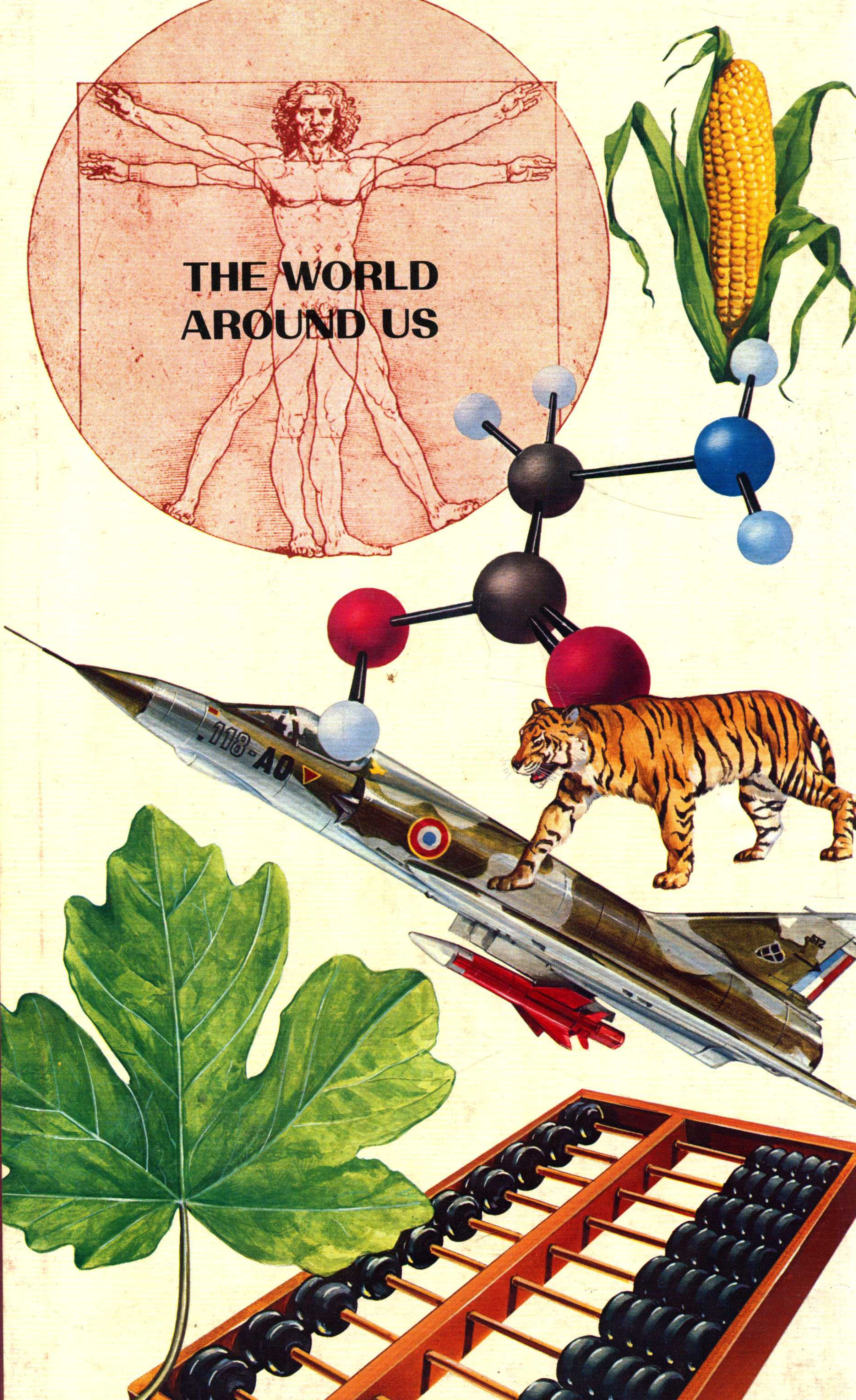
THE WORLD AROUND US

SCIENCE AND TECHNOLOGY ILLUSTRATED



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Encyclopaedia Britannica, Inc.
CHICAGO

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TOKYO • TORONTO

Library of Congress Catalog Card Number: 84-80129

International Standard Book Number: 0-852229-425-5

English language edition by license of Gruppo Editoriale Fabbri

Title page photograph courtesy of Hale Observatories;
California Institute of Technology and
Carnegie Institution of Washington

Printed in U.S.A.

Science and Technology Illustrated

The World Around Us

Science Technology

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Volume 14

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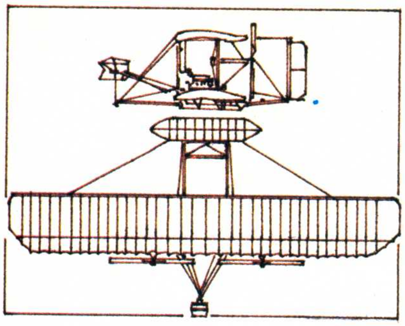
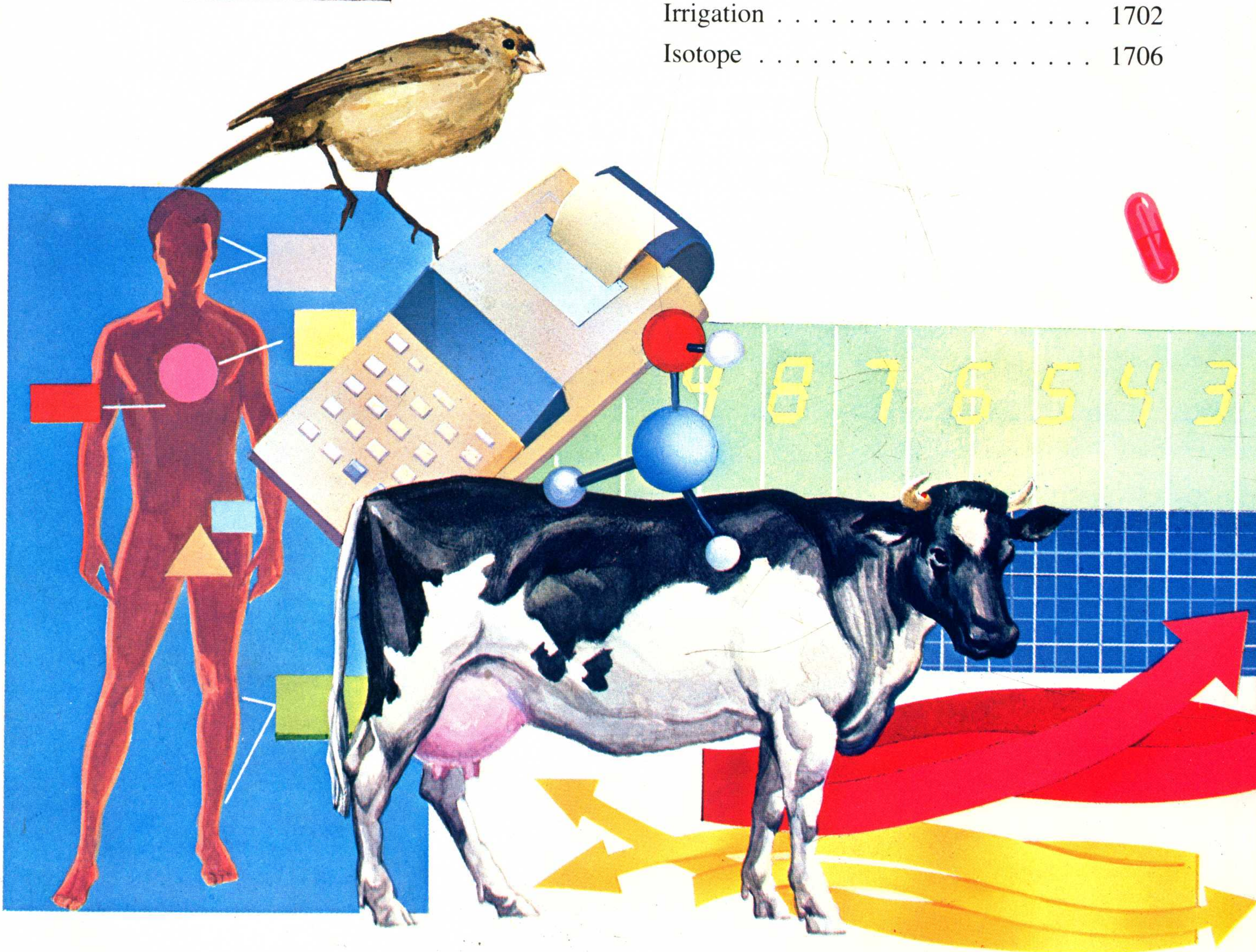




Insect Control

Insects can be annoying or even deadly—to the farmer who is trying to raise crops; to the doctor who is attempting to eradicate deadly viruses carried by flies and mosquitoes; or even to a city dweller plagued by cockroaches. Insect control is an eclectic science involving a multitude of chemical, biological, and mechanical ways to keep the pests from getting out of hand. To solve the problem, it is necessary to identify the culprits, to be familiar with the available means of control, to select methods of control that are most effective and do the least harm to the environment, and to understand how to apply these methods correctly and safely.

The ancient Chinese cultivated predacious ant populations to prey on leaf-devouring insects. In the West, the earliest record of insect control dates from 1762, when the French introduced the Indian mynah bird into Mauritius to destroy the red locusts there. When synthetic organic insecticides became available in the 1930s and '40s, the emphasis of insect control was focused on chemical means. However, now that we understand some of the long-term problems insecticides inflict on the environment, scientists are looking for ecologically sound methods of insect control. Their greatest hopes lie in the integration of biological, chemical, and mechanical methods.

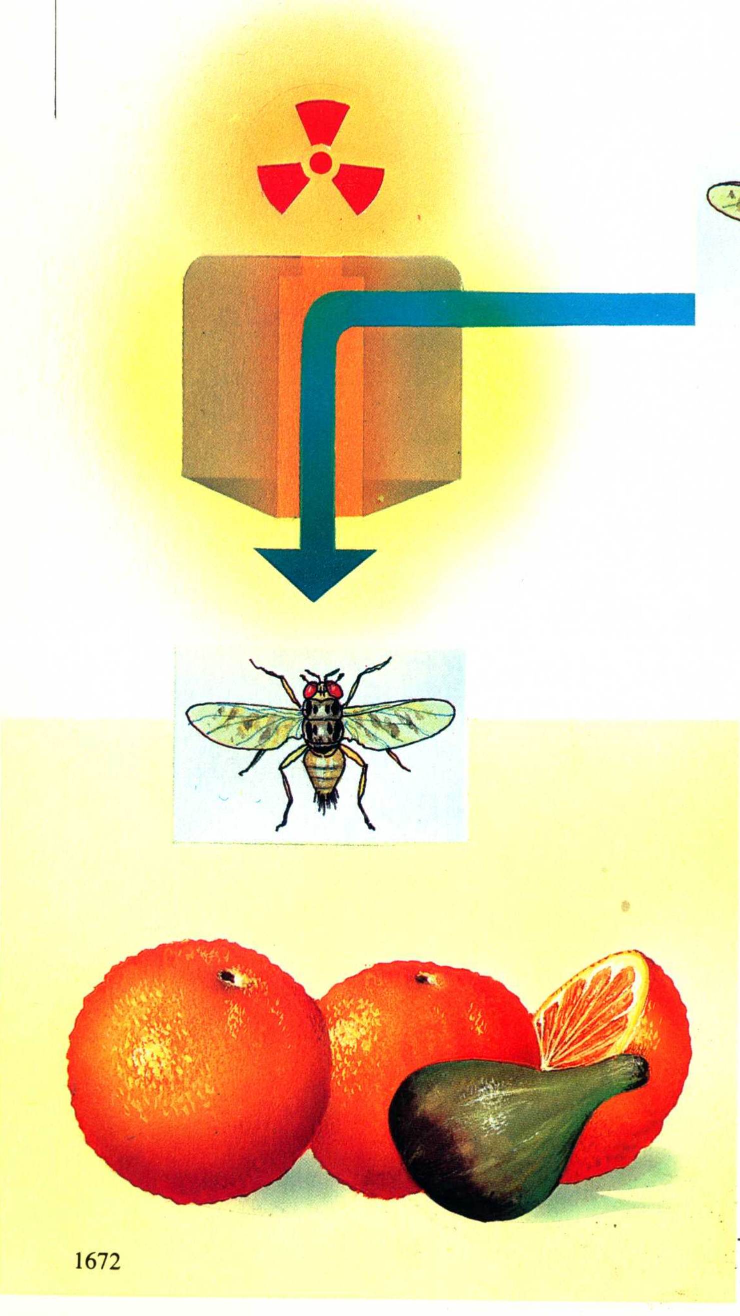
Insect Control with Chemicals

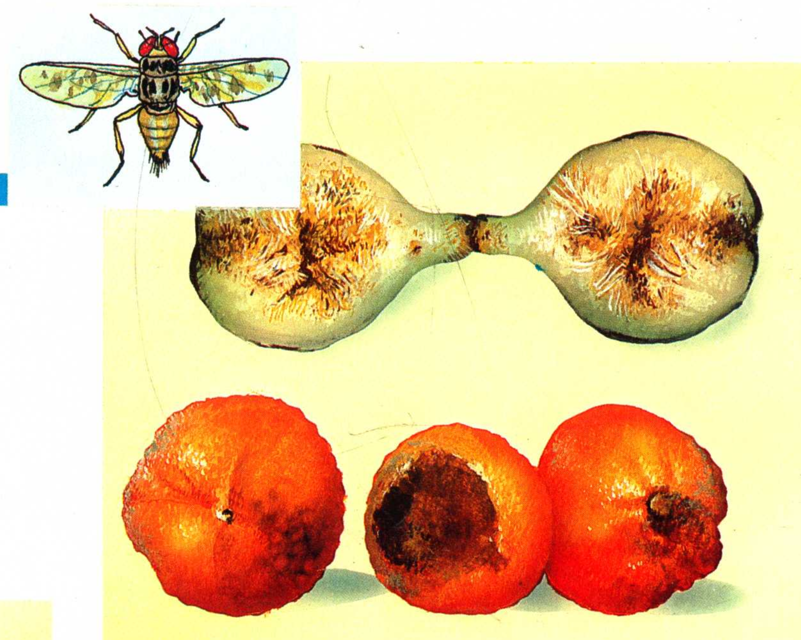
Chemical insect control is the domain of insecticides, which are poisonous substances that damage the metabolic processes of pests and are usually deadly. Insecticides are difficult to confine to a target area and can also persist in the environment long after they have served their purpose. Therefore, they can be harmful to many other forms of organic life, including humans. Insecticides are still necessary tools in the mass growing of single-species crops, where there are no natural predators to prey on the pests, and in areas where disease-carrying insects, such as the malaria mosquito, must be obliterated.

Other Methods

Raising resistant strains of plant and animal life is an ideal form of pest prevention. Thanks to the science of genetics, we have been able to modify certain species of plants and animals so they either do not attract insects or have developed a resistance to their attack. Scientists have also tampered with the maturation time of certain plants so that it does not coincide with the feeding habits or stage of development of the insect that normally eats the plants.

Cultural control means making the environment less desirable to insect pests.





Above: Commercially grown oranges and figs that have been badly damaged by an infestation of the fruit fly *Ceratitis capitata.* Attempts to control the insect by chemical means have been costly in terms of both money and environmental damage. In recent years, a system of control based on biological means has been used successfully to combat the pest. Laboratory-bred male insects are sterilized by exposure to radiation. Released in the orchards, they then breed with natural members of their species, with the result that the overall fertility rate of the insect population is sharply lowered.

Left: Healthy fruit that resulted from reducing the fruit fly population to tolerable levels.

Right: Traps baited with pheromones—insect secretions that act as a sexual lure—are used both to control pest populations and to capture insects for study.

Tilling the earth and keeping it clean of plant refuse can deter insects from settling and breeding.

Ecological changes in the land can diminish or even eliminate insect nuisances. For example, yellow fever and malaria are transmitted by mosquitoes that require swampy habitats for breeding. If the swampland is drained, the mosquitoes cannot breed. Planting hedges around cultivated areas can encourage insect-eating birds to nest and breed near vulnerable crops. Insects can also be discouraged by planting their typical target crops in undesirable regions. For example, it has been found that many insects, particularly small ones, shun the wind because it sweeps them away. If carrots and cabbages are planted in wind-exposed fields, the pest infestation by little flies is reduced.

Diversity in planting seems to be one of the best ways to deter insect pests. Mixed vegetation tends to attract a variety of insects that will eat each other, thus keeping their populations in balance.

Biological Methods of Control

Biological insect control involves encouraging and even breeding natural predators, parasites, and diseases. This is particularly useful when a pest has been imported into a region where its predators have not followed, or in cases where the natural enemy's numbers have been seriously diminished. Scientists determine what the pest's enemies are and either import them full-grown to the target area or actually breed large numbers of them in a laboratory. Fighting insects with microorganisms, such as bacteria or viruses, can be very effective. Scientists collect and breed diseased members of the pest family, crush them, and thereby release active viruses or bacteria into the healthy pest population.

There are also purely mechanical processes that can discourage insect infiltration, such as simply keeping an area clean and food sources sealed up. If an insect cannot get to its delicacy, it will go hunting elsewhere. Barriers and screens can keep out termites and flies. Certain lights, sounds, and smells can attract pests to their death or repel them.

Insect control works on three levels: prevention, or keeping pests from attacking and populating an area to begin with; suppression, or reducing a pest population to a tolerable level; and eradication, or annihilating an insect population in a given region. Decisions as to which approach to take should be made with great discretion. Killing entire pest populations may have the undesirable effect of throwing off life's natural balance; the consequences can be serious and irreversible.

Insulating Materials

As sources of energy become more expensive and less available, people everywhere are giving more attention to energy conservation. One of the easiest ways to save the energy used to heat and cool buildings is by improving their insulation. By keeping heat inside or outside a building, as required by the season, good insulation allows us to maintain a given temperature while using less energy.

How Insulation Works

A wide variety of materials is used to make insulation. But we probably wouldn't think of one of the best insulators as a material at all—air. In a large space, air does transmit heat; this is because the air closest to the warm surface rises, thereby generating motions in the air called convection currents, which transport the heat to cooler surfaces. In a large space, then, convection currents can carry heat from the warm side to the cool side. However, good insulating materials contain countless tiny air-filled gaps—tiny enough that convection currents cannot get started. Thus, insulation is usually composed of thin fibers or tiny granules or the bubbles of a foam; the individual bits of material are surrounded by minute amounts of air that block both the convective flow and contact conduction of heat.

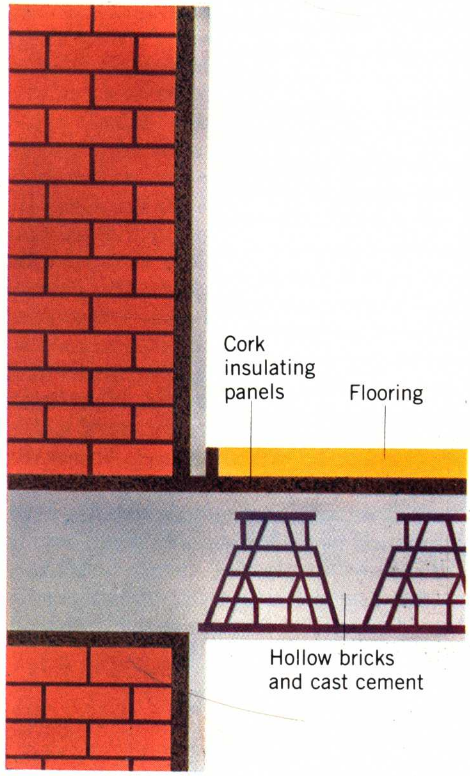
Examples of Insulating Materials

Some of the most common insulating materials are fiberglass, fibers made of minerals or of organic materials, plastic foams, granules of cork, and powders made from various minerals like gypsum, silica gel, and mica, among many others. Different materials are used in different forms depending on the requirements of different jobs. For example, blankets of fibrous insulation are set into the spaces between timbers in wood-frame houses during construction. Granules and foams can be poured or pumped into gaps in the walls of finished houses. Insulation for pipes comes in precast sections, which are fitted around the pipe and held together with bands.

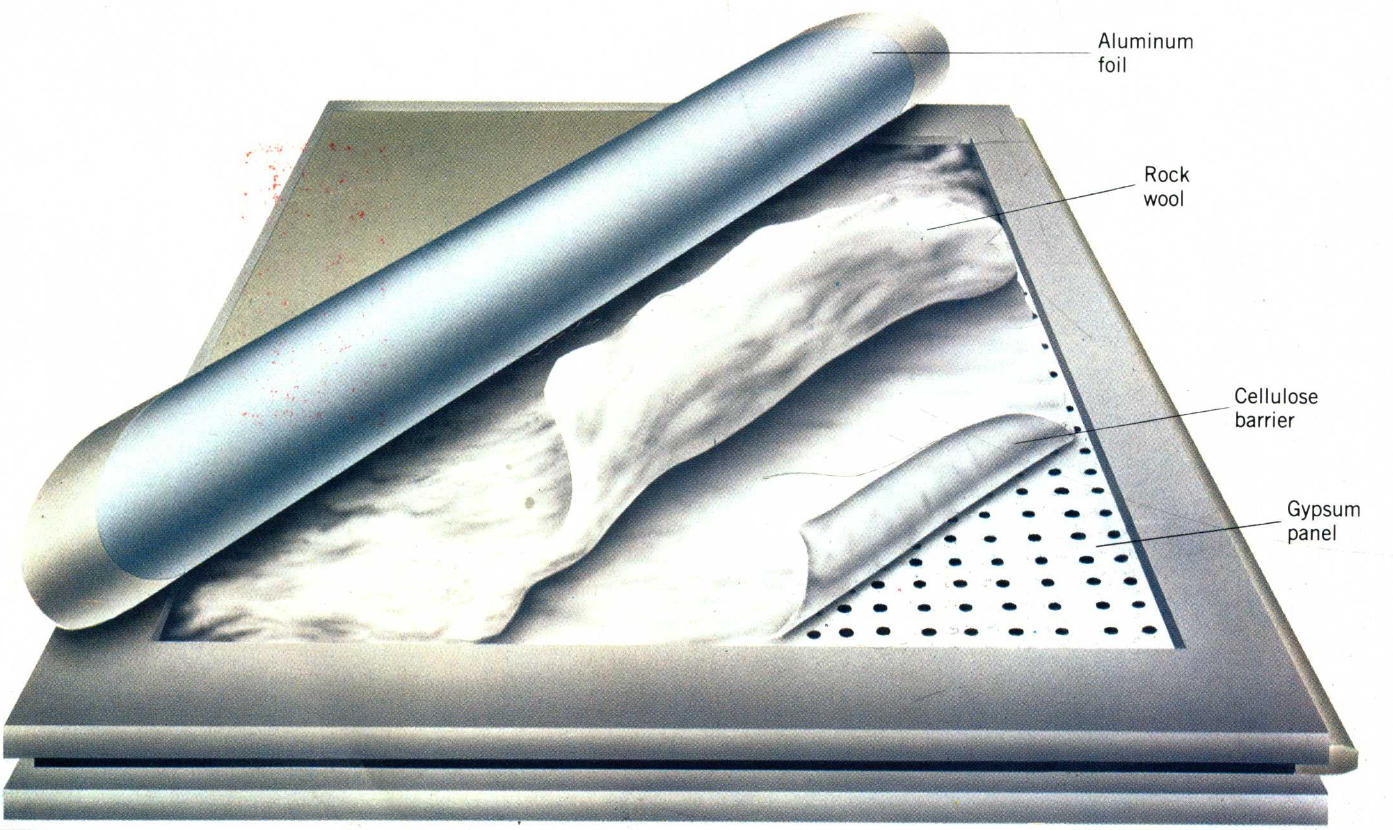
Because insulating materials contain so much air, they tend to be lightweight and not very strong. Thus, even rigid insulating materials cannot bear heavy loads. In cases where more strength is needed—for example, in the floors of furnaces—bricks made of special clay can be used.

Problems with Insulation

There are a number of problems associated with insulating materials. Some materials present health hazards. The microscopic particles of asbestos fibers, for example, can be very dangerous to



Above: Cork, shown installed to insulate a floor, is still widely used for thermal and acoustic insulation in producer countries, but in most of the rest of the world it has been superseded by synthetic products like the composite panel shown below.



breathe, and the use of asbestos has been severely restricted. Other insulating materials—for example, plastic foams—give off poisonous gases when they burn. Thus, building codes require that such materials be treated to make them resist flames.

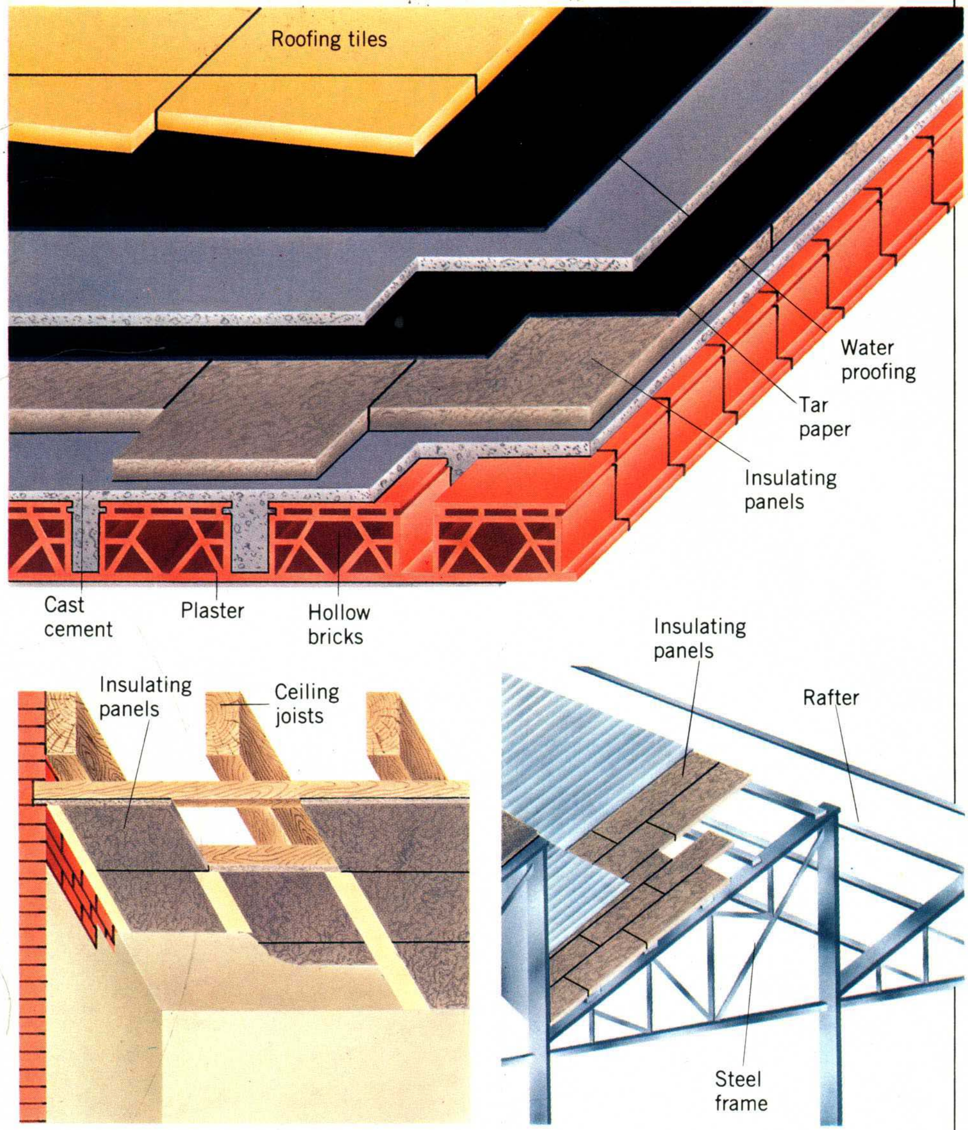
Another problem with insulation is that it can become wet, resulting in a loss in its insulating ability and possibly in structural damage to the building. Thus, special precautions must be taken to prevent moisture from entering insulation.

Guarding Insulation from Moisture

Although insulating materials block the transmission of heat, most allow the passage of water vapor. Now, warm air is able to hold more water vapor than cool air. As warm air cools down, it reaches a temperature called the dew point, where some of the water vapor condenses into liquid—this is what happens at night, causing dew to form. If an insulated wall divides warm air from cold air, then, as water vapor passes from the warm side to the cold side, it might come to a place that is at the dew point. If this place is inside the insulation, the vapor will condense inside the insulating material, causing it to become wet.

To block water vapor from entering insulating material, the warm side of insulation is covered with a vapor barrier. Aluminum foil, through which vapor cannot pass, is a good vapor barrier. Generally, it is mounted on some kind of backing, to strengthen it against accidental punctures. This foil has the additional role of reflecting radiant heat (such as that of the invisible infrared component of sunlight) away from the insulated surface, thereby increasing its effectiveness.

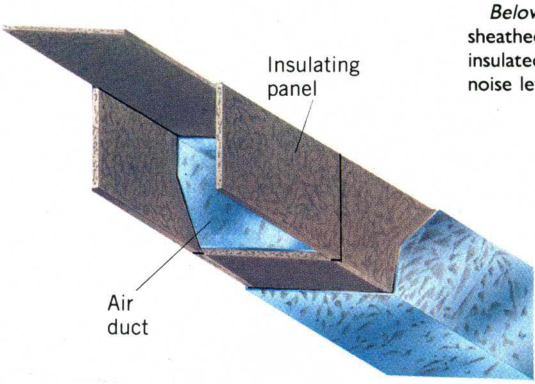
Enormous energy savings can be obtained in temperate climates through efficient insulation, especially in the roofs of typical houses, since rising warm air can be kept from transferring its heat to cold outside surfaces in winter, and solar heat can be kept from air-conditioned rooms during the summer.

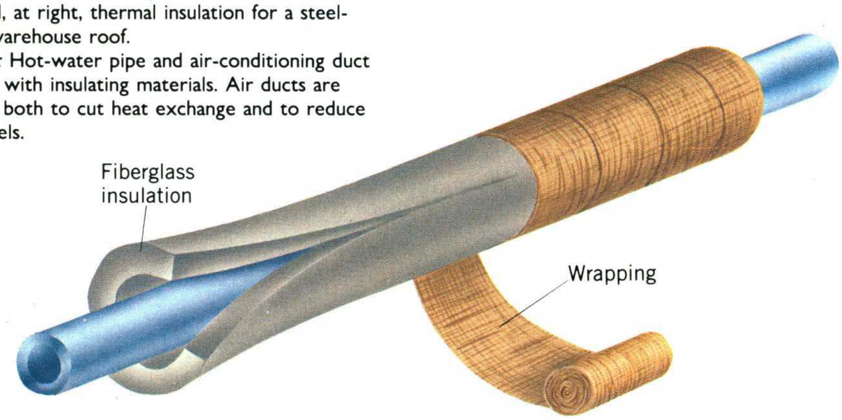


Beyond their thermal and acoustic properties, good insulating materials must also be fireproof. Plastic-foam insulation is treated with fire-retardant materials, and cellulose fibers are bonded with fireproof cement.

Above: Three types of installations that exploit the thermal-insulating properties of cellulose fibers. At top, fiber panels incorporated in a composite roof of a type in use in hot, dry countries. Below these panels, at left, ceiling insulation on wooden joists and, at right, thermal insulation for a steel-framed warehouse roof.

Below: Hot-water pipe and air-conditioning duct sheathed with insulating materials. Air ducts are insulated both to cut heat exchange and to reduce noise levels.





Intelligence Gathering

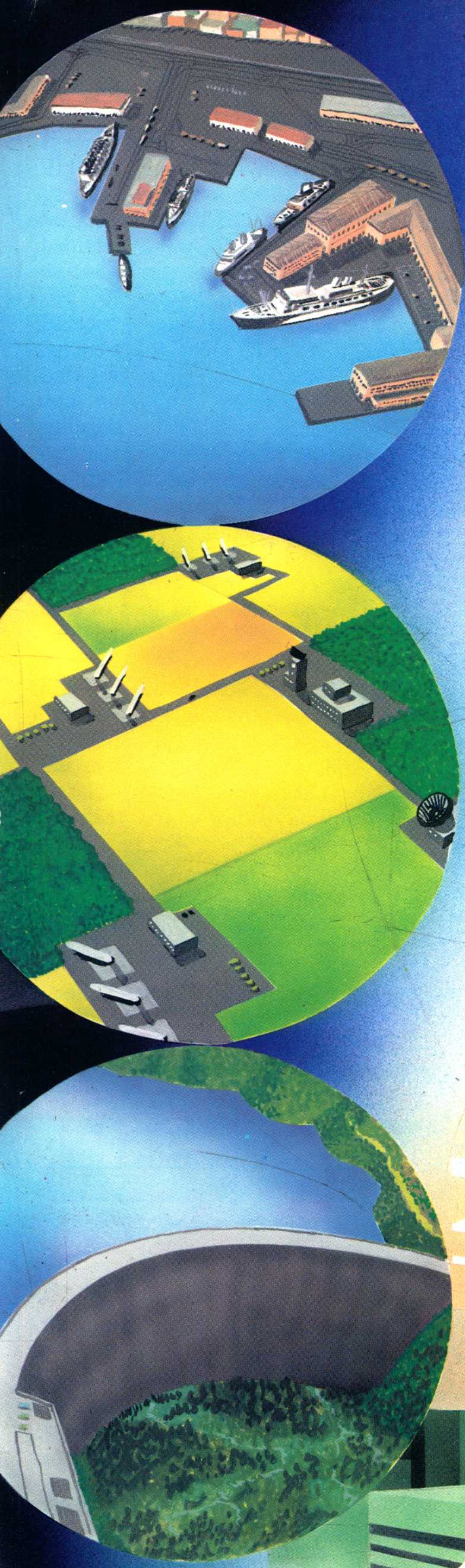
While films and popular novels may have led us to believe that intelligence work is primarily cloak-and-dagger espionage, such is not the case in the real world. Intelligence gathering involves little of such high adventure. It is, for the most part, a laborious and tedious field of endeavor, involving endless hours of painstaking research and analysis. It would bore James Bond to tears.

What is Intelligence?

Intelligence is evaluated information gathered by one entity regarding the capabilities and intentions of another. While a company may seek intelligence concerning a rival's products or plans, or a political candidate may wish for intelligence on his or her opponent, the term is mostly used in the context of international relations. In a world of rapid political, economic, and technological change, intelligence is deemed vitally important by most nations, and so it has become one of the world's great industries.

Techniques of intelligence gathering have been radically altered by improvements in the technology of artificial satellites. Observation stations in Earth orbit, like the one shown in the large illustration, can collect information regarding military installations and troop movements, the activity in transport systems like maritime ports and railways, and other vital data, such as crop yields and weather patterns. If satellite observation has a defect, it is that it collects too much information. The huge volume of raw data transmitted from observation satellites to ground stations must first be processed by computer to render it intelligible and to pick out significant patterns. Then human analysts must examine the data to decide what implications it has for the political and military factors that interest their governments.

Information is usually gathered in two ways: overtly and covertly. About 80 percent of all intelligence is taken from open sources such as newspapers, television and radio broadcasts, unclassified government publications, technical journals, and reports by diplomats and attachés. Covert sources include aerial, space, and other forms of long-distance surveillance, and occasionally the espionage agent. Once this new intelligence has been gathered, it must be evaluated and interpreted before it can be reported to the policymakers of a country. "Top secret," these intelligence reports are highly treasured, and



only those with a "need to know" are granted clearance to read them.

The History of Intelligence

One of the earliest references to intelligence and espionage can be found in *Ping Fa* (*The Art of War*), written by the Chinese scholar Sun Tzu around 400 B.C. Though intelligence gathering has played a role in international politics since the days of Sun Tzu, it has only been since World War II that its role has become so prominent. During that war, and in the years following, many countries established intelligence services. Perhaps the best-known intelligence services are the U.S. Central Intelligence Agency (CIA), formed in 1947; the Soviet Union's *Komitet Gosudarstuvennoi Bezopasnosti* (KGB), the *Service de Documentation Extérieure et de Contre-Espionnage* (SDECE) of France, China's Social Affairs Department, the *Shin Bet* of Israel, and Great Britain's Secret Intelligence and Security Services, MI-6 and MI-5.

Types of Intelligence

There are many things that one country would like to know about another. Perhaps the most important—and most difficult to obtain—information concerns political trends, currents, and personalities that may shape or in some way affect the actions of a foreign power. Diplomats regularly prepare reports composed of such political analysis. This information may be supplemented by data from other sources, including espionage. Since economics plays an increasingly important role in policy making, intelligence gathering must also include economic information and analysis. Military intelligence and analysis are needed to determine the location of a country's forces and weaponry. Scientific and technological information enables planners to judge the various strategic capabilities of another power. Even geographical information concerning the climate, weather, and resources of a nation can be of vital importance in analyzing its strengths and weaknesses. And, as governments are essentially organized groups of individuals, biographical information on those individuals can have great significance and is, therefore, highly valuable intelligence.

Is Intelligence Intelligent?

There have been, and will probably continue to be, gross injustices perpetrated by various intelligence services around the world. In many instances, intelligence operations have been carried out that do not seek merely to report on another country, but attempt to intervene and change its government. Even with such flagrant abuses, in an increasingly dangerous and uncertain world, many governments believe that it is necessary to know what other governments are doing.

Intelligence Quotient (IQ)

How intelligent are you? For many years, the intelligence quotient, or IQ, has provided a seemingly simple answer to that question. Many people assume that if you have a high IQ, you are very intelligent. But the IQ is not a literal measure of intelligence. Your IQ is merely a score representing your performance on an IQ, or mental ability, test in relation to the performances of others of your age group who have taken the same test. Although the development of the IQ concept has occurred principally in the United States, the tests are administered around the world.

IQ Scores

The IQ score was originally based on a ratio of actual age to level of mental development, or mental age. Alfred Binet devised a reference scale on which the mean test scores of average age groups were designated as the average score for that age. Any child achieving the score of, say, the average 12-year-old had a mental age of 12. To indicate the difference in development between a 10-year-old and a 12-year-old with the same mental age of 12, Binet divided the mental and chronological ages into months, put them into a ratio, multiplied by 100 to eliminate decimals, and came up with an intelligence quotient. Later, at Stanford University in California, Lewis Terman used this scale to develop the Stanford-Binet Intelligence Test.

The IQ is meant to reveal whether a child is bright or slow for his age. A 10-year-old and 12-year-old sharing the mental age of 12 have different IQs. The 12-year-old has a score of 100 ($144/144 \times 100 = 100$), while the 10-year old's score is 120 ($144/120 = 1.2$, and $1.2 \times 100 = 120$). The 12-year-old shares a mental age with his own age group; his score of 100 shows he is average. But the 10-year-old's IQ of 120 is above average; his mental age is ahead of his age in years.

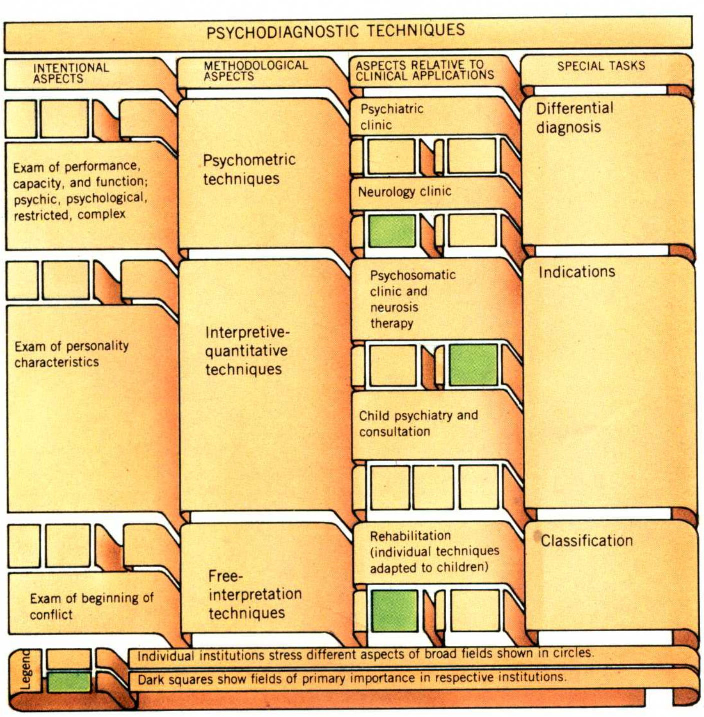
Binet's ratio IQ shows an uneven score distribution around the average, because of the greater degree of difficulty in tests for higher age levels. This variation is corrected by including a standard deviation of 15 or 16 (depending on the test being used) in the computation of the score. Since mental age generally stops increasing by the age of 18, the correlation with age is no longer useful past that point. For this reason, the ratio IQ is usually replaced with the deviation IQ, a system suggested by one of Terman's students, Arthur S. Otis. The average score for every age group is assigned to a mean of 100, and the individual is scored according to his deviation from his group's norm based on standard scales.

IQ scores are ranked according to range: 90-109 is considered average; 110-119, bright average; 120-129, intellectually superior; above 130, gifted; 70-89, considered low average, 50-69, mildly retarded, 35-49, moderately retarded, 20-34, severely retarded, and below 20, profoundly retarded. It must be remembered, however, that the IQ alone is not enough to identify someone as retarded or gifted. The mentally retarded in addition must show deficiencies in self-help, learning, or social skills, while the gifted must reveal some unusual abilities in learning, originality, or other adaptive skills to warrant such designations.

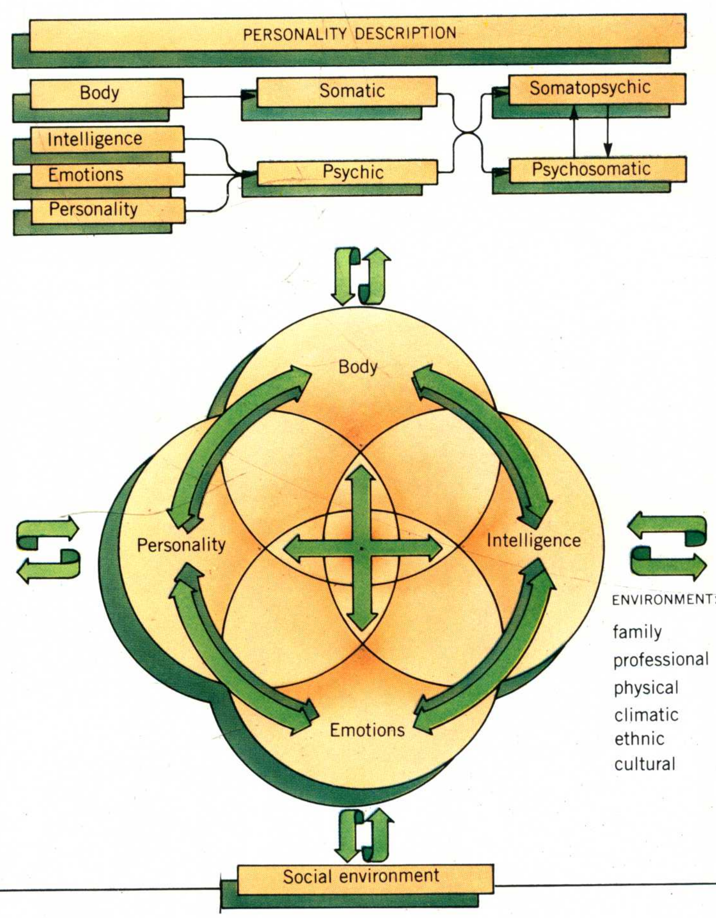
IQ Tests

There are now many versions of mental-ability tests in addition to the Stanford-Binet test. Some others are the Wechsler Adult Intelligence Scale (WAIS) and the Wechsler Intelligence Scale for Children (WISC), the Otis Group Test of Mental Ability, and the Army Alpha test, which the U.S. Army used to classify nearly 2 million recruits who were drafted or enlisted during World War I.

All mental ability tests, whether individual or group, are designed to test general mental aptitude, not specific skills.



IQ tests are generally used during childhood to determine the mental age of children in order to orient them scholastically. Although these tests are important, their results should not be used alone; they are strictly a guide, never a final verdict. It must also be remembered that the individual's personality is constantly changing, a factor that may invalidate the results of a test.



SCORES FROM A WECHSLER IQ TEST

	RAW SCORE	WEIGHTED SCORE
General culture	23	16
Comprehension	17	15
Figure memorization	7	3
Arithmetic computation	9	12
Analogy	11	9
Vocabulary	32	14
VERBAL SCORE		57
Figure recording	4	4
Figure completion	9	8
Drawing using cubes	12	6
Figure reconstruction	12	5
Association of figures and numbers	23	5
PERFORMANCE SCORE		28
TOTAL SCORE		
Verbal scale	57 IQ 116	
Performance scale	28 IQ 90	
Total scale	85 IQ 104	

Test profile provides 2 types of information:

1. Suggestion of an organic mental problem, since results on the verbal scale are better than those on the performance scale. Only one error in the verbal test confirms an organic problem.

2. Calculations of degree of mental deterioration.

Gen. cult.	16	Fig. mem.	3
Vocab.	14	Arith. comp.	12
Fig. com.	8	Design	6
Fig. recon.	5	Sym. assoc.	5
	43		26

% of deterioration $\frac{43-26}{43} = 39\%$

A loss of 14% can be considered normal considering the age of the subject. The subject exceeded this by 25%.

There is a great probability of pathological deterioration.

52 years, farmer, traumatic cerebral atrophy.

Most intelligence tests measure the intellectual abilities that show a high correlation with abilities needed to succeed in school and at work. They usually include tests of verbal, motor, abstract-reasoning, and spatial-comprehension skills.

Use and Abuse of the IQ

IQ scores are used most often to analyze a child's school progress; they reveal children working below their abilities or those able to move ahead more quickly. Schools sometimes use IQ scores to place children in learning groups according to ability. IQ scores are very often factors in determining suitability for jobs or admittance to college. Results of intelligence tests generally show a high correlation with success in school, but they are only moderately effective in predicting success in the postgraduate, professional, business, and social realms.

Recent controversy has made the IQ a less popular evaluating tool than it once was. Scientists differ over the relative contributions of heredity and environment to intelligence. Some claim that environmental deprivation, rather than heredity, is responsible for the fact that, in the United States, IQs in the average groups of black children are lower than those of white groups. Many have pointed out that test questions and formats are biased in favor of the dominant culture. Again in the United States, Spanish-speakers and those with different cultural references and values are penalized. Some attempts have been made to create culture-free or culture-fair tests that do not reflect cultural bias. However, the possibility that IQ differences between socioeconomic groups may be used as a tool for further educational and social discrimination is a continuing cause of concern.

The mechanical accuracy of the IQ test has also been criticized. Some psychologists claim all general tests are inadequate measures, since they combine the test scores of several unrelated mental abilities. These scientists suggest that those abilities should be tested and scored separately. Also, IQ scores can vary 5 points or more, depending on the subject's condition on the test day, on inaccuracies in administration and scoring, and on interpretation and relative priority given to IQ scores as evaluating tools.

Interference and Interferometry

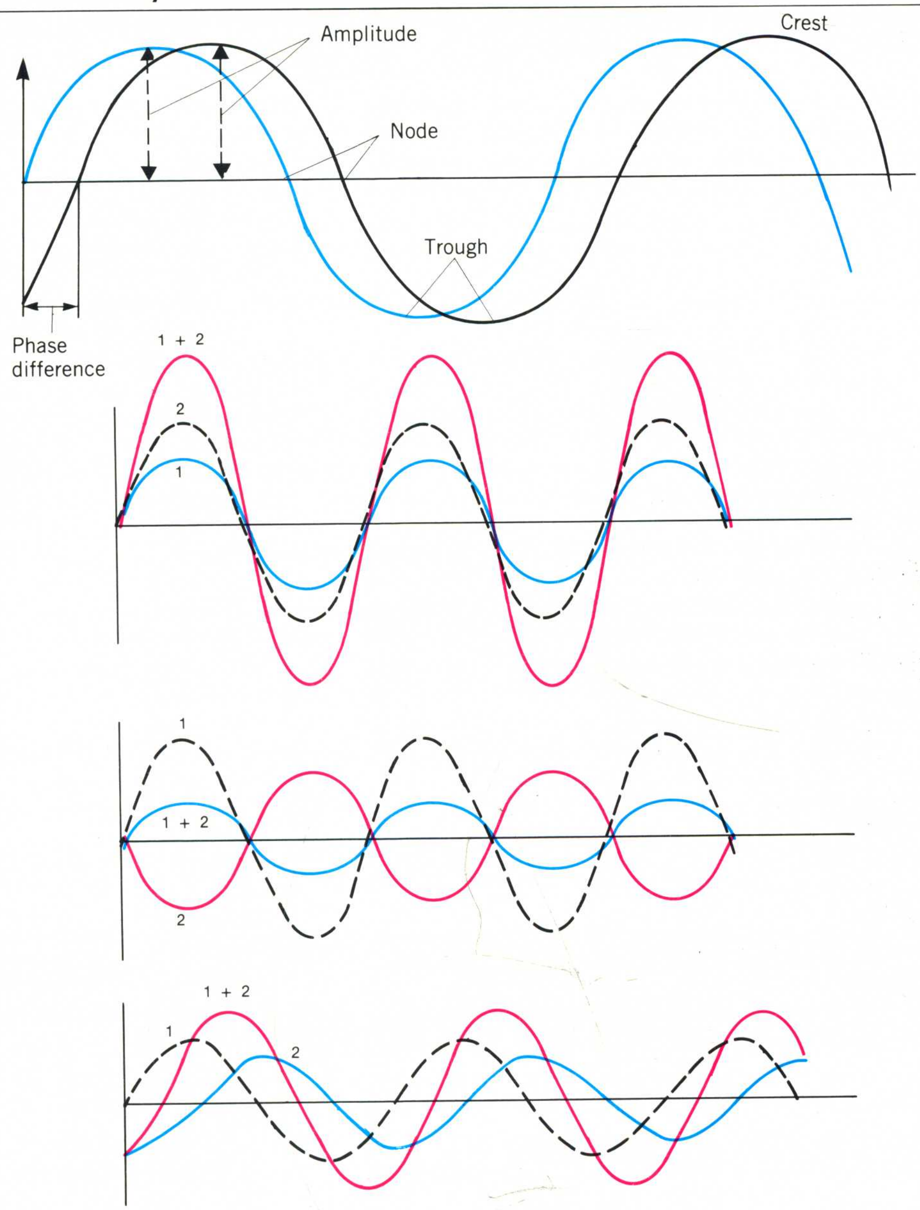
The Universe as we perceive it with our senses—and with instruments designed by scientists—encompasses many different phenomena. Light, sound, subaudible vibration of masses, gravity, electromagnetic effects, and the strange, newly discovered kinds of subatomic particles define the physical world. Some of these phenomena have one essential feature in common: they behave, or appear to behave, as waves. Since the Universe is full of waves, the waves bump into each other and affect each other's behavior. The study of the rules governing the mutual interference of waves and the techniques for using such interference in scientific measurement is called interferometry.

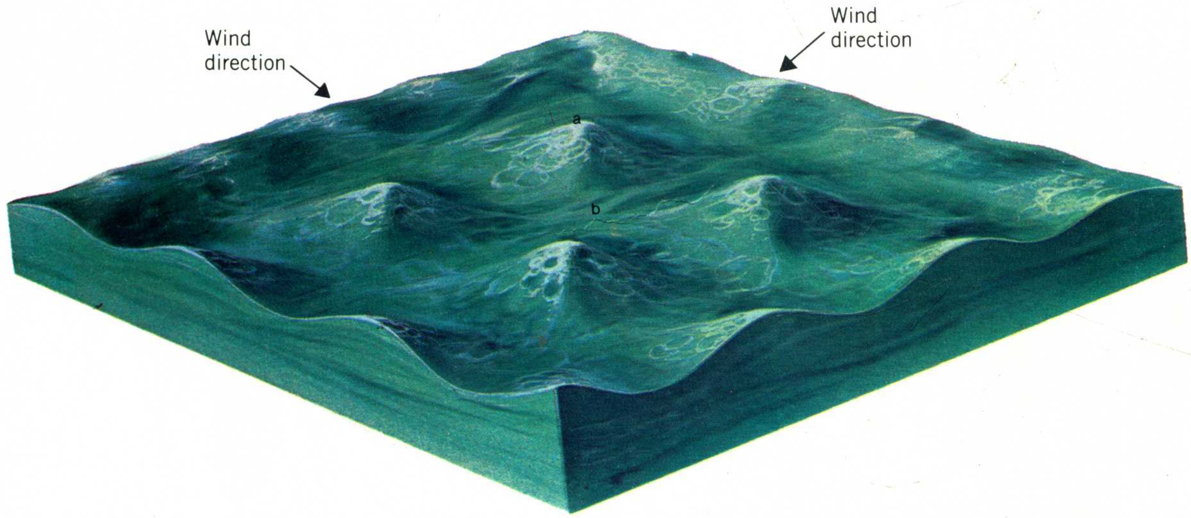
Characteristics of Waves

Waves of all types have several properties in common.

First, they all have a source. The source of a radio-frequency wave may be a radio transmitter or a star; the source of a sound wave may be a footstep or a voice; the source of a light wave may be the Sun or a flashlight.

All waves are marked by amplitude and frequency. The amplitude wave is, in effect, its "height." Imagine a wave at sea: its amplitude is the distance from its trough to its crest. One sequence of a crest followed by a trough—one complete wave—is called a cycle. A wave's frequency is, simply, how many cycles pass a given point per second. Electromagnetic waves can range from thousands of cycles a second (radio waves) to hundreds of millions of millions of cycles a second (gamma radiation), with visible light, in the millions of millions of cycles, between the two ex-





Top: Graph shows 2 waves having the same amplitude but different phases. Proceeding downward, the second graph shows 2 waves having different amplitudes but in phase. The red line represents the resultant wave (sum of 2 amplitudes). However, if the 2 waves are opposite in phase (crest of one is generated with trough of the other), the resultant wave has a decreased amplitude. The fourth graph shows the resultant wave of 2 waves that have different amplitudes and are out of phase. As illustrated above, this is observable in sea waves generated by wind. If waves moving in one direction encounter waves of another system, either larger waves (a) or smaller waves (b) will result, depending on whether generation is in phase or out of phase.