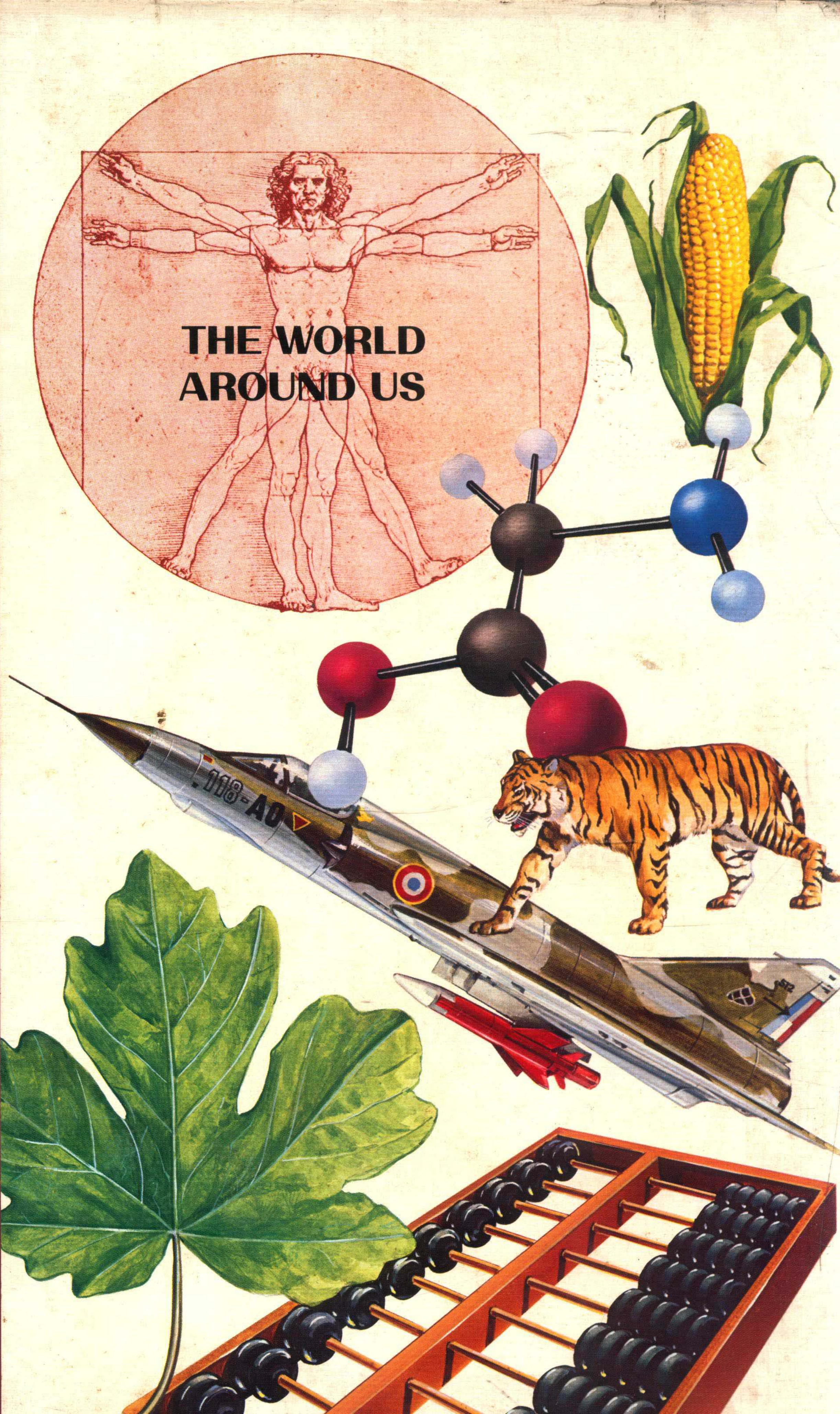
SCIENCE AND TECHNOLOGY ILLUSTRATED

THE WORLD AROUND US



Science Technology

The World Around Us

Library of Congress Catalog Card Number: 84-80129

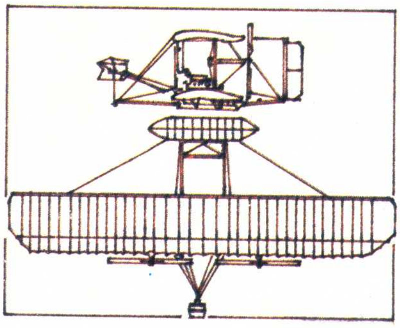
International Standard Book Number: 0-852229-425-5

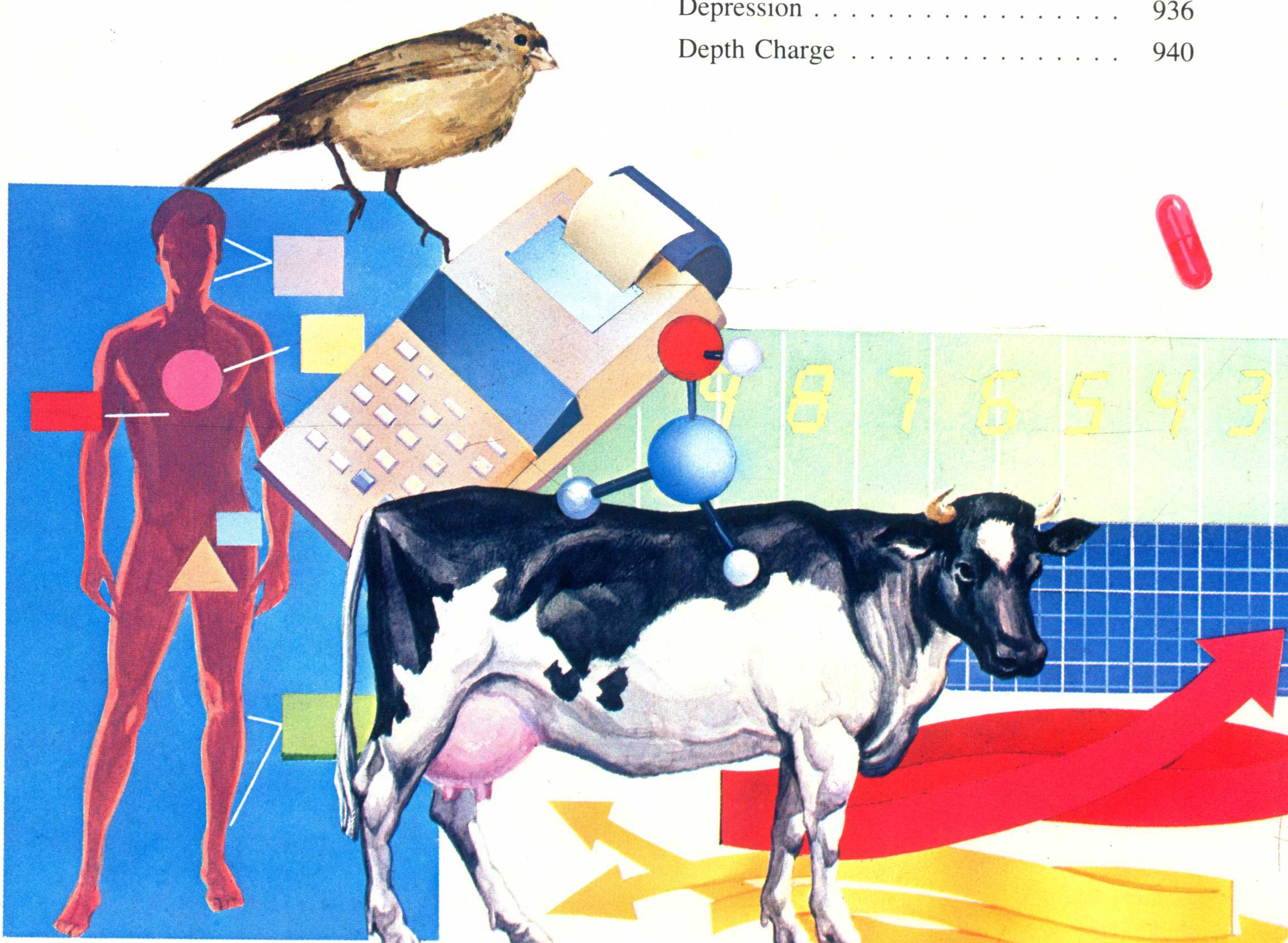
English language edition by license of Gruppo Editoriale Fabbri

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

Printed in U.S.A.

Contents





Science and Technology Illustrated

The World Around Us

Science Technology

The World Around Us

and Illustrated

17 68

Encyclopaedia Britannica, Inc.
CHICAGO

AUCKLAND • GENEVA

LONDON • MANILA

PARIS • ROME

SEOUL • SYDNEY

TOKYO • TORONTO

Library of Congress Catalog Card Number: 84-80129

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

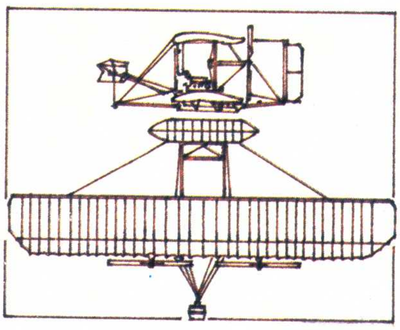
English language edition by license of Gruppo Editoriale Fabbri

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

Printed in U.S.A.

Volume 8

Contents



Cybernetics

Cybernetics, the study of communication and control systems, crosses the boundaries of many disciplines and reveals principles and mechanisms that different things have in common. In particular, its interest is in the similarities between the internal control and communication systems of animals (including man) and the automatic control systems designed for machines and manufacturing processes.

The term itself is derived from the Greek words meaning either to steer a ship or the man who does the steering—the pilot or steersman. It was the title of a book published in 1948 by Norbert Weiner, who suggested that an interdisciplinary science that studied the relationships between natural and artificial systems would produce fruitful results. Because cybernetics crosses over various fields of study, its definition varies somewhat according to the primary interests of the person using the term and the aspects of cybernetic theory that are being developed.

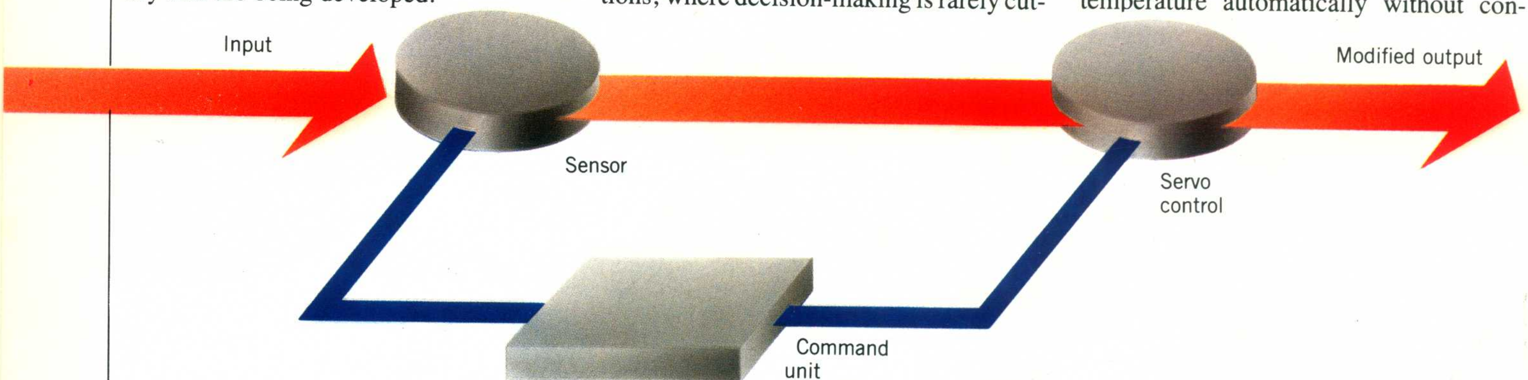
Automation

The development of computers, both digital and analog, has greatly increased the capacity of machines to perform some of the functions that formerly could only have been done by humans. The development of greater capabilities in such machines—a study that overlaps with the general technological field of automation—is a major interest of cybernetics. Simulation of the operations of the human brain and the attempt to develop a machine or system that displays intelligence may be possible. However, it is generally agreed that the way the computer operates has very little resemblance to the way our own brains work. The main difference is that the computer is best at performing simple and repetitive tasks, which it does extremely well. It is ideal for handling algorithms, which are very precisely defined processes and sequences of operations.

The human mind, on the other hand, is adapted to unstructured real-life situations, where decision-making is rarely cut-and-dried. What it usually does, therefore, is to act on the basis of an educated guess, which generally involves a thinking process that is extremely difficult to define but can be said to take in simultaneous consideration from many sources—sense data, experience, information learned many years earlier and never used, hunches, and desires. We are still a long way from achieving a complete understanding of how that marvelous instrument, the human brain, does all this, but computer scientists have been able to create computer programs—called knowledge-based expert systems—that mimic the decision-making process of human experts.

Other Areas

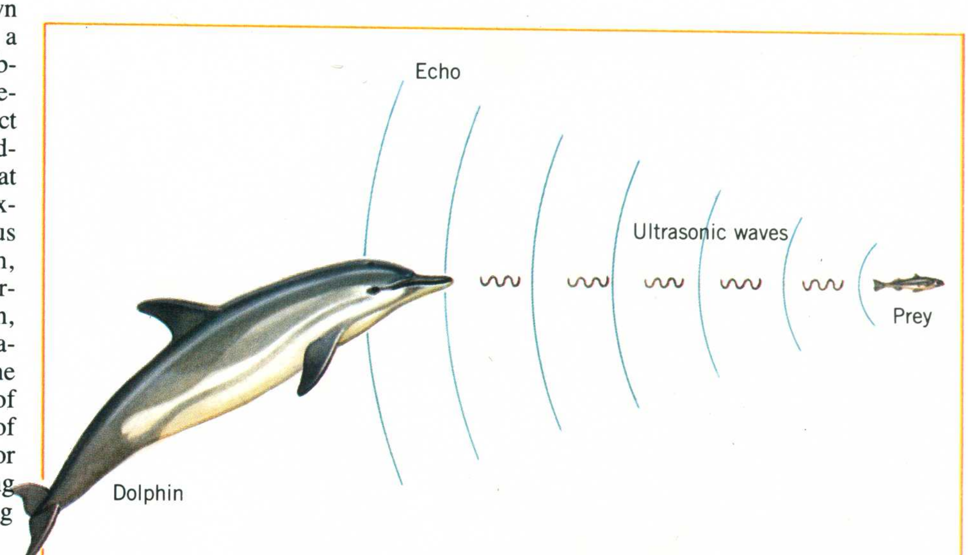
Among other areas of interest to cybernetics are the subjects of homeostasis and entropy. Homeostasis is the ability of a system to maintain an internal equilibrium. A natural example is the ability of the human body to maintain its internal temperature automatically without con-



Above: In the feedback system illustrated, the machine senses its own activity and uses the information to control itself. This is conceptually similar to the management process illustrated on the facing page, where business executives use past sales data to make decisions that will affect future sales trends. *Below:* A dolphin depends on feedback information carried by the echoes from ultrasonic waves it sends out to locate the fish that are its prey. *Above right:* James Watt's steam governor, shown in red, was an early example of a mechanized feedback device. It used engine speed to control steam pressure.

Feedback

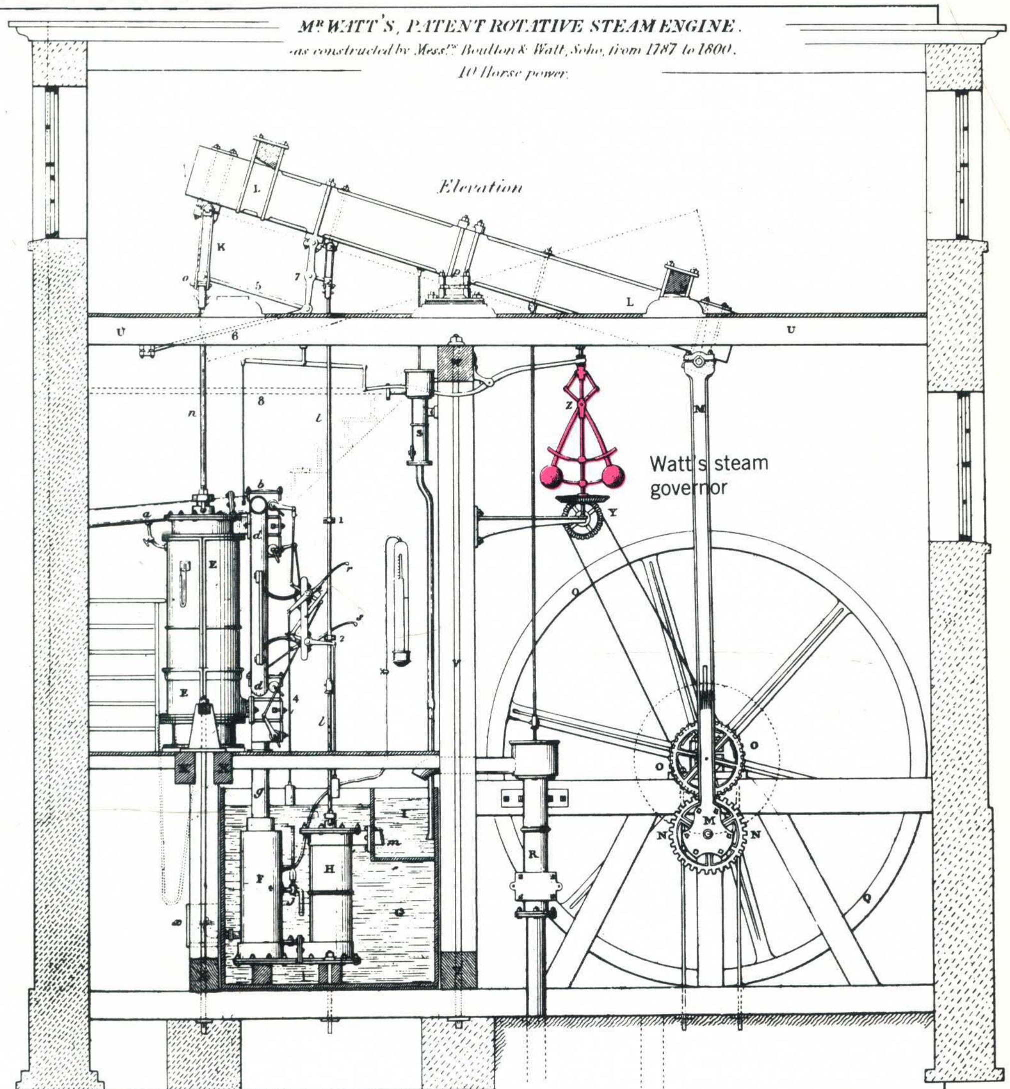
One element that people generally agree belongs to the study of cybernetics is the closed-loop feedback system, which involves a machine or organism using information gathered from the output of some process under its control to modify its own activity. The feedback loop between a thermostat and a heating device is an obvious example. In the area of human behavior, the act of picking up a small object with a hand is a good example of feedback. The action is so habitual to us that it appears trivial, yet it is in reality extremely complex, involving continuous feedback; that is, adjustment of the arm, hand, and finger movements by the nervous system under the control of the brain, which in turn is guided by its interpretation of the information gathered by the eyes and the sense of touch. Examples of feedback can be found in the response of business organizations to economic or market conditions and in the functioning of automated processes in manufacturing plants.

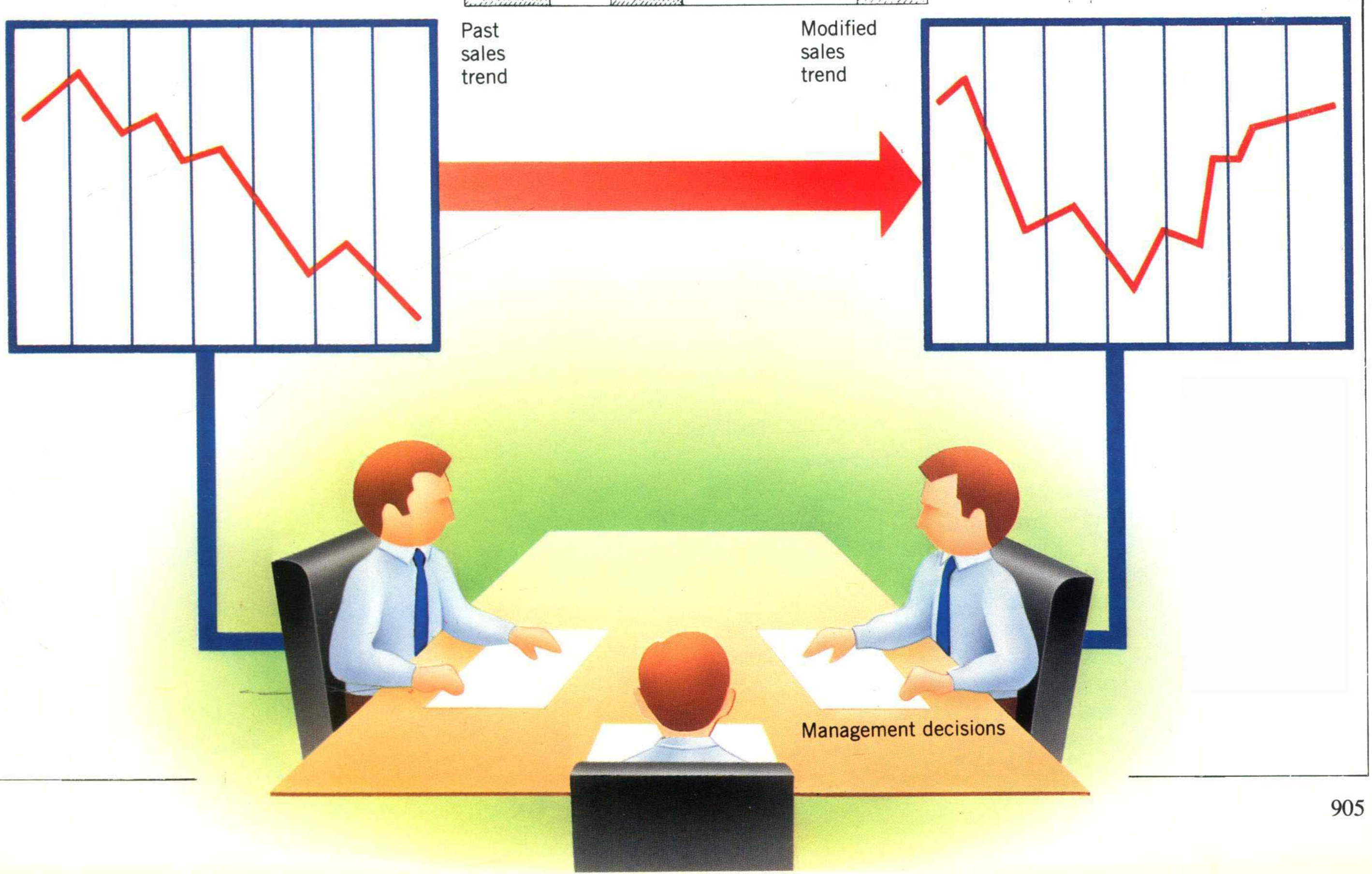


scious intervention. The process is so natural to us that we are normally totally unaware of it, yet it is in operation 24 hours a day. Entropy, on the other hand, is the tendency of systems to run down spontaneously or become more disordered, as a wound clock unwinds in time or a cup of hot coffee cools to room temperature. What is most interesting about entropy from the standpoint of cybernetics is the ability of living organisms to counteract the tendency to increasing disorder through a combination of biological processes including metabolism, growth, and reproduction, and adaptive behavior.

Cybernetics is also concerned with understanding the mechanism involved in pattern recognition, the nature of perception, the meaning of learning and understanding, and whether machines can be developed with the ability to form concepts and hypotheses, to think, make plans, and use language.

See also ANALOG DEVICE; ARTIFICIAL INTELLIGENCE; AUTOMATION; BRAIN; COMPUTER.





Dairy Industry

Milk is the single most important food a young person can consume. In addition to sufficient calcium and phosphorus for normal bone development, milk contains all the essential vitamins and amino acids. Adults who drink a pint of milk a day get 90 percent of the calcium, 30-40 percent of the riboflavin, 25-30 percent of the protein, 10-20 percent of vitamins A and B, 10-20 percent of the calories, and up to 10 percent of the iron and vitamin D recommended for a balanced diet.

Scientists do not completely understand all of the ways in which milk performs its nutritional functions, even though all mammals can, and usually do, live entirely on milk for the first part of their lives. Lactose (milk sugar) deficiencies can result in bone and nerve disease, but it remains unclear if lactose is important because of its role in metabolic processes or because of special properties it may possess. Besides calcium and phosphorus, milk contains other vital minerals—potassium, chlorine, sulfur, magnesium, zinc, copper, and iodine among them—that interact with other food nutrients to keep the body's mineral and acid-base levels in balance, to regulate enzyme activity, and to help essential compounds travel through the body, though it is not known precisely how.

Milk Production

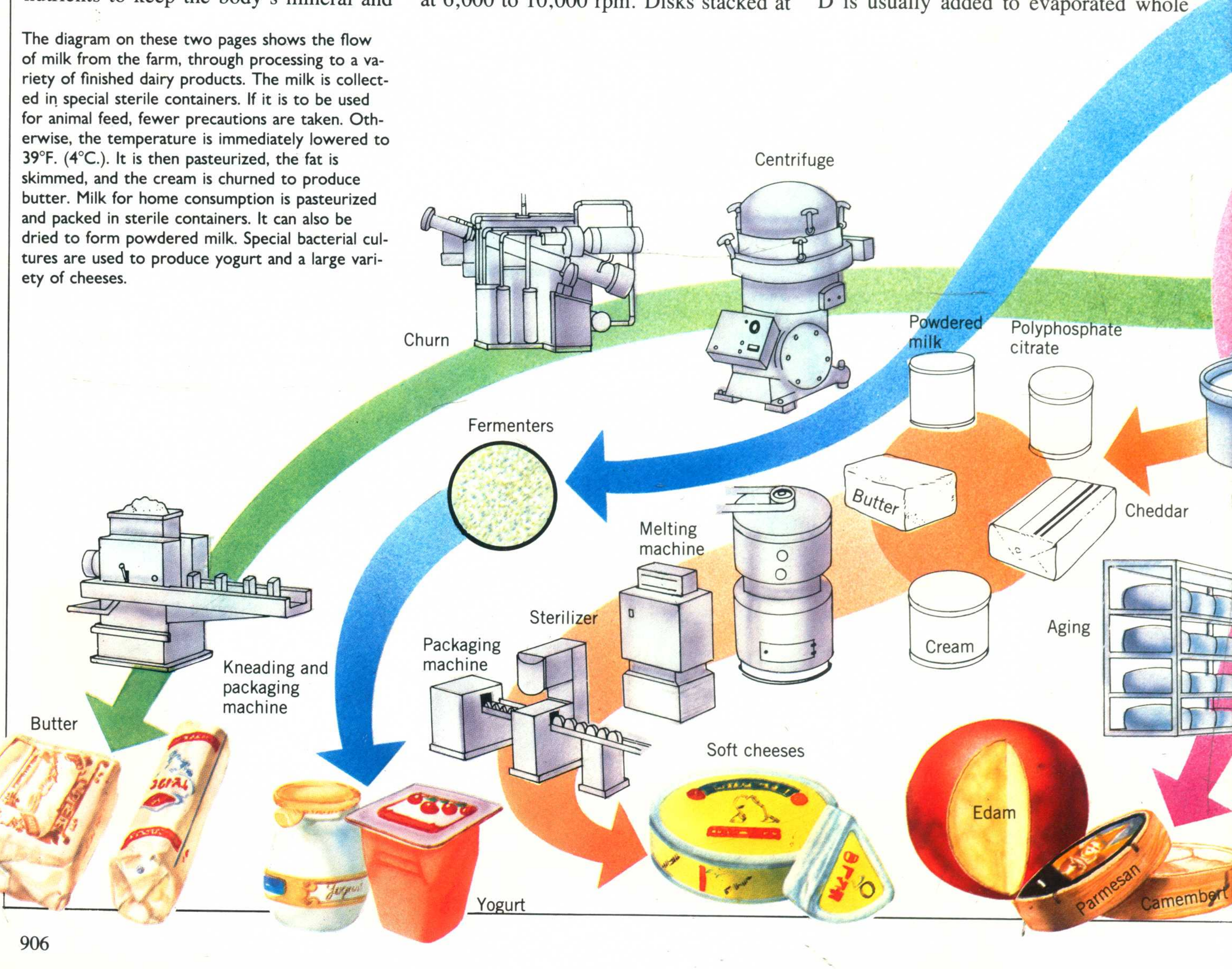
Not knowing exactly how milk works does not seem to impede its use. Milk, cheese, butter, and other products derived from milk have been dietary staples for centuries, and the production of milk and dairy products is an enormous industry.

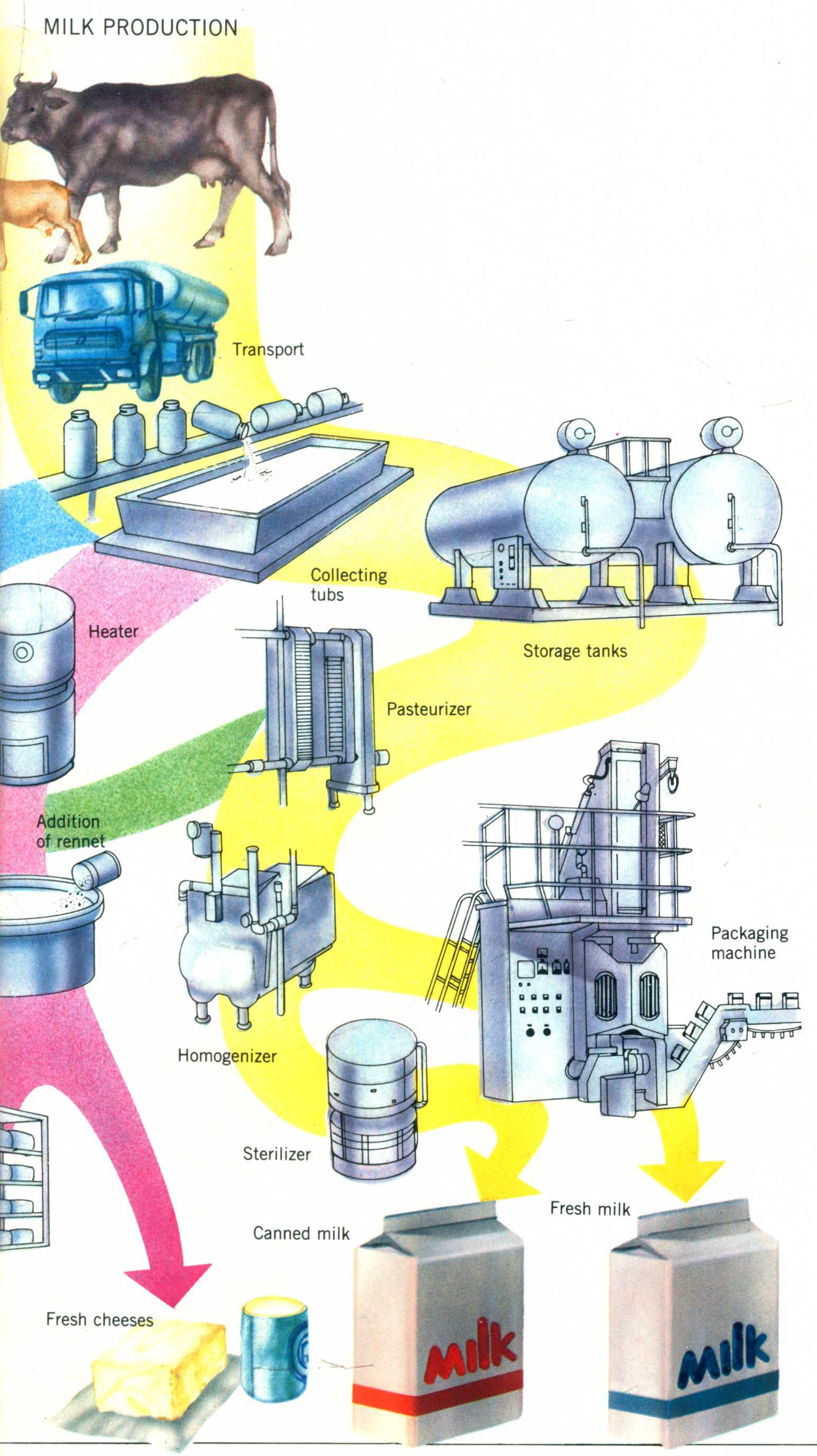
Most milk comes from cows, although water buffalo in India and parts of Asia, goats in the Mediterranean region, camels in North Africa and Arabia, and reindeer in northern Europe are also important milk sources. In its natural state, milk contains potentially harmful bacteria, and in order to remove the disease-producing microbes called pathogens, milk is heated to either 145°F. (63°C.) for 30 minutes, to 162°F. (72.2°C.) for 16 seconds, or even to 185°F. (85°C.) for immediate pasteurization. The pasteurized milk is then transferred to a cream separator where, placed at the bottom of an airtight bowl, it is spun at 6,000 to 10,000 rpm. Disks stacked at an angle along the inside of the bowl catch the milk as it is spun, dividing it into layers. The lighter cream, with fewer fat globules, tends to rise up through the center; the heavier cream, with larger and more numerous fat globules, flows downward, along the sides of the bowl.

The layers are eventually separated in order to make skim milk, milk, and cream. All of the milk layers are then clarified to remove any remaining foreign substances. This is done in a machine that works by centrifugal force, like the cream separator. The last stage in milk production is inspection. If all quality standards are satisfied, the milk may be sold. Milk, cream, and skim milk must all be stored at about 40°F. (4.5°C.) or less.

Concentrated milk is canned and widely used in tropical regions and in areas where refrigeration is not feasible. To produce this evaporated milk, raw milk is heated to 203°F. (95°C.) to remove most of the water; the solid-liquid ratio of the concentrate is 2:1. This mixture is then reheated to 240°F. (115.5°C.) to sterilize it, or to destroy all living organisms in it. Vitamin D is usually added to evaporated whole

The diagram on these two pages shows the flow of milk from the farm, through processing to a variety of finished dairy products. The milk is collected in special sterile containers. If it is to be used for animal feed, fewer precautions are taken. Otherwise, the temperature is immediately lowered to 39°F. (4°C.). It is then pasteurized, the fat is skimmed, and the cream is churned to produce butter. Milk for home consumption is pasteurized and packed in sterile containers. It can also be dried to form powdered milk. Special bacterial cultures are used to produce yogurt and a large variety of cheeses.





milk, vitamins A and D to evaporated skim milk.

Dried milk is another alternative to fresh milk in hot climates. There are two ways of drying milk to produce a powder that will dissolve in water. In the first, milk is poured in thin sheets onto heated, revolving drums. After one revolution, the milk granules are scraped off. Though basically effective as a means of drying milk, this method does not produce a powder that dissolves easily. Drum drying is usually used to produce powdered milk for animals. Spray-dried milk, however, dissolves completely in water, making it nearly indistinguishable from fresh milk. Usually, the milk is sprayed into a stream of hot air, which causes rapid evaporation of milk liquids, leaving a powder. This powder is than placed in a separator to remove any air remaining from the drying process. To ensure that the milk particles will mix thoroughly with water, sugar—because it crystallizes—may be added.

Milk Products

Butter, made mostly from milk fat, is widely used as a condiment and cooking ingredient.

Legend has it that cheese was accidentally invented thousands of years ago by an Arabian merchant who discovered that some of the milk he'd packed for traveling had hardened overnight into curds. Today, cheese is manufactured in a three-step process. Milk is heated so that milk solids (curds) separate from the liquid (whey). Bacteria, rennet (an acidic curdling agent found naturally in the cow's stomach), and/or acid may be added here to accelerate fermentation. The curds are then reheated so that the whey is released, and the curds are ripened by bacteria. Bacterial enzymes produce lactic acid, which facilitates curd formation. Because bacteria break down milk protein and fat, they greatly affect the flavor and fragrance of cheese. Specific bacteria produce specific cheeses: Roquefort, for example, is made with the help of *Penicillium roqueforti*, the colonies of which appear as blue mold.

Ice cream is made from a mixture of milk fat, water droplets, and sugar, which is chilled until syrupy. Egg white is added in some varieties. Air, which increases volume, is beaten into the syrupy mixture as it undergoes freezing.

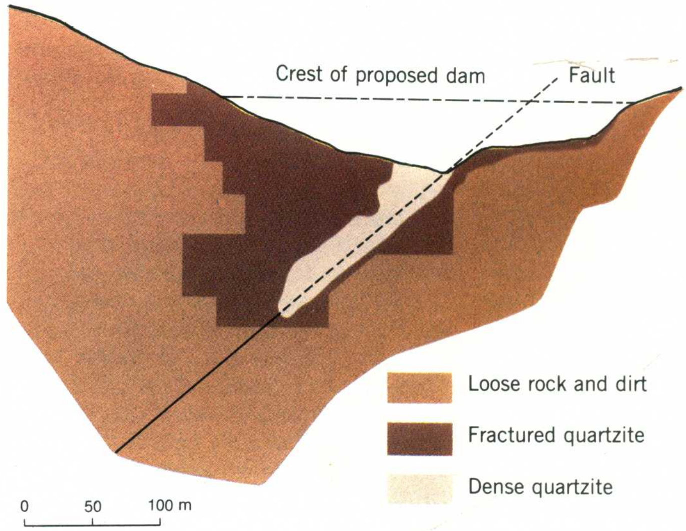
Other milk products include buttermilk, butter oil, ice milk, and yogurt. Many humans are allergic to milk, which causes nausea, skin itch, and so on. For these people, skim milk, yogurt, and cheese are often acceptable. Casein, a milk protein that is basic to cheese, is also used in the manufacture of paints, adhesives, and plastics.

See also BUTTER; CATTLE; CHEESE.

Dam

A single dam can change an entire region's economy—and ecology. By blocking the course of a river, it can provide water for human consumption, irrigation, and industry; control flooding; improve the navigability of a river; and generate electric power cheaply. And the reservoir formed by the dam can also be used by swimmers and boaters.

The nearly 30 major dams built by the Tennessee Valley Authority in the southern United States since the 1930s are a good example of how radically dams can change a region. They have provided cheap electric power to over 2 million residents of seven states, bringing a measure of prosperity to a previously depressed region. The Tennessee River is now navigable for its entire length of 650 miles (1,000 km). Yet in the 1970s, the TVA's plans to build the Tellico Dam were opposed by environmentalists, who doubted that its industrial and recreational benefits outweighed the costs of displaced families, threatened wildlife, and lost farmland. In a developing country, the economic and social effects of a single dam can be profound, bringing industry and irrigation to traditional cultures.



Cross section of the geological structure beneath the site of a proposed dam. Preliminary engineering studies like these ensure the dam will rest on a firm bed.

History

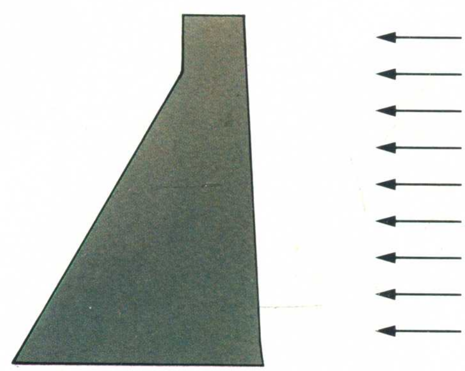
The earliest recorded dam was a 50-foot (15-m) masonry structure built across the Nile about 2900 B.C. It was built to supply water to the capital at Memphis. Other ancient civilizations (notably the Assyrians, Babylonians, Persians, Indians, Chinese, and Japanese) built many dams, for irrigation as well as drinking water. In the 6th century A.D., the Byzantines apparently discovered the virtues of a dam with a wall that curved upstream, a principle still observed in the modern arched dam.

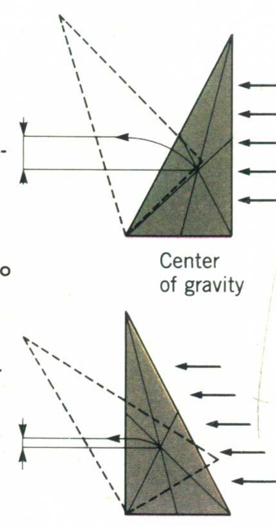
At first, dam construction was strictly empirical—what stood was imitated. But by the mid-19th century, the growth of physics and engineering knowledge since the Renaissance began to bear practical fruit. In the 1850s, the designs of W. J. M. Rankine, professor of civil engineering at Glasgow University, demonstrated the extent to which theoretical knowledge could aid the engineer. His work on the stability of loose earth, for example, meant that stronger, larger dams could be built. His successes encouraged many others to advance the science of civil engineering.

In the 19th century, interest focused on the weight and slope of the dam as determining its resistance to the water. The early 20th century, however, brought greater interest in the dam as a structure with its own internal dynamics—a structure whose strength at any one point really depends on that at many other points in the structure. Mere bulk no longer makes a good dam.

Design and Construction

Modern dams are of two major types: masonry/concrete and embankment/earthfill. Masonry or concrete is typically used to block narrow streams in mountainous terrain; such a dam can be high, but relatively little material is used. Embankment





Above and right: The gravity dam as illustrated in these cross sections depends on weight distribution to resist water pressure. The energy required to displace its center of gravity is greater than that of the head of water behind the dam.

Left: Egypt's Aswan Dam across the Nile.