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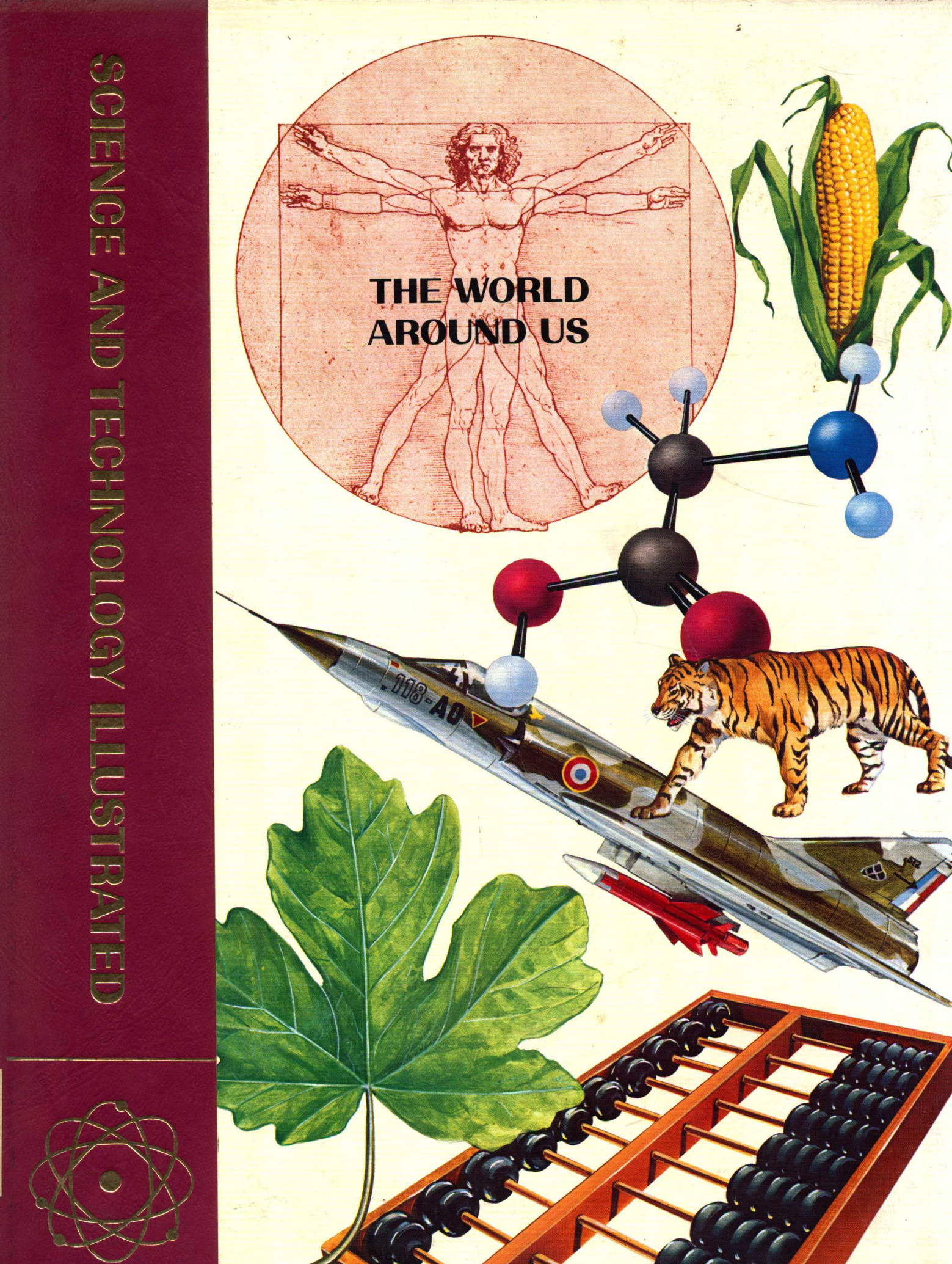

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Science and Technology Illustrated

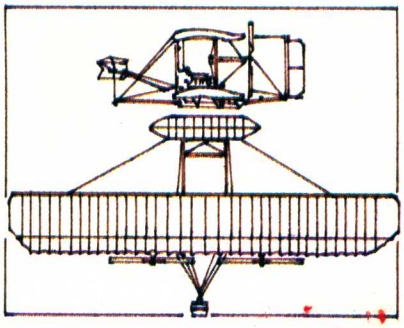
The World Around Us

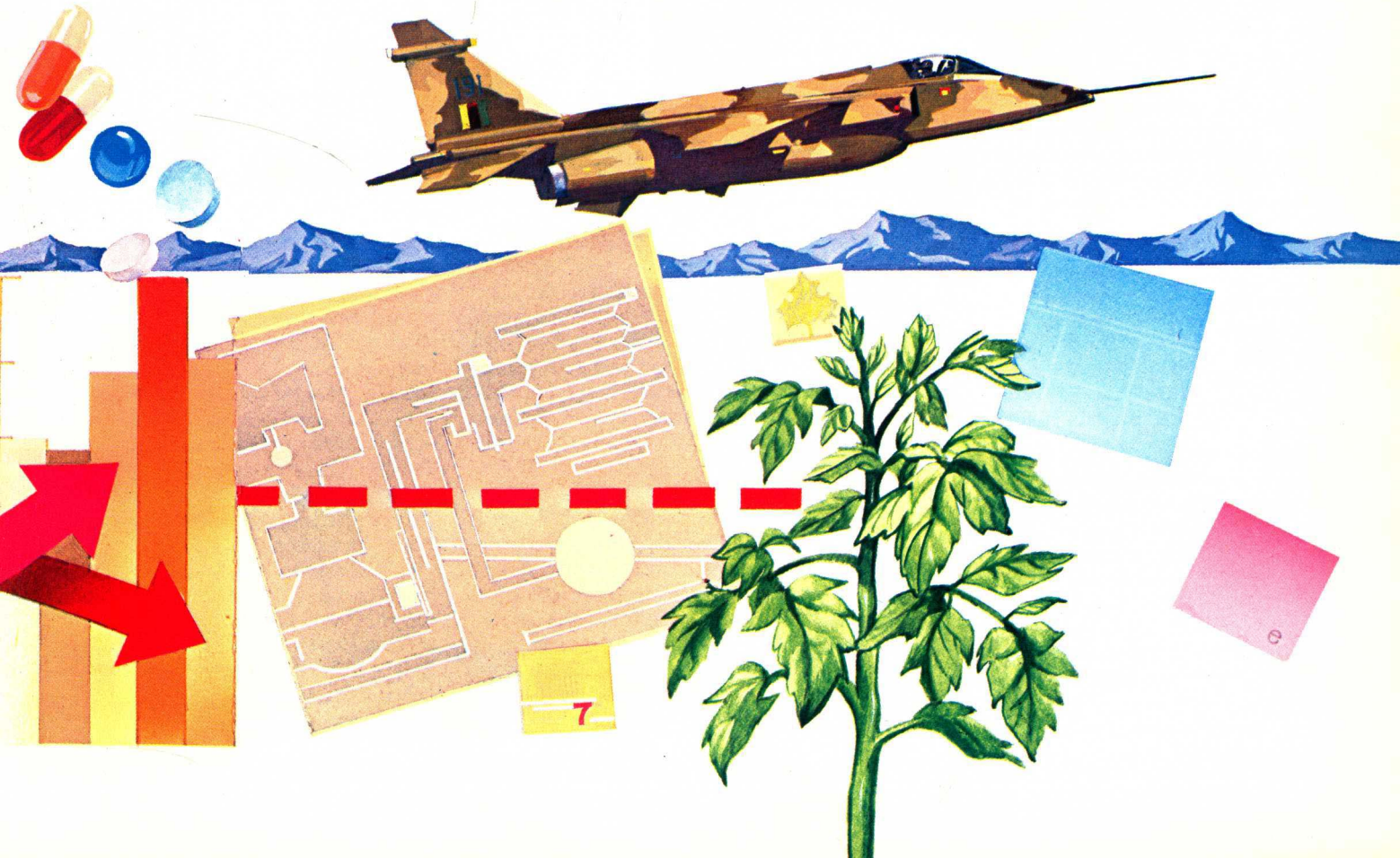
Science Technology

The World Around Us

Volume 15

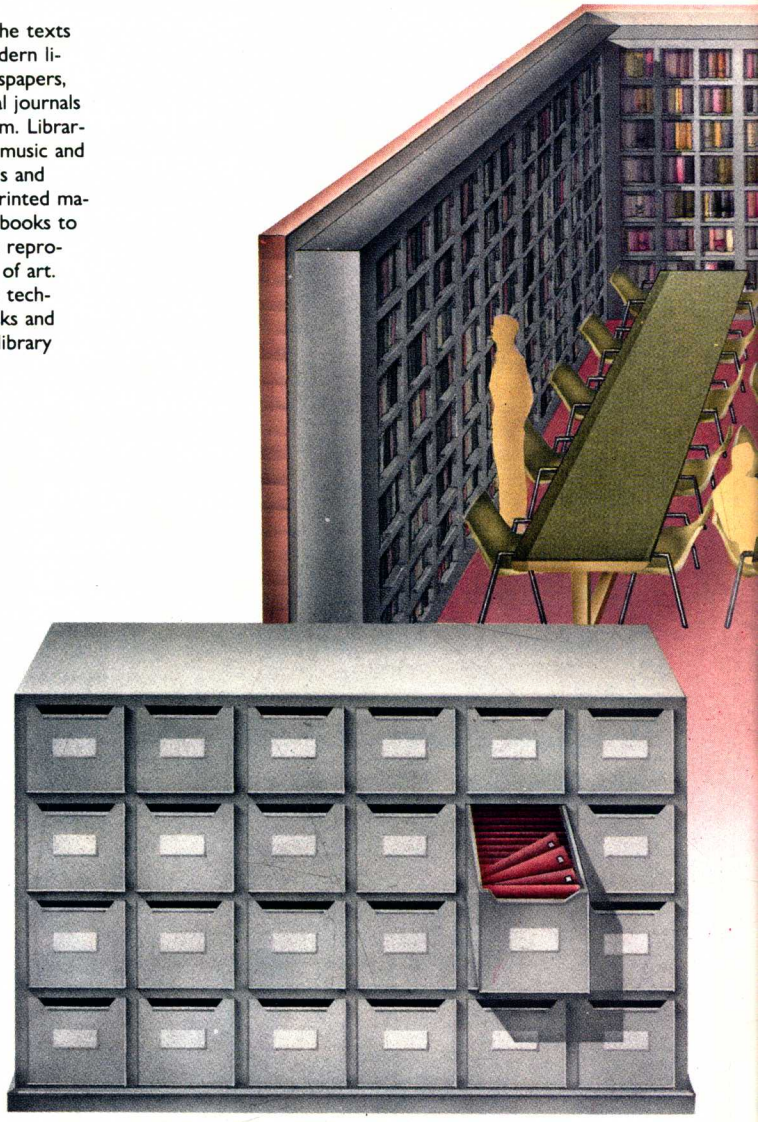
Contents





Library Science

There's a saying that you can judge a warrior by the booty he takes. If that's so, we can only think well of Sulla, who, after conquering Athens in 84 B.C., chose the library collected by Aristotle as a major part of his spoils. His concept of acquisitions may well be the envy of librarians, for whom acquiring books is a complicated task and only a part of the intricate, multifaceted field of library science.



Books are only a part of the texts that are collected in a modern library. Back copies of newspapers, magazines, and professional journals are often kept on microfilm. Libraries may also collect sheet music and music recorded on records and tapes. Some also collect printed material ranging from comic books to advertising posters to fine reproductions of famous works of art. The spread of information technology is now bringing disks and tapes for computers into library collections as well.

Acquiring Books

Most libraries amass their collections from a relatively standard list of classic works. Librarians enlarge on this by adding contemporary works of topical, as well as literary and scholarly, interest.

"Demand buying" is the newest and most controversial way of acquiring books. It was a response to criticisms in the 1960s that libraries had become "irrelevant" and to the sharp decline in their use. Developed for the public library system of Baltimore (Maryland) County, demand buying has as its first principle, "Know your public." The second principle is "Give people what they want." Books are purchased according to in-depth community profiles and best-seller lists. The library may purchase as few as five copies of a given title or as many as 800 of a highly popular title. In the early 1970s, the branch libraries in Baltimore County were all but empty; today, as the result of its use of demand buying, this system has the highest circulation rate in the country. However, opponents argue that demand buying, much like network television, caters to the lowest common denominator in the public's interest. That you read is not enough, they say; it is what book you read that matters. Informing and guiding the reader's choices should be an important part of the librarian's job.

Specialized libraries, such as university, medical, business, and government libraries, cater to patrons with particular needs. University librarians frequently have advanced degrees in an academic discipline as well as in library science. Often their jobs involve a knowledge of complicated computer systems and of computer-aided national networks that provide information about both new and old books and their location in libraries nationally. Many of these libraries order books in cooperation with others, with whom they have banded together as a consortium. In this way, individual libraries can specialize, and patrons can have access to many more books.

Cataloging and Classifying

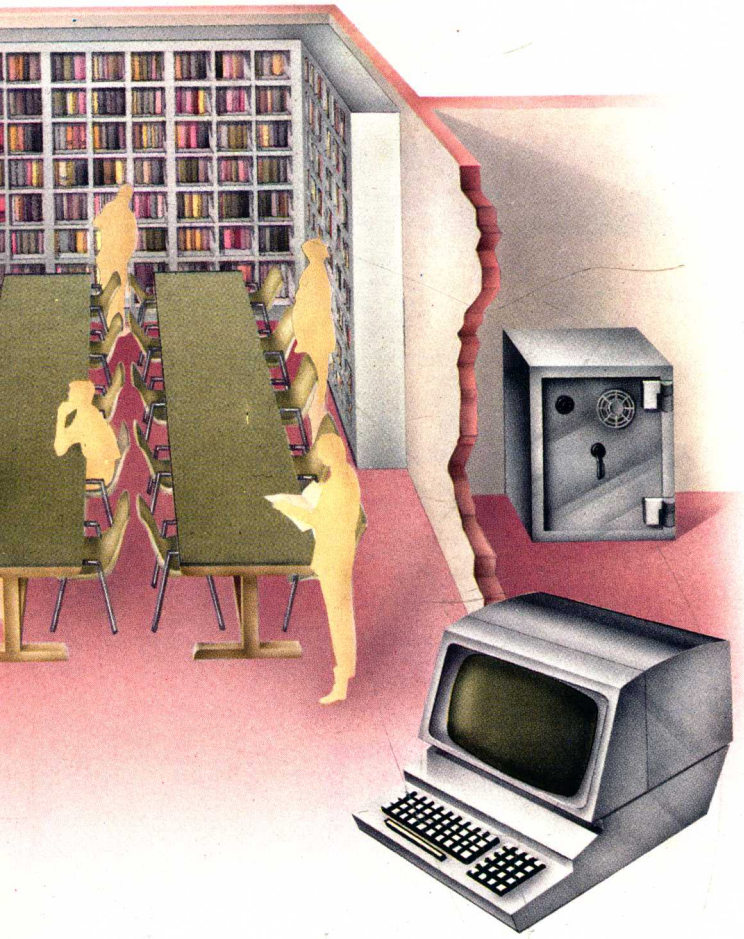
Possibly the first library, dating from 3000 B.C., was a storehouse of clay tablets found in Babylonia; some 1,700 years later, Egyptian archives were being organized systematically. Today, we have not only nationally produced lists, or catalogs, of almost everything that is published, but smaller catalogs (often using cards) listing what our libraries contain. These catalogs are generally arranged alphabetically according to the author's name, the book title, and the subject of the book. Subject headings are devised principally by the Library of Congress, which records the publication of most books. It also publishes the National Union Catalog, a listing of the major libraries containing each title.

Books and other library materials are arranged according to one of several classification systems, the most common being the Dewey decimal system. In this classification, topics are assigned a number (.001 to 999.999), and books are shelved according to their subject matter. For example, recreation, art, and music are topics with call numbers in the 700s, which means that in libraries using this system, books on tennis will be shelved relatively close to books on the violin. Another popular classification system is that of the Library of Congress. This is a much more specific system than the Dewey decimal. There is no limit to the available categories and no duplication of call numbers. The Library of Congress system tends to be used most frequently by larger libraries; smaller libraries, especially public libraries, tend to prefer Dewey.

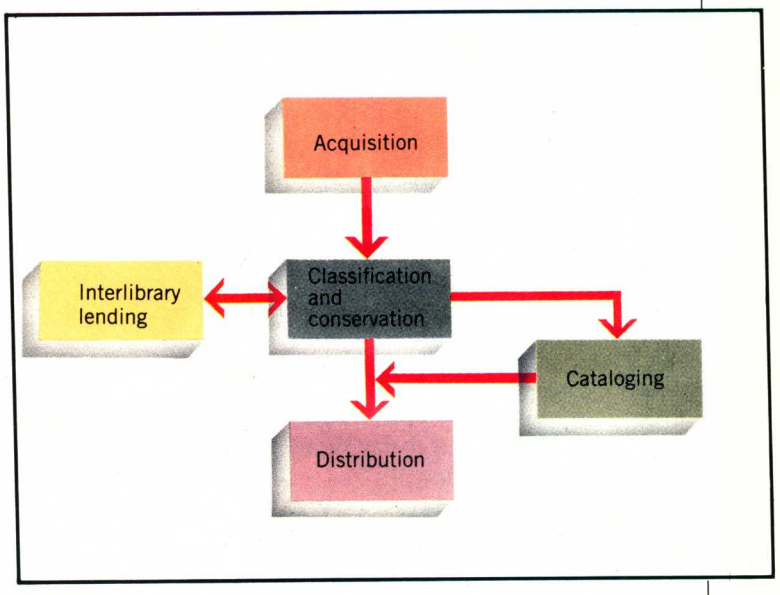
Certain collections, such as government documents and maps, are classified according to date of publication.

Books Are Only Part of a Librarian's Business

Books have proven more practical than clay tablets and scrolls, but bound vol-



Keeping accurate catalogs of acquisitions is an important part of a librarian's job. The introduction of computers has greatly aided catalog updating as well as control of circulating materials. The automation of routine chores like the compilation and mailing of overdue notices has freed librarians for more productive work.



Above: Flow chart describes movement of texts within a major library system. After the initial acquisition, texts are classified and then stored according to the chosen classification system. They must be cataloged accurately and distributed among the system's branch libraries. Most libraries also participate in interlibrary lending programs to expand the range of texts available.

umes are not always the most manageable way to store information. Newspapers and periodicals are often photographically reduced and transferred to microfilm, which we then read from a screen with the aid of a magnifying projector.

Computers, too, have simplified many of the librarian's tasks. Computers not only can keep track of who has checked out which book and the book's due date, they are also capable of storing catalog information and reference aids. In many public libraries and most academic libraries, patrons can have either free or pay-as-you-go access to such computer data bases as news services, census information, periodicals indexes, and even *Books in Print*.

Library automation has enabled librarians to become more, rather than less, active. Today, libraries are on the forefront of the adult literacy and "right to read" programs, with librarians designing curricula, teaching, and organizing staffs of tutors. Many libraries also have sections devoted to employment counseling. They offer aptitude and interest tests, resumé guidance, and information on local job listings. Public libraries were among the first public institutions to become actively involved in helping the handicapped. Many libraries have machines to enlarge print for persons with critically impaired vision. Kurzweil Reading Machines, which mechanically convert print into sound, have been installed in many libraries, and special typewriters enable persons with severe speech defects to communicate their requests. Some major urban libraries offer teletype services that enable the deaf person to type any message on a machine at home and have it automatically relayed to a receiver in the library, which then transmits a teletype message back to the patron over the telephone lines.

The recent boom in computers and data bases has also created opportunities for librarians outside the traditional library setting, since it has given rise to the allied field of *information science*. Where library science emphasizes the management of libraries, information science emphasizes sophisticated research and information management. Librarians with advanced research and computer skills are now frequently employed in business, for example, where they may be hired to conduct complicated marketing surveys.

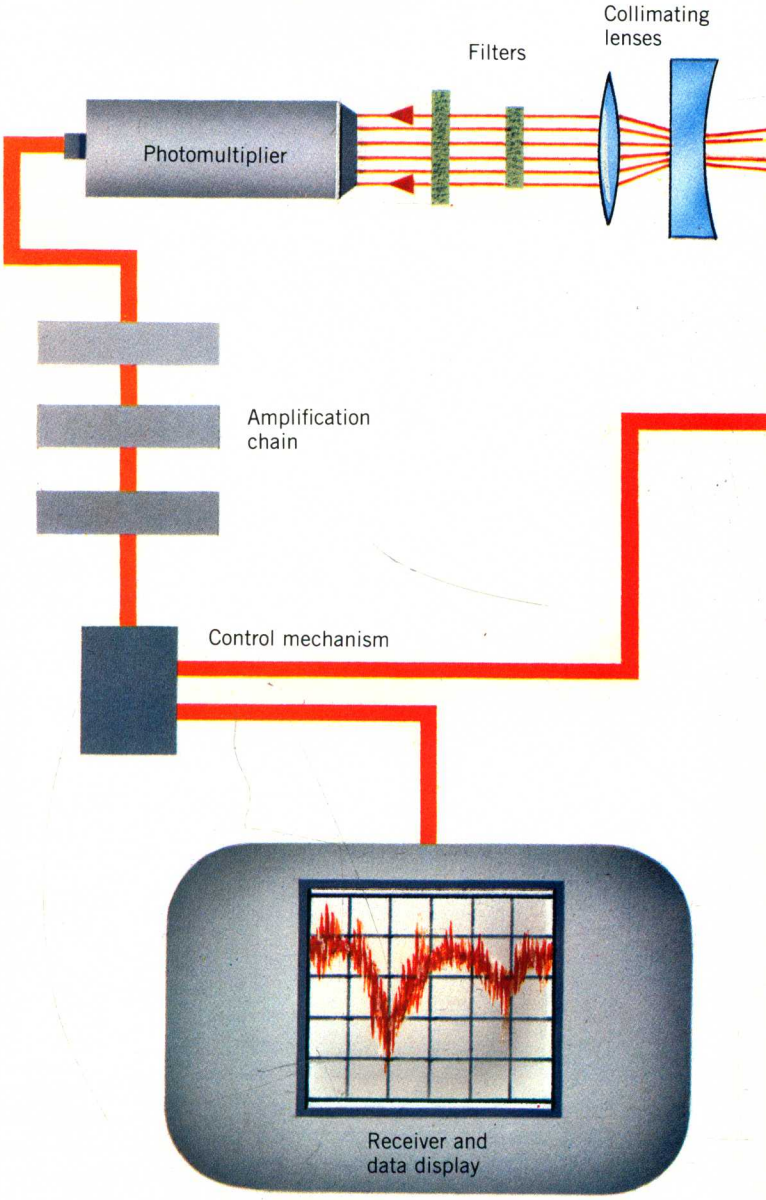
Librarians become certified after completing a graduate program in library science, usually lasting one year. Specialties include reference work, administration and management, information science, service to the aged and handicapped, and subject specialties such as fine arts.

Maybe Sulla had to conquer the library of his choice by force in 84 B.C.; today, the enterprise is much more delicate.

Lidar

The cruise missile glides above the ground at a constant low altitude, finding the way to its target by comparing the terrain it flies over with an internal preprogrammed computer map. As the missile closes in, it can recognize its target by comparing what its guidance system sees with an electronic portrait embedded in its circuitry. Crucial to the accuracy and versatility of this guidance system is lidar, or laser radar.

Lidar (*li*ght *d*etecting *a*nd *r*anging) was first developed in the early 1960s. It operates on a principle similar to conventional microwave radar. Like sound, both light and microwaves (radiolike electromagnetic energy) bounce off objects, returning a reflection, or echo, to their source. The lidar unit transmits a brief laser flash called a pulse, detects the "echo" from a target, and times the interval between transmission and detection. The length of this interval—only millionths of a second—can then be translated into the distance to the target, since the speed of light is known. Moving targets change the echo's wave pattern. Thus, the difference in frequency between the original pulse and the echo (called the Doppler shift) can reveal the speed and direction of a moving target.



What Makes It Special

One of the lidar's principal advantages over microwave radar is its high resolution, or ability to detect small objects and distinguish between them, a result of the narrow beam and high frequency of laser light. (With a carbon dioxide laser, this frequency is in the neighborhood of 30,000 gigahertz—30 million million cycles per second—a thousand times that of microwave radar.) That is, lidar can distinguish between two small targets that are close together, whereas the wider beam of microwave radar might see the pair as one. Lidar gives extremely accurate velocity readings of moving targets with just one reading; microwave radar usually requires several. Lidar can produce detailed silhouettes of targets for computer analysis or video display, permitting automatic or human identification of the target. Because of its narrow beam, lidar is difficult for an enemy to detect or jam. And lidar units can be made compact and lightweight, requiring little power.

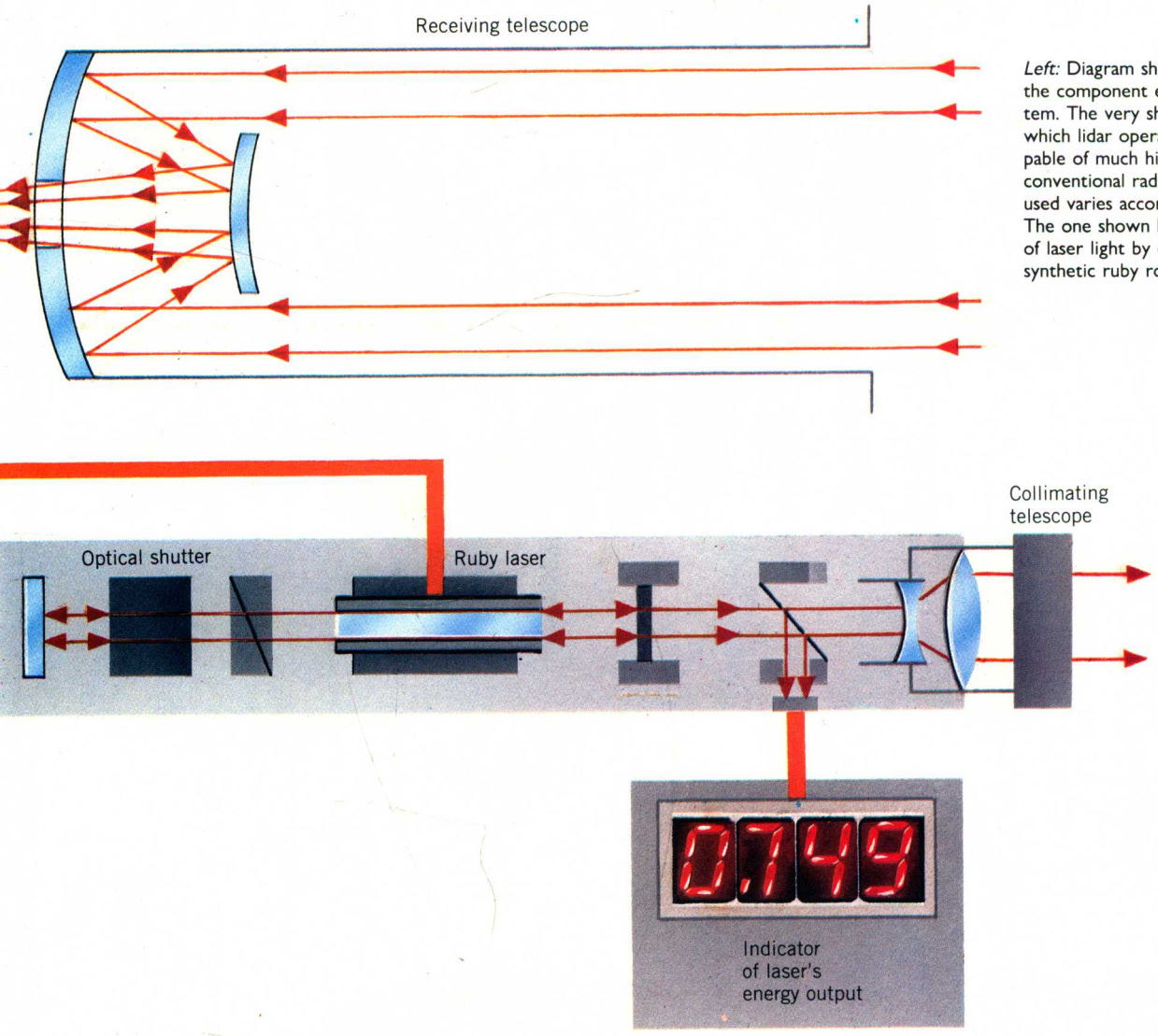
But lidar is not perfect. Since its medium is light, it is susceptible to distortion from sunlight, rain, haze, air turbulence, and fog. The light signal weakens as it travels long distances through air. Optical and electronic filters on the receiver can compensate for some of these problems, but lidar is still more weather-dependent than microwave radar. The narrowness of the laser beam makes it unsuitable for scanning a large area for an unknown target. So, lidar can best be used to complement a microwave system. The microwave radar discovers the target, and the laser system tracks it closely and images it.

Uses of Lidar

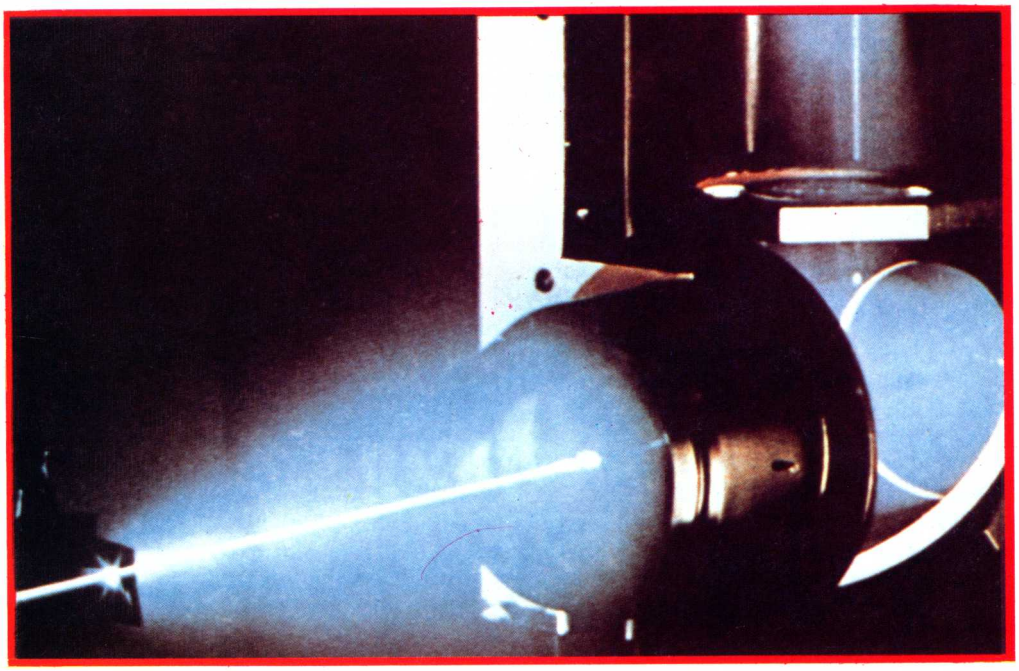
Laser radar is particularly suited to studying atmospheric patterns, since echoes can be obtained from dust particles suspended in air. For example, lidar systems warn airplane pilots of turbulence or sudden pressure changes in apparently clean air. Lidar is also used to study storms, wind patterns, and air-pollution dispersion patterns.

Simultaneous lidar shots directed at reflector arrays placed on the Moon from observatories on separate continents can measure not only the distances to the Moon and between the observatories, but also the rate at which the continents are drifting closer or apart. The high resolution and long-range accuracy in reading velocity by laser radar is also useful in tracking satellites.

Nonetheless, most applications of lidar are military. A simple battlefield use of laser radar is an artillery range finder not much larger than a pair of binoculars. Lidar fire-control systems are built into tanks and bombers to assist operators in aiming their weapons.



Left: Diagram shows in simplified form the component elements of a lidar system. The very short wavelengths at which lidar operates mean that it is capable of much higher resolution than conventional radar. The kind of laser used varies according to the application. The one shown here generates a beam of laser light by electrically exciting a synthetic ruby rod.



Right: Photograph taken in a research facility studying the optical characteristics of a beam of laser light. The beam, composed of coherent light—that is, light of the same wavelength and of uniform phase—resists widening and dispersion over long distances, making it suitable for range-finding applications.

Lie Detector

Almost since its invention around the turn of the century, the lie detector has been a controversial tool of law enforcement, regarded as extremely useful by criminal investigators and as extremely inconclusive by psychologists and civil libertarians. Although the lie detector is very much a part of life in the United States—as many as a million Americans may take a lie detector test each year—its use has never caught on much in Europe or elsewhere.

The lie detector, also called the polygraph, is a machine that measures a number of key body reactions—changes in breathing, blood pressure, pulse, and perspiration—of an individual who is being questioned. These reactions are chosen because they represent involuntary physiological reactions, and the basic theory of the lie detector is that lying causes the kind of emotional stress that provokes rapid breathing and sweating, for example. The results of a test can then be interpreted, according to this theory, to determine the truthfulness of the subject.

The Equipment

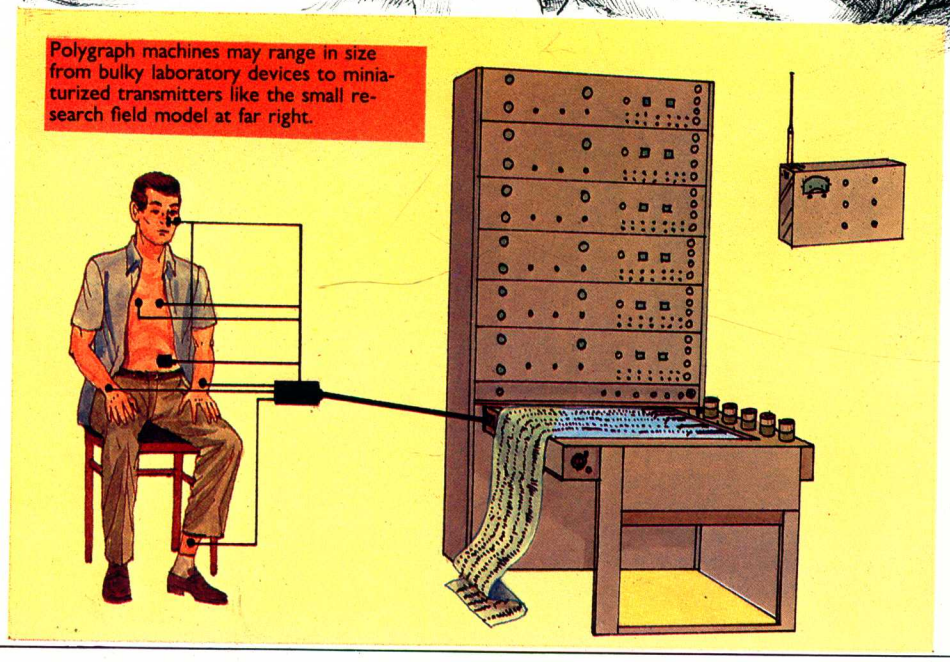
Modern polygraph machines are small enough to fit into a standard briefcase. Each machine has a number of attachments. The pneumograph tube is placed around the subject's chest to measure changes in respiration, and a blood-pressure cuff—like the one used by doctors—is wrapped around the arm to measure blood pressure and pulse. Electrodes are attached to the fingers to record the galvanic skin response—a measure of electrical conductivity between parts of the body that is related to perspiration. In some cases, a second pneumograph tube is wrapped around the subject's midsection to measure abdominal respiration.

All these instruments are connected by wires to inked styluses, which record the changes on a moving roll of graph paper. The first modern polygraph machine, constructed in 1921 by a University of California medical student, John A. Larson, derived its name from the fact that at least three different responses were recorded simultaneously on the paper.

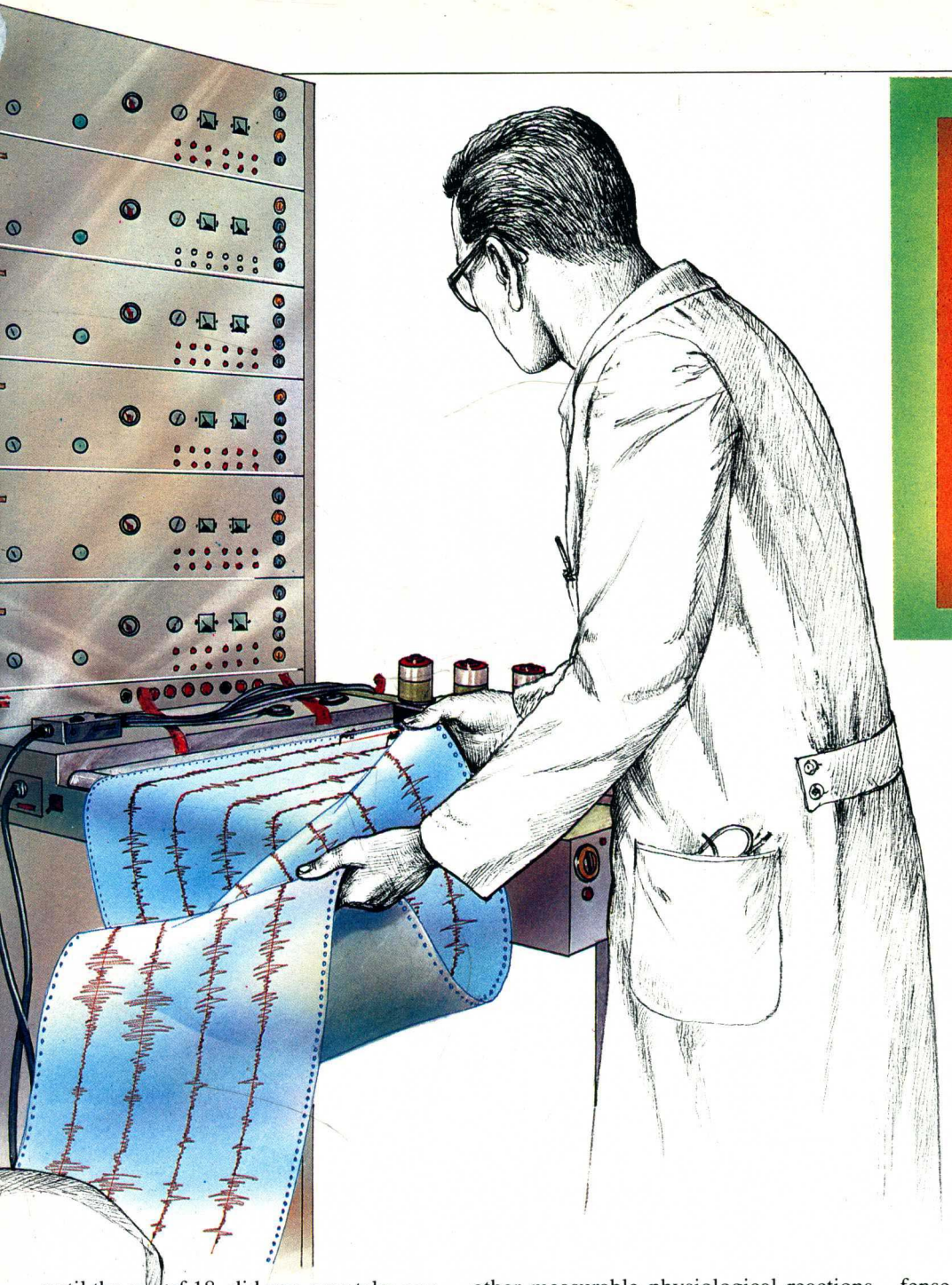
Operating Technique

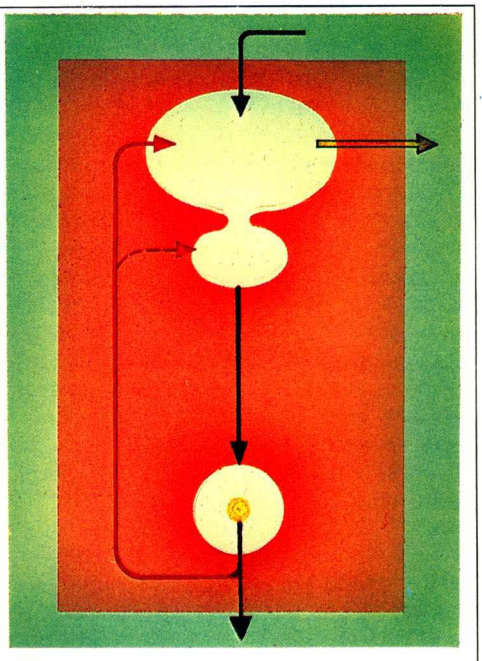
A successful lie detector test relies not only on the technological hardware but on the cunning of the questioner. The key factor in any lie detector test, in fact, is the alternation of control questions (which are irrelevant to the investigation at hand) and pertinent questions (which deal with the crime being investigated).

Control questions are framed so that the subject is expected to respond to them by lying. A typical question would be, "Up



Polygraph machines may range in size from bulky laboratory devices to miniaturized transmitters like the small research field model at far right.





Above: Relationship among the brain—particularly the hypothalamus—and body systems like the sympathetic nervous system, the endocrine glands, and the activity of some organs. Proponents of the use of lie detectors argue that it is not really possible to 'beat' the machine because it measures biological factors regulated by this involuntary brain and glandular activity. It has been suggested, however, that the functioning of these systems may not be completely involuntary. Techniques ranging from yoga to hypnosis to light sedation can reportedly mask the outward physiological signs of the emotional stress generated by telling a lie.

until the age of 18, did you ever take anything that did not belong to you.?" Although yes is a very reasonable response, many people will answer no out of surprise or fear of embarrassment, and the polygraph machine may register a mild physiological reaction to the question.

Pertinent Questions

The pertinent questions separate the truth-tellers from the deceivers, according to polygraph theory. When the operator asks, "Did you rob the National Bank on the Fourth of July?" the innocent subject will answer no. The assumption is that this answer, because it is *not* a lie, will provoke less sweating, heart beating, and other measurable physiological reactions than the control question.

When a deceiving subject is asked the same question, it is expected that the polygraph machine will record greater reaction than the subject had to the control question. Over a period of 1 to 2 hours, a pattern will emerge: Innocent persons tend to react more strongly to the control questions, while deceivers tend to react more strongly to the pertinent questions.

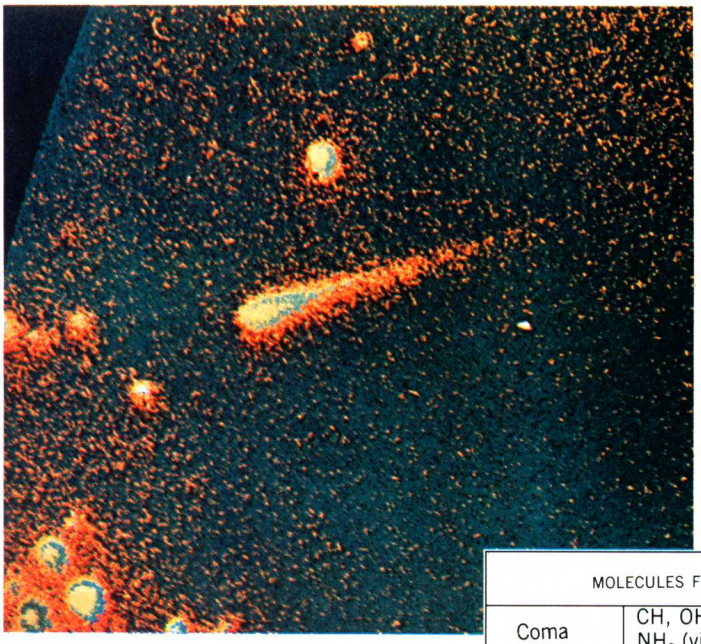
Legal Acceptance

No state in the United States freely admits the results of a polygraph test as evidence in court, although it is allowed in about 25 states if both prosecution and defense teams agree to its use in advance of the testing. Some psychologists maintain, however, that feelings of anxiety or indignation provoke physiological reactions similar to those of lying and the results of lie detector tests can be misleading.

It has also been alleged that a subject can "cheat" on polygraph tests—by stepping on a tack, for example, while answering the control qestions. Even though questions about the reliability of lie detectors persist, their use expands. Employees of U.S. banks, stores, major corporations, and even the Department of State (in the case of news leaks) are occasionally required to take lie detector tests as a condition of employment.

Life, Origin of

The recipe for life—at least for the molecules that join together to form living organisms—has been known for quite some time. Take a mixture of methane, ammonia, and hydrogen gases. Add water, and bring to a boil. Allow vapors from this mixture to be braised by sparks passing between two electrodes. Collect the residues by passing the vapor through a condenser tube. Cook for approximately 1 week, or until the broth starts to turn brown. At this point, it is thick with chemical compounds—amino acids, urea, hydrogen cyanide, and, in some cases, even purines and pyrimidines. All these substances are the ingredients of life—although in no case has life ever been recreated in this experiment.



New interest in the origins of life on Earth has been generated by the discovery that organic molecules also exist in interstellar space and even in comets. The existence of these organic molecules raises the possibility that life exists on other planets. *Left:* Comet Kohoutek, photographed with an ultraviolet camera from the orbiting Skylab.

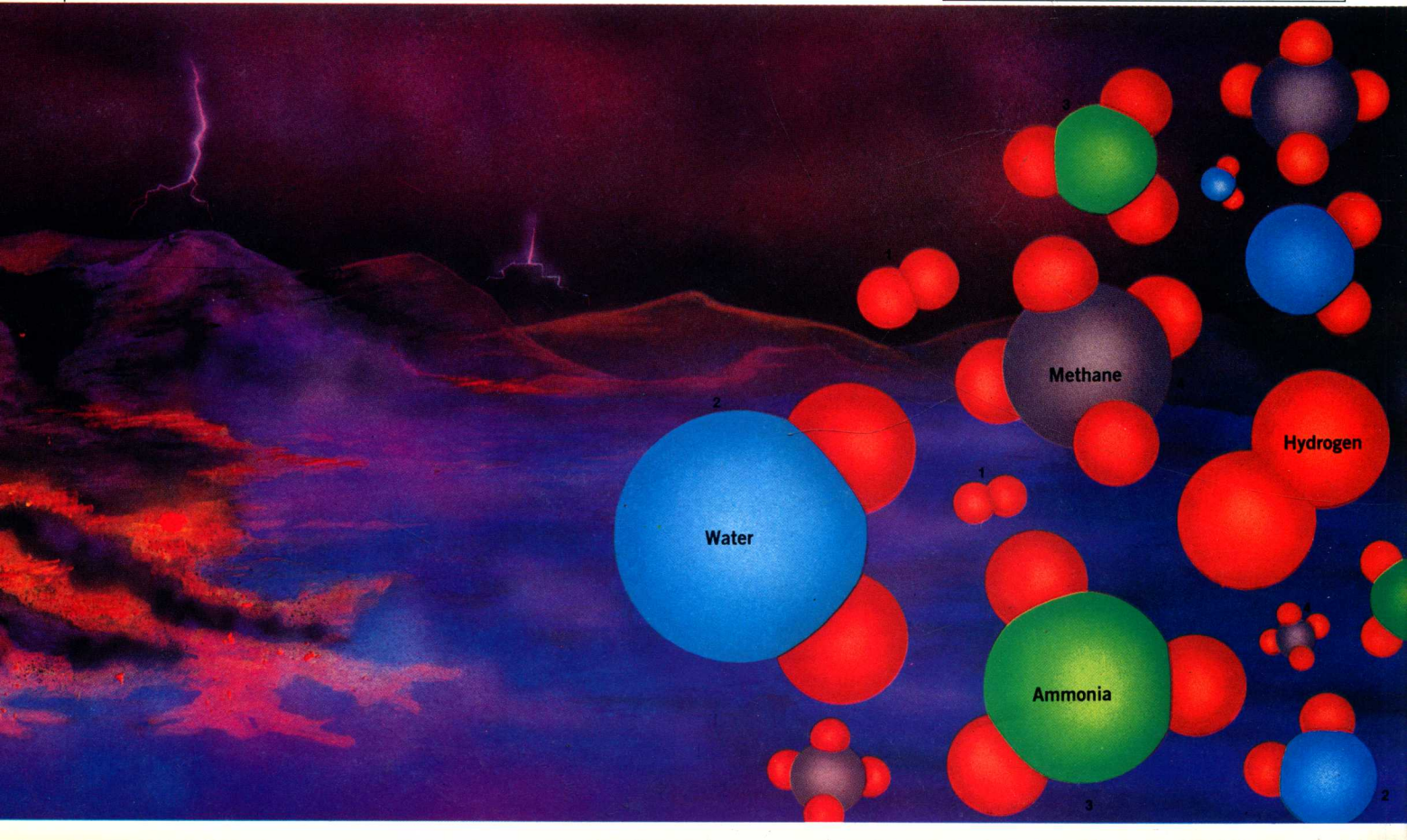
Below: Table of the inorganic and organic molecules presently known to exist in comets.

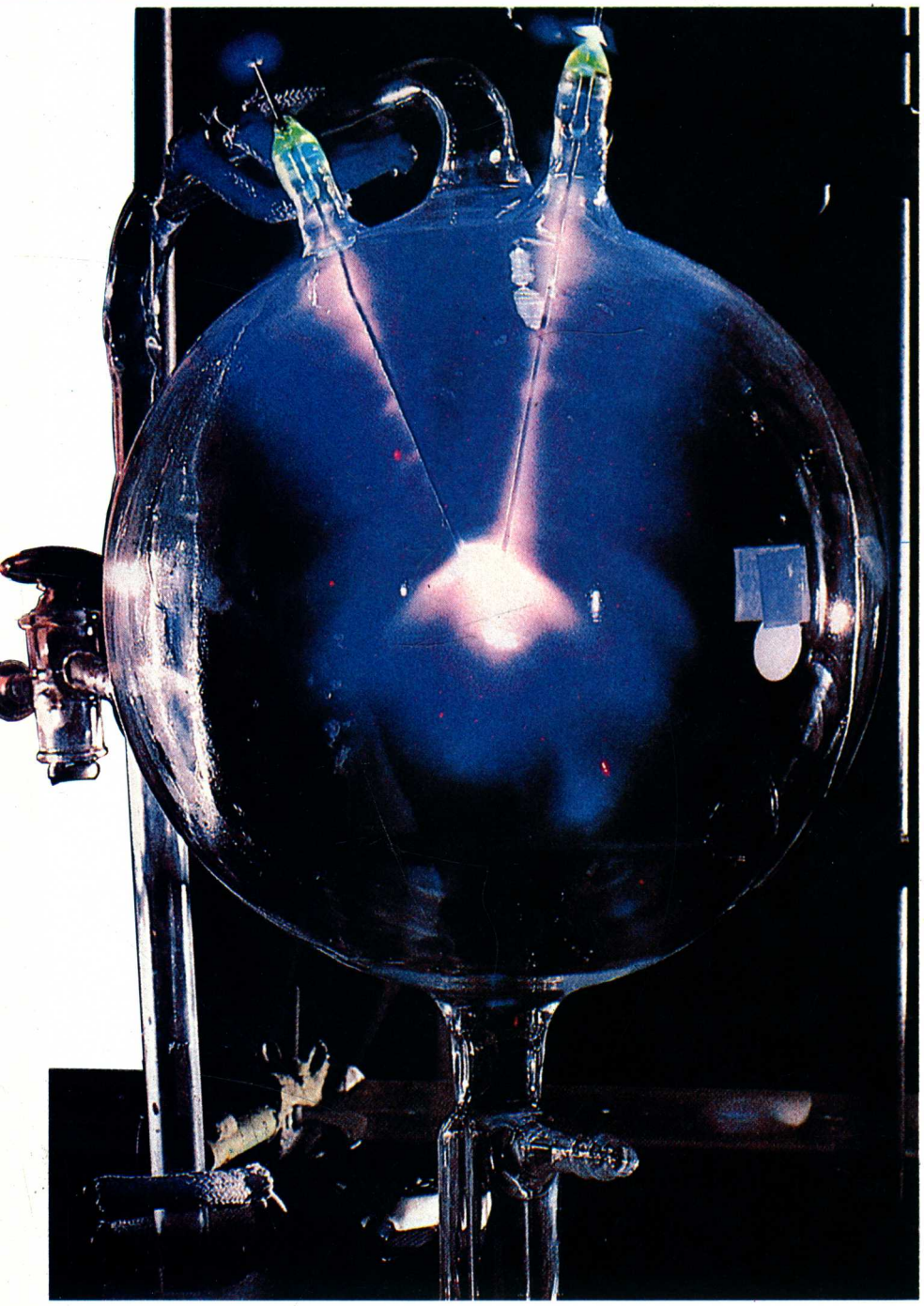
MOLECULES FOUND IN COMETS	
Coma (head)	CH, OH, C_2, C_3, CH, NH, NH_2 (visible spectrum) H_2O (Bradfield 1974) (radio spectrum) CH_3CN, HCN (Kohoutek 1973) (radio spectrum)
Tail	CO+, CO_2+, N_2+, CH+, OH+ (visible spectrum) H_2O− (Kohoutek 1973) (visible spectrum)
Hypothetical prelife molecules	H_2O, CH_4, NH_3, H_2CO, CH_3CN
Molecules found in comets come from evaporation of the nucleus or the ionization of the tail by solar winds	

Cooking Up Life

In 1953, a graduate student at the University of Chicago named Stanley Miller prepared the first laboratory batch of this primordial soup. The recipe was based on the theories of J. B. S. Haldane of Great Britain and A. I. Oparin of the Soviet Union, who hypothesized in the 1920s that these raw ingredients (methane, ammonia, and hydrogen) represented the Earth's atmosphere thousands of millions of years ago and that energy (in the form of lightning or ultraviolet radiation) was available to join simple molecules together to form more complex compounds. These compounds—particularly the amino acids, which are the main components of proteins—bring random chemical reactions to the very lip of life.

The primordial soup remains the most widely accepted theory for explaining the origin of life, although there is no dearth of alternative speculations. These range from the idea of "chemical laboratories" in interstellar clouds to spores from outer space to supernatural explanations (which cannot be replicated in any laboratory).





Far left: Molecules of hydrogen, water, ammonia, and methane—the compounds scientists believe were present when life originated on Earth. The planet was then largely without oxygen or a protected ozone layer, so that ultraviolet radiation and electric forces reached the surface unimpeded. The reaction of the basic molecules with these forces created the first organic compounds. *Above:* Laboratory apparatus constructed by Pannamperuma to simulate the conditions present on Earth when life began. *Below:* Table of naturally occurring energy sources capable of creating organic compounds.

The Realm of Hypothesis

The origin of life occurred only once on the Earth, and there was no one around to watch. This seems obvious, of course, but it is important to remember that the scientific effort to explain the origin of life is purely theoretical. It is the rich abundance and variety of life on this planet, once a sterile and forbidding terrain, that compels scientists to attempt to explain a process that is ultimately unknowable. The best we can come up with are feasible models of how, and when, life emerged.

We must define life before we can speculate on its origins. The first living organism had to satisfy several criteria. First and foremost, it had to be able to reproduce. It also had to be able to interact chemically with its environment, to obtain food and expel wastes—in short, to metabolize.

Both reproduction and metabolism suggest a third element: organization into a particular collection of molecules that is separated from its environment and retains its integrity by some kind of boundary. This organizational unit is the cell.

In the Beginning

According to the best estimates, the Earth was formed about 4,500 million years ago. It presented a desolate landscape compared to the wild profusion of plant and animal life evident now. This still-cooling planet was very hot during the period of its formation, and surface temperatures probably reached 3,600° F. (2,000° C.) or more. Volcanoes all around the globe coughed up copious amounts of dust and lava; spectacular electrical storms and driving rainstorms raked the surface; showers of X rays, cosmic rays, and ultraviolet radiation scoured the gray, rock-strewn landscape.

The Basic Ingredients

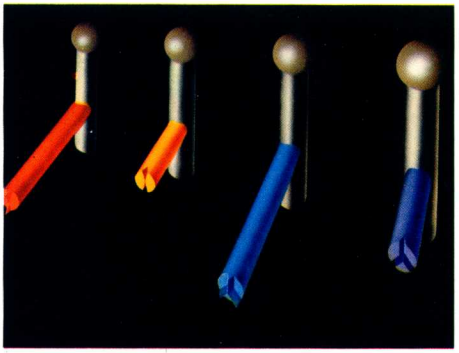
It was in this environment that the very first molecules assembled. Their origin—to say nothing of life's—is a matter of considerable uncertainty. According to the Miller experiment, the first primitive atmosphere of the Earth contained methane (CH_4), ammonia (NH_3), and hydrogen (H_2), as well as water vapor (H_2O). These substances, taken together, provide four key atoms necessary for living matter: carbon (C), nitrogen (N), oxygen (O), and hydrogen (H). A fifth ingredient, phosphorus, was available as an inorganic component of the Earth's crust; it is important not only as a component of nucleic acids but also as the source of nature's energy-rich phosphate bonds, crucial to metabolism.

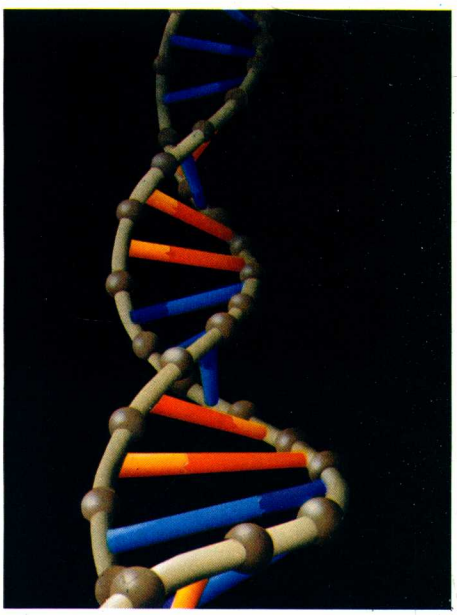
Carbon, in particular, is the essential atom for life. It can be thought of as an

NATURAL ENERGY SOURCES		CAL/CC²/ YEAR
Solar radiation		260,000
Ultra-violet light	λ <2,500 Å	570
	λ <2,000 Å	85
	λ <1,500 Å	3.5
Electric shocks		4
Cosmic rays		0.0015
Radioactivity		2.8
Volcanic heat		0.13
Meteor collision		0.1

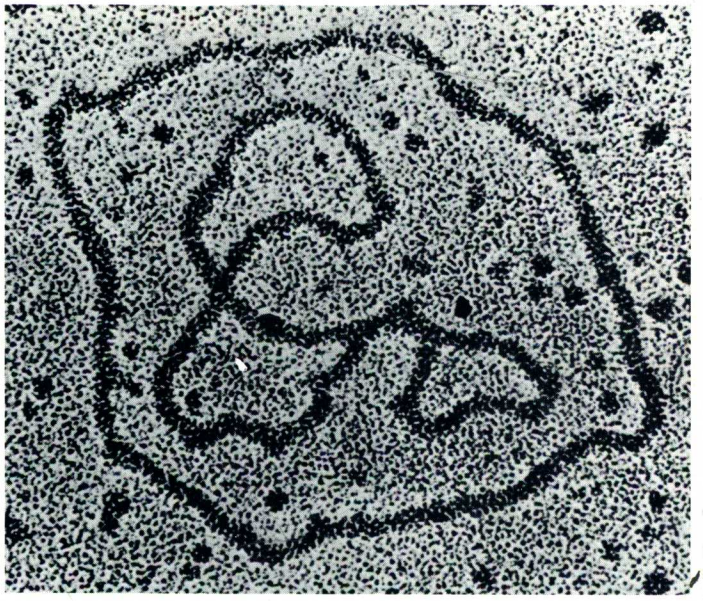
The intensity and wavelength of these energy sources acted on primitive molecules, catalyzing them and causing the reactions that allowed the formation of the first complex organic compounds.

atomic "glad-hander", well disposed to combine with many other molecules and even linking up with itself to form complex molecules. According to the model proposed by Miller, the hypothetical methane-ammonia-hydrogen atmosphere of early Earth was subjected to electrical sparks. These sparks provided the energy needed to break up the gas molecules and form new ones. These new molecules—including the amino acids—condensed in the cooler temperatures of the upper atmosphere, fell to the Earth as rain and collected in the burgeoning oceans. After hundreds of millions of years, the oceans were dense with molecular flotsam—complex, lifelike compounds known as biological precursors.





Above and right: Representations of a portion of the DNA (deoxyribonucleic acid) molecule present in all living cells. The nucleotides are represented by the cross bars of the double helix; the spheres are phosphoric acid; the vertical posts are deoxyribosomes; the colored posts are nitrogenous bases. *Below left:* Primitive forms of vegetable life. *Below right:* DNA molecules seen through an electron microscope.



Alternate Models

The primordial-soup model described above has been challenged by geophysicists and astrochemists. Although the end results of these contrary speculations are essentially the same, the way in which they suggest the biological precursors formed is different.

It has been argued, for example, that the Earth's early atmosphere might have contained carbon dioxide (CO_2) and gaseous nitrogen (N_2), as well as water vapor, instead of the methane-ammonia fog. In one recent experiment using carbon monoxide gas, nitrogen, and water, electrical sparks prompted the formation of amino acids and two purines, adenine and guanine (which form important parts of deoxyribonucleic acid, or DNA).

Another theory suggests that carbon dioxide and hydrogen, aided by the energy of sunlight, could have formed as much as 3 million tons of formaldehyde (H_2CO) in the primitive atmosphere, which later rained down on Earth. We now regard formaldehyde as a liquid that preserves dead things; in a prebiotic environment, however, it is now believed to have been among the more important precursors of life. In fact, formaldehyde is an intermediary stage in the formation of five-carbon sugar molecules of the type that provide a structural backbone for DNA.

Galactic Smog

The most controversial alternative to the primordial-soup theory might be referred to as the galactic-smog theory. Developed by astronomers Fred Hoyle and Chandra Wickramasinghe, it theorizes the formation of organic compounds in outer space. Clouds of dust and gases in space, the unsettled residue of star formation, appear to be made of tiny particles of carbon as well as other elements and gases. Radiotelescope data suggest that ammonia, water, formaldehyde, and about 90 other complex molecules are present in this interstellar smog.

Some scientists now speculate that amino acids, complex sugars such as cellulose, and porphyrins (a group of complex organic molecules that form chlorophyll, the key ingredient of photosynthesis) are routinely formed in outer space. According to the same speculations, these compounds reached Earth via comets and meteors. Two meteorites that crashed into Antarctica some 200,000 years ago (and quickly froze) recently underwent chemical analysis. A number of amino acids were identified, but about half of them possessed a peculiar physical-chemical quality (the way in which molecules reflect polarized light) that is