors constant body temperature. In hibernating animals, the body temperature often drops to near 32°F. (0°C.), the heart rate slows down markedly, and metabolism—the consumption of energy needed to maintain warm-bloodedness—almost comes to a halt.

Onset of Hibernation

Hibernation is normally nature's way of solving the problem of scarce food supplies over an extended period of time and thus is associated with winter. However, a related state of torpor known as aestivation occurs during the summer months, when conditions of extreme heat or drought may also affect the availability of food. In any event, hibernation appears to be triggered by an animal's "internal clock." The exact mechanism of this clock is still unknown, but it may respond to such environmental factors as changing temperatures and seasons and the movement of the Sun. In this way, animals as various as chipmunks, bats, and hedgehogs obey the alarm of this internal clock and retreat for the winter.

Hibernation takes place in a sheltered retreat (a burrow or den) that is sometimes called the hibernaculum. The onset of hibernation is marked by the changes in an animal's physiology or foraging habits. Ground squirrels, for example, add a great deal of body fat prior to hibernation; these reserves of fat are then slowly burned off during the reduced metabolism of winter seclusion. Hamsters, by contrast, build up stores of food in their nests and delay hibernation as long as possible. Besides the obvious need for a food source that will last through the hibernation period, two elements also must be conserved—water and body heat. The hibernaculum is insulated, small, and humid, which conserves heat and reduces evaporation of body water.

The Deep Sleep

The actual process of hibernation involves a near-total shutdown of the living system. Body temperature drops down to reflect the air temperature of the hibernaculum. If the air temperature drops below freezing, the hibernating animal—essentially cold-blooded now—may freeze to death; in fact, many hibernators never awaken from their deep sleep.

Under normal circumstances, a warm-blooded animal would shiver-respond to cold temperatures. Shivering has the effect of generating heat and perpetuating warm-bloodedness. In hibernating animals, however, the impulse to shiver is suppressed. Instead, the rate of heartbeat drops noticeably, and arteries serving tissues throughout the body slowly constrict. These actions have the dual purpose of reducing body warmth while maintaining blood pressure. The ground squirrel, to cite a dramatic example, has a normal heart rate of 300 beats per minute and a hibernating heart rate of 7 to 10 beats a minute.

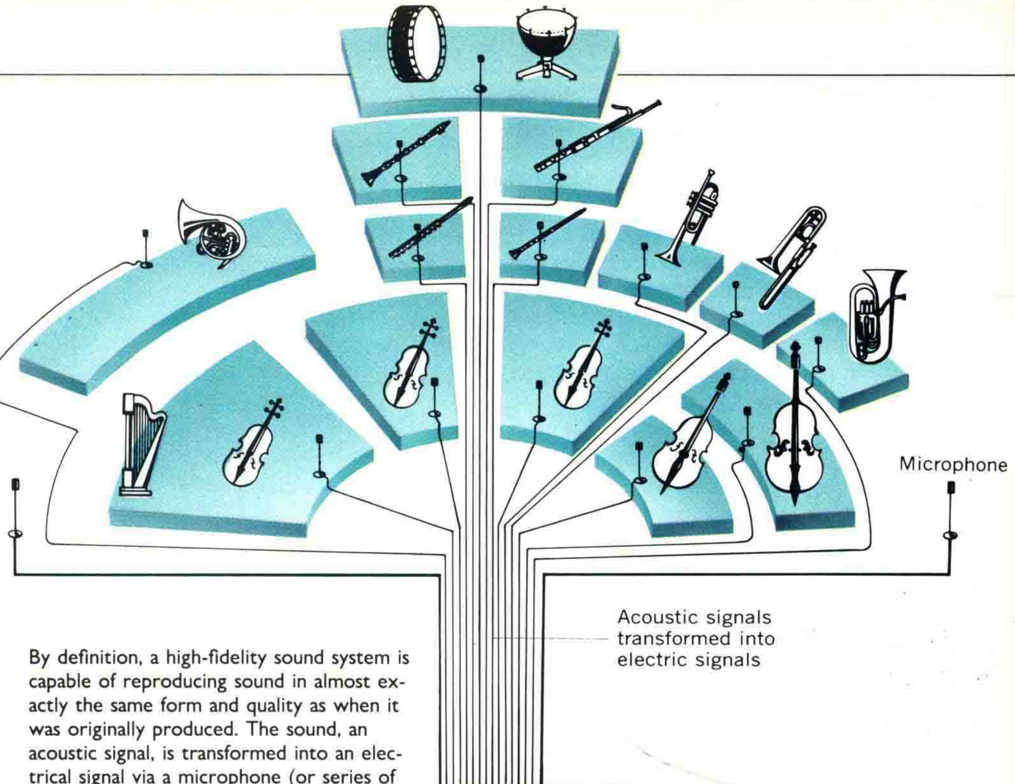
Arousal

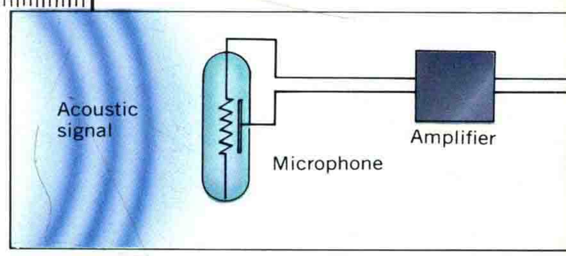
Many hibernating animals wake up in the midst of winter to eat, drink, or excrete wastes; then they return to their state of torpor. When the animal rouses itself from torpor, the physiological changes are swift and massive. Body temperatures

have risen as much as 86°F. (30°C.) over a period of several hours, and this sudden burst of energy is often accompanied by a burst of activity. Some animals pick up where they left off months before, even in reproduction. Female bats, which copulate in the fall, store male sperm in the body during hibernation and do not allow their eggs to be fertilized until the following spring.

Though the hibernation of mammals like bears and chipmunks is most familiar to us, there are many kinds of living organisms that resort to the technique as a means of surviving long winters or other periods of food scarcity and difficult weather conditions. *Below:* Illustration of 16 different hibernating animals and the burrows, or hibernacula, they use.

High Fidelity





By definition, a high-fidelity sound system is capable of reproducing sound in almost exactly the same form and quality as when it was originally produced. The sound, an acoustic signal, is transformed into an electrical signal via a microphone (or series of microphones; there are 16 in the diagram above). These electrical signals are recorded on tape. When the music of a large group like an orchestra is being taped, usually each instrumental part is recorded on a separate track. The quality of the sound reproduction depends on the ability of each piece of equipment to record the electrical signals exactly as they were generated by the instruments of the orchestra.

Below: Microphones may pick up undesired or distorted sounds: In the recording studio, recorded signals are filtered and sound defects are corrected. Then the sounds of the various sections of the orchestra are mixed together again, just as they were first produced, and transferred to a record.

Whether they are called record players, hi-fi's, gramophones, stereos, or phonographs, stereos have firmly altered the habits of hundreds of millions of people and turned the music world upside down. Until U.S. inventor Thomas Alva Edison invented the first practical phonograph in 1877, people could only listen to a symphony if they were actually in the presence of the musicians playing it. This meant that only the very rich could have any but the simplest kinds of music in their homes, and that operas, symphonies, and popular music were almost never heard outside a concert hall. Now, more than a hundred years after Edison's invention, it is frequently complained that there is too much music in people's homes, and nobody can think straight with all that blasting rock 'n' roll.

The world "stereo" is something of a misnomer, because it really refers only to stereophonic sound reproduction systems—that is, sound systems with two independent speakers, each handling a different part of the music. If the two (or more) speakers are arranged in the right position, listeners receive almost the same play of sound that they would get at the original concert hall. Monaural record players, on the other hand, have only one sound track.

Stereo or mono, all record players consist of three parts: a turntable, an amplifier, and one or more speakers. All three play an essential role in the process of producing sound from a record. Each side of a record is almost completely covered with a single narrow groove that runs in a tightly packed spiral from the edge around to the center. Less than 0.00125 inch (0.032 mm) deep and about 0.0025 inch (0.064 mm) wide, record grooves have slanting walls whose angle from the vertical varies in a way precisely corresponding to the music.

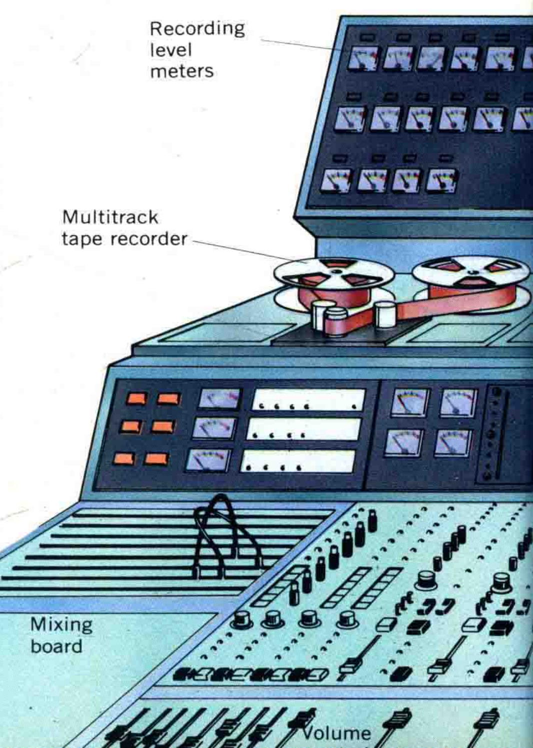
Turntables

There are two parts to a turntable: a drive, which is a motor that smoothly spins the record around at a precise speed, and a tone arm, which has the mechanism for playing the record. The tone arm is usually a steel tube attached by a pivot at one end to the rest of the turntable, with the other end tipped by a stylus or needle, which is usually a tiny chip of diamond. As the record turns, the stylus rides in its groove. Because the walls rapidly change their inclination, the needle vibrates rapidly from side to side in the groove, wiggling in a way dictated by the sound grooved onto the record.

The needle is connected to a cartridge, a type of transducer, or device that converts one kind of signal (in this case, the motion of the diamond) into another (pulses of electricity). In most turntables, the top end of the needle has a small permanent magnet, which wiggles with the motion of the stylus. The magnet is set next to two coils of wire within the cartridge at the head of the tone arm. When a magnet moves back and forth near a coil of wire, it sets up an electric voltage in the coil that fluctuates with the motion of the magnet. In this way, the vibration of the needle is transduced into pulses of electricity that are fed into the amplifier. Stereos have two coils to create two electric voltages, mono tone arms have only one, but both feed electricity into a single amplifier.

Amplifiers

In most large stereo systems, the "amp," as it is often called, has a box of its own, separate from the turntable. Its face bris-



tles with an array of dials and switches: an on-and-off knob, jacks to plug in headphones, a volume dial, and controls for the balance and quality of sound.

The task of the amplifier is to boost the voltage coming in from the turntable, amplifying it enough to drive the speakers. To do this, the circuits in the amp draw on household electric current to create pulses of electricity that are identical in form but much more powerful than the ones from the tone arm. In addition, amplifiers clean up the signal from the turntable, correcting for the distortion introduced by the needle's inherently imperfect pickup from the record.

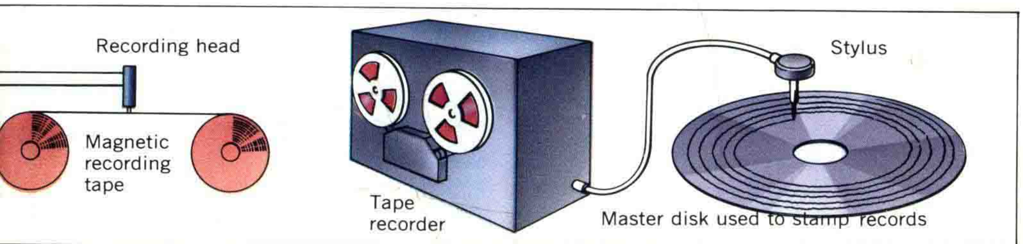
In the past, amplifiers were made with tubes; now, they are full of transistorized circuitry. Transistors are made from elements like germanium and silicon, which have atomic structures that endow them with special electrical properties. These materials can act as "gates" for the electricity. In the amp, they hold back household current until a second current, the pulses from the turntable, "tells" the circuit to open up the flow of household current. The gate opens and closes in a way that precisely corresponds to the signal from the stylus, which in turn matches the shape of the grooves in the record. The result is to produce the much larger pulses of electricity that go into the speakers.

Speakers

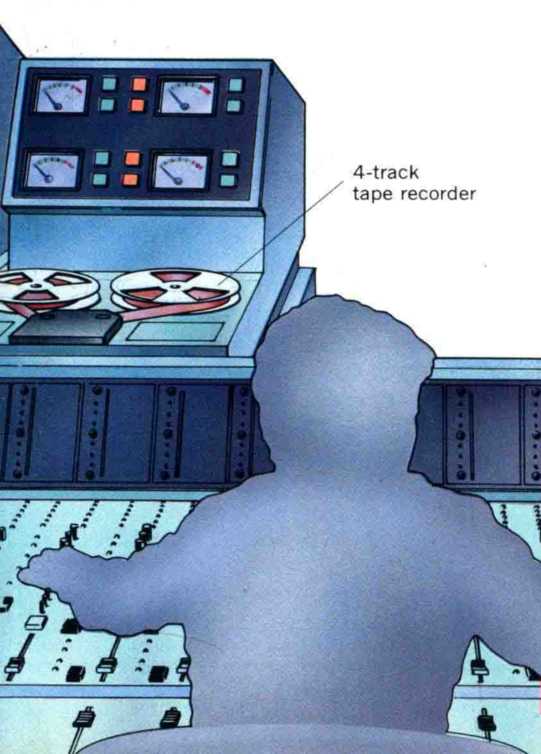
In a sense, speakers are the opposite of turntables. Whereas turntables convert the physical motion of the needle into electric pulses, speakers take electric pulses from the amplifier and convert them into physical motion—the sound waves rippling through the air. The electric pulses coming into the speaker are used to rapidly push and pull a coil of wire attached to the tip of a wide, shallow cone. The cone moves in and out, creating sound waves. This motion of the cone is directly tied through the amplifier to the motion of the needle—and this is how a stereo works.

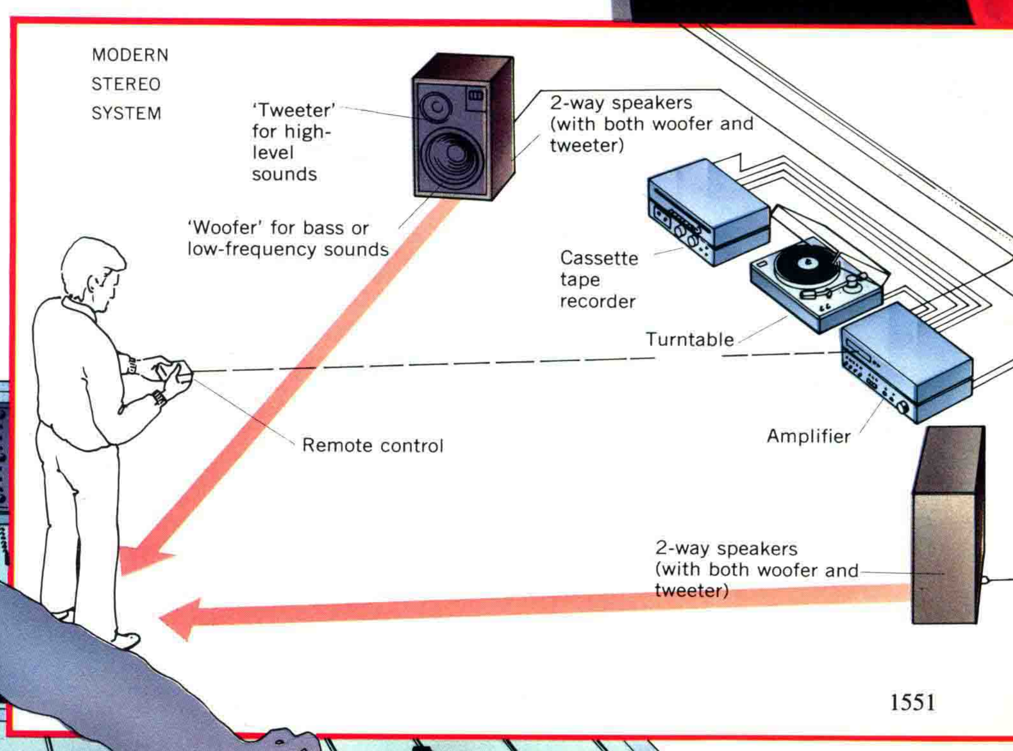
The result of the linked efforts of the turntable, amplifier, and speaker is the everyday miracle of turning a switch and instantly hearing music—a privilege denied to everyone until Thomas Edison invented the phonograph.

See also RECORD; SEMICONDUCTOR; TRANSISTOR.



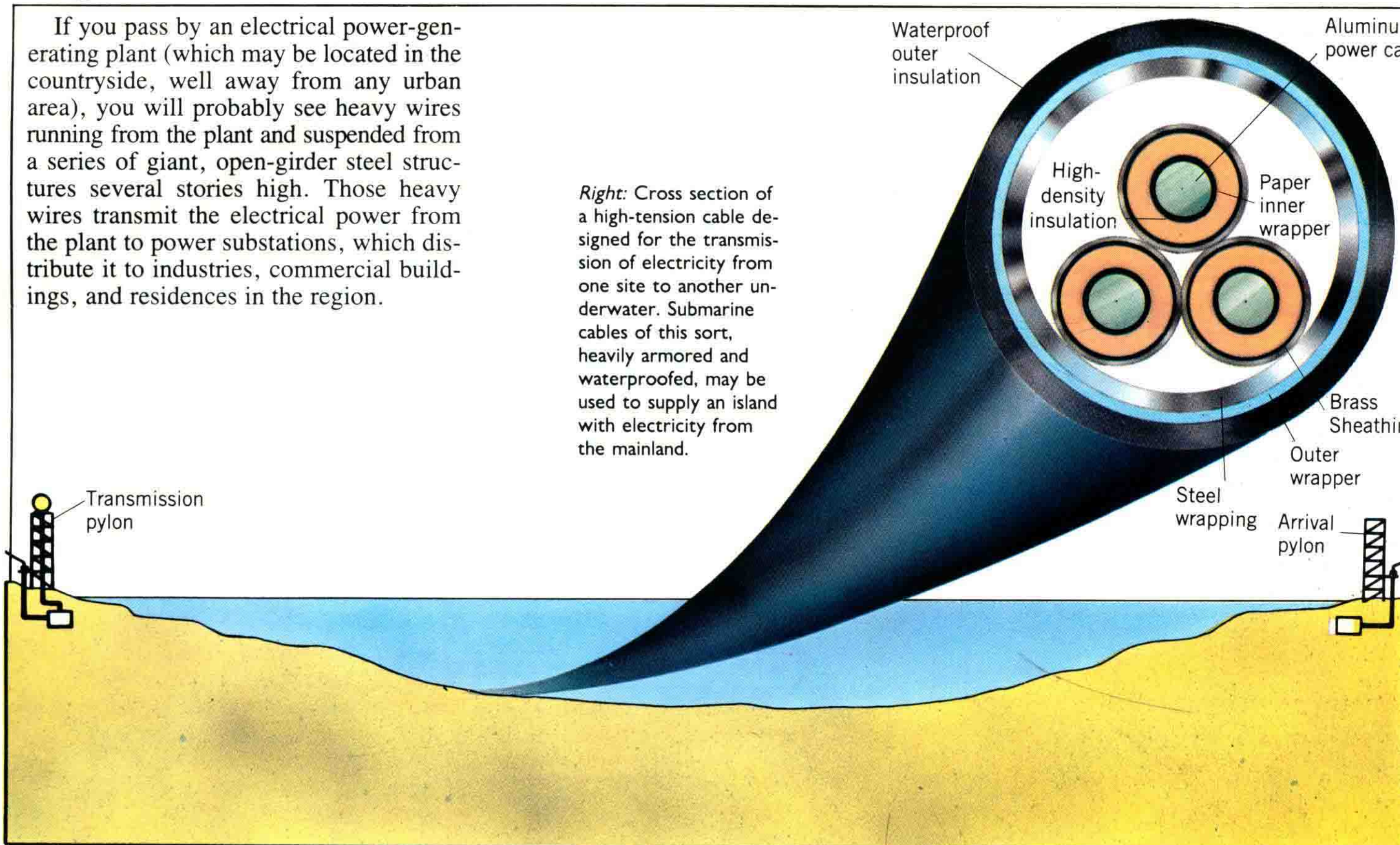
RECORDING STUDIO





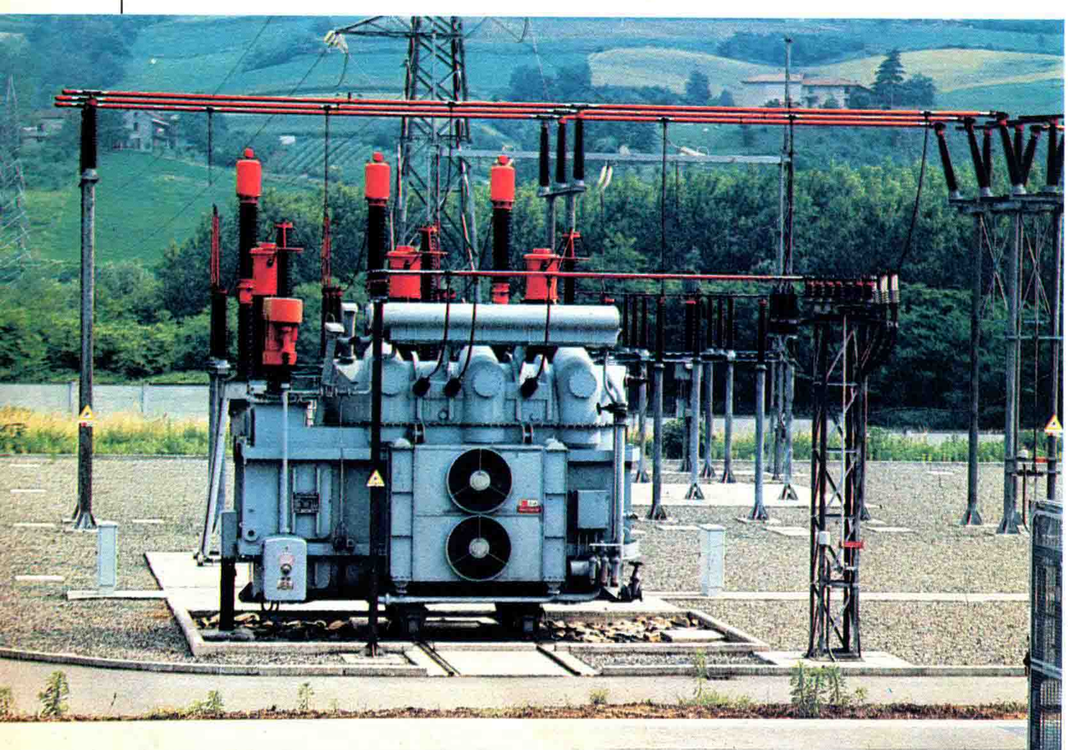
High-Tension Line

If you pass by an electrical power-generating plant (which may be located in the countryside, well away from any urban area), you will probably see heavy wires running from the plant and suspended from a series of giant, open-girder steel structures several stories high. Those heavy wires transmit the electrical power from the plant to power substations, which distribute it to industries, commercial buildings, and residences in the region.



Right: Cross section of a high-tension cable designed for the transmission of electricity from one site to another underwater. Submarine cables of this sort, heavily armored and waterproofed, may be used to supply an island with electricity from the mainland.

Below: Since electric power is most efficiently transported over long distances at very high voltages, transformer substations like the one shown in the photograph are necessary to step down voltages to lower levels before the power can be used by the consumer.



Transmission of Power

When large amounts of power must be transmitted over long distances—as between a power-generating plant and a power substation—the most efficient way to transmit it with minimum loss is to send it through a conducting wire at very high voltage. (Voltage is a measure of electrical potential for doing work, rather than of electrical flow, which is called the "current" and is measured in amperes.) The voltage of house current—that is, the electricity available in the sockets of your home—is low, typically 110 volts in the United States and 220 volts in many parts of Europe. High-voltage power lines, however, transmit electricity over long distances at 400,000 volts and above.

High voltages can present some hazard if not handled with care. The conducting wires become hot when they transmit electricity. Moreover, at high voltages, an electric charge can build up on the wire—especially in dry weather—and cause a lightninglike discharge of electricity to arc between neighboring wires or between a wire and the ground. For these reasons,

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