

Winter 1964

The Rockefeller Institute Review 1964, vol. 2, no. 1

The Rockefeller University

Follow this and additional works at: http://digitalcommons.rockefeller.edu/rockefeller_institute_review

Recommended Citation

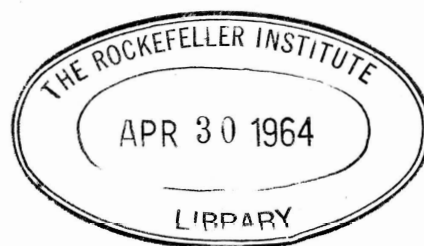
The Rockefeller University, "The Rockefeller Institute Review 1964, vol. 2, no. 1" (1964). *The Rockefeller Institute Review*. Book 5.
http://digitalcommons.rockefeller.edu/rockefeller_institute_review/5

This Book is brought to you for free and open access by the The Rockefeller University Newsletters at Digital Commons @ RU. It has been accepted for inclusion in The Rockefeller Institute Review by an authorized administrator of Digital Commons @ RU. For more information, please contact mcsweej@mail.rockefeller.edu.

THE ROCKEFELLER INSTITUTE REVIEW

JANUARY • FEBRUARY 1964





THE ROCKEFELLER INSTITUTE REVIEW, January-February 1964. The Review is issued bi-monthly. This is volume 2 number 1. Published by The Rockefeller Institute, Sixty-sixth Street and York Avenue, New York 10021. Second class postage paid at New York, New York. Copyright © 1964 by The Rockefeller Institute Press. Printed in the United States of America.

TOWARD A SCIENCE OF THE LIVING

BY RENÉ DUBOS

Man is more than a machine. For the study of living as experience the reductionist methods must be complemented by new integrated techniques.

THE ACCUMULATION and organization of knowledge is as old as mankind, but it was not until the 16th and 17th centuries that men began using the experimental method systematically and thus learned to acquire knowledge at will. Ever since, it has become increasingly evident that the experimental method is applicable to all problems of matter and to some, at least, of the problems of life. In fact, its success has been so great that from the very beginning the urge to approach scientifically all theoretical and practical problems of mankind took possession of the European intellectual community. The Encyclopedist Condorcet symbolized this attitude in his *Esquisse d'un tableau historique des progrès de l'esprit humain*, which proclaimed the possibility of an unlimited improvement of mankind's condition through science. In the succeeding two centuries natural and social scientists of the Western world have labored incessantly to bring to pass the Utopian dream of health and happiness born of faith in the power of reason and of science.

Nevertheless there has always been some rivalry, and even at times some conflict, between two aspects of the scientific endeavor—the pursuit of knowledge for its own sake, and the application of knowledge to the practical affairs of man. It is tempting to speak of a professional schizophrenia of science in this re-

spect and to contrast, for example, a pure theoretician such as Gibbs, who remained aloof from the world in his university post, with Edison, whose work typifies the use of science to meet or anticipate social demands rather than to answer abstract questions. But, in fact, the conflict between theoretical and applied science is more apparent than real, and there is a deep-seated unity in all knowledge. It was this faith which inspired Franklin's retort to a skeptic who questioned the usefulness of balloons: "What is the use of a newborn baby?" The same point has been made by other scientists. Shortly after he had discovered electromagnetic induction, for example, Faraday was visited by an important official. He demonstrated the phenomenon to his visitor, who inquired: "What is the good of this discovery?" Faraday is alleged to have replied: "Someday, sir, you will collect taxes from it." Still more explicitly, Louis Pasteur wrote: "There are not two sciences, there is only science and the applications of science, and these two activities are linked as the fruit to the tree."

It is true that an important government official in the United States a decade ago scoffed at basic research because it dealt with such "useless" subjects as "why grass is green." But the explosion of scorn and ridicule that greeted his remark in the public press bears witness to the large number of persons who are aware that theoretical science has become the real source of power and wealth in our societies. It is now widely recognized that the most unexpected results of scientific research often turn into its most exciting fruits. Increasingly the public accepts theoretical science without being too much concerned about the usefulness of the newborn baby.

For many centuries science toiled obscurely in the

rear of empirical procedures, and the scientific age did not really begin until science stepped forward as leader to carry the torch. Faraday's electromagnetic experiments led to the dynamo and other electromagnetic machines; Maxwell's studies of waves led to wireless telegraphy; Pasteur's work revolutionized fermentation industries and the practice of medicine; and the process of discovery is now going on at an accelerated pace. As a result, modern life depends on the tools provided by science, and more importantly the very character of human life is molded by the products of scientific technology. The Encyclopedists, were they to be back among us, would find that most of the practical goals in their social dreams have now been reached in the countries of Western civilization. Science has truly become the servant of mankind.

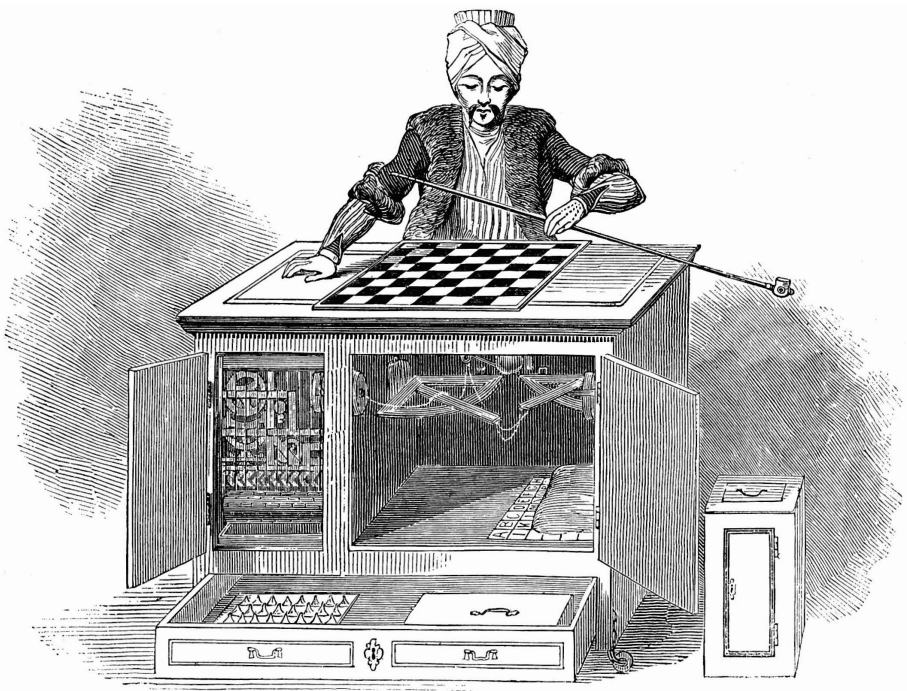
Knowledge That Will Never be Lost

While almost everyone is convinced that scientific technology constitutes the basis of power and of wealth, paradoxically many persons mistrust and even dislike science. This hostile attitude derives in part from the fear of nuclear warfare, but only in part. Its real sources are more distant and more com-

plex. As far back as two or even three generations ago, it was fashionable among many groups of theologians, philosophers, and artists to speak of the bankruptcy of science. Scientists were blamed for having destroyed religious, philosophical, and ethical beliefs without having offered any valid substitute to guide behavior or to explain the riddle of the world and of human destiny. Not so long ago a famous English theologian advocated a moratorium on science, asserting that factual knowledge had accumulated faster than it could be digested and thus had become useless or even dangerous for mankind!

The belief that our societies can establish a moratorium on science fails to take into account one of its most important characteristics. The theoretical and practical knowledge that made possible the construction of nuclear bombs is now part of the human heritage. Barring catastrophic upheavals, this knowledge will never be lost. Even if all the bombs now in existence are destroyed, the ability to make them will survive, and nothing can extinguish the human will to add still further to the body of knowledge on which this technology is based. Similarly, man has now lost the illusion that the earth occupies a central and privileged place in the cosmos. No moratorium

The Automaton Chess Player, invented in 1769 by Wolfgang de Kempelen, a native of Hungary, reflects the scientific interest of the day in the construction of mechanical models of human beings.



on science can still in curious minds the eagerness to learn more of human nature and of its relation to the universe. It is as ineffective to burn books as to destroy the bomb.

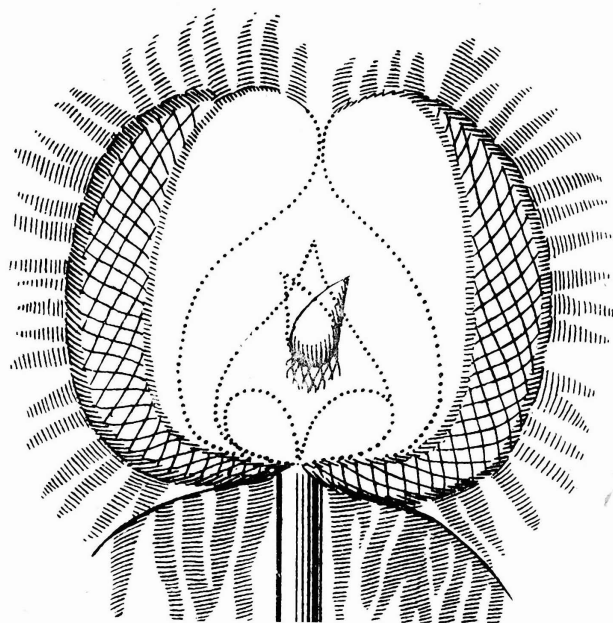
There is no way for mankind to retreat from reason or from science. It is no exaggeration that science has now given man the power to shape the external world and his own very nature according to his wishes. Indeed, the built-in drive of scientific knowledge is so irresistible that man can no longer avoid exercising this power. The world of tomorrow will express the mental image that man is at present creating of himself and of his future. The real problem, therefore, is whether social conscience can be incorporated into science, whether the goals of the scientists can be decided on the basis of human values.

Unfortunately, there still exists a widespread feeling that goals and values have no place in science, except for values concerned with purely intellectual abstractions. This attitude developed at a time when the activities of scientists had little influence on human destiny. But the plain fact is that, now, scientists *are* shaping human destiny. True, they do not give much thought to the distant consequences of their actions. They are intensely, almost selfishly, interested in matter, forces, and mechanisms, and often they behave professionally as if they were unconcerned with the problems peculiar to life and especially to human life. This apparent neglect of the problems which are of greatest significance to man may well be the most powerful reason for the indifferent and even hostile attitude of the public toward science.

Renovating the Biological Sciences

Needless to say, there has been much soul-searching on this subject among physicists, prompted by the threats that their achievements are posing to the very survival of the human race. But the discussions that are presently going on among biologists may be of greater importance in the long run, and may foreshadow a change of direction comparable to that which took place during the 17th century.

Philosophers and scientists have long recognized that the body can be regarded as a machine, and studied by the methods used for inanimate objects. The technique of biological sciences derived from this outlook has been to separate living things into



Drawing of the pineal gland, "the point of junction of soul and body," from L'Homme by René Descartes.

their constituent parts, so as to determine how these are geared together and what kinds of forces make them move.

Ever since the time of Descartes the study of the body machine has reflected the state of knowledge in physics and chemistry. At first, the mechanical aspects of structure and function were singled out; from the 16th to the 18th centuries it was scientifically fashionable to build animated mechanical models of human beings and other living things, capable of performing extraordinarily complex maneuvers. Then, increasingly, chemical interpretations took the upper hand, and the problems of energy requirements, nutrition, and metabolism became predominant during the 19th and 20th centuries. This movement has progressed so far that the very fabric of the body can now be described in the terms of modern chemistry. Today molecular biology can provide an approximate picture of the giant molecules that constitute the cellular structure. The nucleic acids and their associated proteins have been shown furthermore to act as systems for carrying information, both through the cell and from one generation to the other. Even the brain is being described in physico-chemical terms; the increasing knowledge of feedback and of servomechanisms has revealed that men-

tal activities exhibit some of the characters of a complex electronic system. Thus biological science is continuing on the road it has traveled since Descartes' time. From models imitating the mechanical motions of the body, it has moved to models representing genetic codes and to electronic machines that solve problems and can even learn from experience.

Increasingly, however, there is a feeling among many biologists that this analytical approach by the ordinary techniques of physics and chemistry is not sufficient to account for the phenomena most characteristic of life, such as growth associated with differentiation, individual responses to the environment, or evolutionary and adaptive changes. These entail a continuous interplay with the environment involving "purposiveness," or at least "directiveness." In the words of P. T. Mora, a physicist turned biologist:

Directiveness is obvious when living processes are observed as a whole, and under natural conditions where many complex processes operate simultaneously. However, when observation and scientific research are done on biologic problems on the molecular level and under simplified conditions, often in an isolated state, this directiveness is lost from sight . . . Since the age of Galileo our experimental and theoretical approach to physical science is fundamentally analytical, which includes simplifications, omissions of disturbing influences, to allow us to study only one thing at a time, and most important of all, we carefully avoid any consideration of purpose. Could it be then that such an approach is not sufficient to study or to explain the complex interrelationships so essential to life?

It is worth emphasizing in this regard that living is not a state but a process. The responses made by organisms to the environment in which they function are the only manner in which we know life; and these responses constitute *par excellence* the substance of biology. They are conditioned by a number of characteristics which, as far as can be judged at present, distinguish living organisms from inanimate matter. Breaking the living organism into smaller and smaller entities results in the progressive loss of all the forms of integration upon which life depends, and which are its most characteristic aspects.

At each higher level of organization the living organism displays traits, properties, and activities which could not have been predicted from the study of its isolated parts. There is no mysticism in this statement. Its practical meaning is that the traits,

properties, and activities associated with the living process are expressions of the interplay between constituent parts rather than of their individual characteristics. Indeed, many of these characteristics do not have a chance to manifest their existence until they are brought into an environment, or related to other structures, with which they can react. Just as the activities of a computer are determined more by the pattern of wiring than by the metal of which the wires are made, so the activities of a living cell or of a multicellular organism are determined by the interplay between the component parts. Likewise the characters of a population are determined by the interplay between its individual members.

In comparison with the enormous effort that has been devoted to the components of the body machine, living as experience has hardly been studied by scientific methods. The reason commonly given for this neglect is that techniques are not yet available for the study of such complex problems, and that it must wait the completion of more "fundamental" steps. But the real reason is that this field of research does not fit in the reductionist philosophy which has prevailed since the 17th century. Many phenomena which have long been known empirically have been neglected by orthodox biological and medical sciences, not for lack of techniques but because their study was not fashionable and therefore not considered scientific. Such is the case with conditioned reflexes, subconscious manifestations of the mind, effect of sensory deprivation, imprinting, adaptive processes, and the like.

Man Meets His Environment

Pavlov, Freud, Fritsch, and Lorenz opened new avenues to the scientific analysis of the responses made by man and animals to various situations, not so much by introducing new techniques as by accepting the need of dealing with the organism as a whole functioning entity. The techniques that they used could have been developed many centuries earlier. The areas of knowledge to which they devoted themselves could have blossomed into full-fledged sciences long before the physicochemical sciences. This is equally true for many other fields such as immunology and population genetics. Similarly, techniques could now be developed to study the living process in the full complexity of its manifestations without



waiting for further advances in the knowledge of the unit structures and reactions through which the body machine operates.

The performance of living man in his physical and social environment presents of course very special obstacles to the scientific approach. By the exercise of free will man constantly introduces unpredictable complications which affect both his behavior and the environmental factors which impinge upon him. For these reasons studies of human life cannot achieve the precision and elegance of studies devoted to the inanimate world or the properties of living things not involving freedom. Nevertheless man's response to his environment poses problems of such urgency that scientists cannot long remain indifferent to them. The social pressures that are building up all over the world bid fair to force biological and medical sciences into directions focused on environmental factors and on population dynamics.

Throughout his evolutionary past man has experienced profound environmental changes, either of natural origin or of his own making. He has had to adapt to them in order to survive, often at the cost of much suffering. In fact the pattern of disease characteristic of each time, place, and culture is a reflection of the environment, or rather an expression of human failure to adapt to the environment. The world is still changing, and modern man is now encountering everywhere the products of industrial civilization. He is able, theoretically, to adapt to the new ways of life created by chemistry and automation, just as his ancestors did when they moved to new climates or began using new instruments, or when they replaced the horse by steam and electric power, then by the automobile and the airplane. In practice, however, the explosive rate at which change is now occurring makes adaptation more difficult than in the past.

Countless technological innovations are being introduced simultaneously and reach all parts of the world and all social classes long before their potential effects can be recognized. Almost 100,000 years elapsed before the rough Chellean hand ax was

"Modern man is now encountering everywhere the products of industrial civilization . . . the explosive rate at which change is occurring makes adaptation more difficult than in the past."

replaced by the smoother Acheulian tool during paleolithic times; the horse remained the fastest means of transportation until the middle of the 19th century; the speed of railroads has hardly increased in the past hundred years. In contrast, we have moved from the propeller to the supersonic aircraft in one generation. The techniques of food production and distribution have remained much the same since neolithic times, but suddenly, farmers and food processors are using thousands of chemicals which find their way into plant and animal products and thus into the human body. As long as environmental changes were slow and few in number, mankind could adjust to them progressively through genetic, phenotypic, emotional, and social changes. Now, too much is happening too fast. The diseases of civilized life are, to a large extent, the expression of new environmental factors to which man has not yet become adapted. Biologically and socially, the experience of the father has come to be of little use to his child.

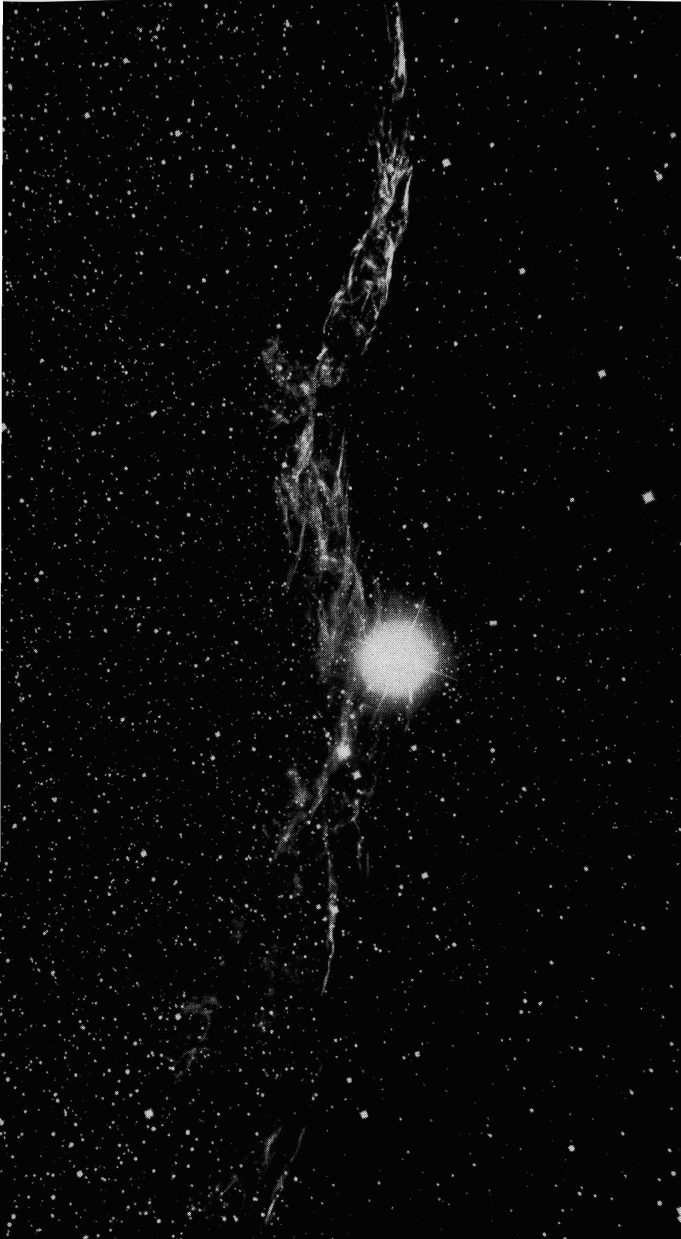
Study of the problems of health posed by urbanization and industry is handicapped by the lack of scientific knowledge concerning the manner in which man responds to his environment. Biological and medical scientists have focused their attention on the functions and submicroscopic structures of cell constituents as well as on the molecular events that provide fuel and building stones to the body, but this detailed knowledge, elegant and essential though it is, is not sufficient to deal with the effect on man of the chemicals that contaminate his air, water, and food; of constant exposure to artificial light and noise; of the boredom engendered by automation; or of the emotional solitude that prevails in crowded cities. And these are the very aspects of modern life on which depend the health and happiness of man, and indeed his very survival.

Specialized Studies

Needless to say, there does exist some scientific knowledge of man's response to his environment, but it is a highly episodic kind of knowledge, derived in a haphazard way from attempts to solve a few practical problems. For example, research on the responses of living man has been stimulated by air pollution, abnormal behavior, the effect of solitary confinement, the training of combat forces for operation in the tropics or in the Arctic, the preparation of

human beings for space travel, and so on. These and other specialized studies have provided useful information which could not possibly have been obtained from the analysis of isolated cellular and chemical systems. Yet this information does not constitute a systematic scientific knowledge of man as a living entity, comparable to what has been acquired for the isolated constituents of the body machine.

The same is true of the problems posed by the increase in world population. This increase is conditioned by many biological and social factors which are ill understood. For this reason it cannot be controlled by placing exclusive emphasis on any one particular measure, whether it be food production or contraceptive techniques. On the other hand, surveys have revealed that many animal species in the wild adjust their populations to such levels that they do not overtax their resources, and similar automatic adjustments have been observed under laboratory conditions. In all parts of the world and throughout history, furthermore, certain human populations have also maintained a satisfactory equilibrium with their food and other resources for long periods of time. Polybius indeed complained that the Greeks were endangering their future by extreme limitation of family size. Thus, it is certain that in animal and human populations homeostatic mechanisms can be highly effective in suitable circumstances, but it is also true that these mechanisms do not always operate effectively. The understanding of the factors which control population dynamics is still very meager. Progress can be made in this very important field only by studying experimental populations maintained under a wide range of conditions. The emphasis in such studies would have to be not on the component parts of the organisms, and not even on the individuals themselves, but rather on their interplay as effected by the environment. While it is not possible to specify here the scientific problems bearing on the study of populations and of environmental effects, it seems worthwhile to mention a few of their para-scientific aspects. In many cases the toxic effects of the environment are so delayed that they do not become manifest for many years, or even until another generation. Likewise, studies of populations have little meaning unless such studies are continued for many years and furthermore they demand the manipulation and observation of large groups. The



From this planet, once believed the center of the universe, man now contemplates the infinite galaxies stretching beyond his own.

study of these problems will require, therefore, institutional research with long-range programs, different in organization from the individual type of research that prevails today.

To a very large extent the object of public health practices so far has been to shelter man from exposure to agents of disease and from any form of stress. Yet it is certain that man is endowed with a wide range of adaptive potentialities. This suggests the need for research programs focused on the utilization of these potentialities.

Man can indeed become adapted to almost anything, even to conditions and ways of life that are

undesirable in the long run, either for the individual person or for the social group. Thus scientific concern with man's response to his environment and with the genetic and phenotypic aspects of population control cannot be dissociated from a consideration of social and ethical values. In its applications the science of man must be governed by social conscience.

Complementary Aspects of Science

The social attitude toward science has changed greatly during the past two hundred years, and not entirely for the best. Until late in the 18th century most educated men believed that it was within the power of science to reach a complete understanding of the universe and of life, as well as to provide the means for health and happiness. Furthermore, scientists then took it for granted that all the necessary knowledge could be acquired by breaking down complex phenomena and structures into their ultimate constituent parts, and by studying each one of the separate parts with refined analytical techniques. Whatever may be thought of the validity of these beliefs, there is no denying that they are no longer held as widely as in the past. The euphoric attitude of the 18th and 19th centuries has given way to some disenchantment and, in some circles, to overt hostility and contempt.

Few are those who now believe that the immense accumulation of factual knowledge has provided acceptable theories for the origin of the universe and of life; that the detailed study of smaller and smaller fragments of nature suffices to achieve understanding; that scientific medicine and material prosperity are sufficient to create health and happiness. I realize that the mere expression of this skepticism is considered by many to be anti-scientific or anti-intellectual. But in my opinion the worst form of anti-intellectualism is the unwillingness to acknowledge the present limitations of science in both its conceptual and experimental structure. It is this self-satisfied attitude, furthermore, that interferes with the development of a scientific method applicable to some of the problems of living which have direct relevance to the future of mankind, especially in certain areas of human biology, psychology, and sociology.

There is no need to belabor the obvious truth that,

while modern science has been highly productive of isolated fragments of knowledge, it has been far less successful in dealing with the complexity of natural phenomena and especially those involving life. The high degree of specialization required for professional effectiveness accounts in part for this difficulty; no one person can give thorough attention to all the multiple facets of any natural phenomenon or can control its multiple determinants. But above and beyond these technical complexities, the natural sciences present other problems of a more philosophical nature which require a profound change in the conceptual attitude of scientists. In the most common and probably the most important phenomena of nature, the constituent parts are so interdependent that they lose their character, their meaning, and indeed their very existence, when they are dissected from the functioning whole. In order to deal with problems of organized complexity, it is therefore obligatory to investigate situations in which several interrelated systems function in an integrated manner.

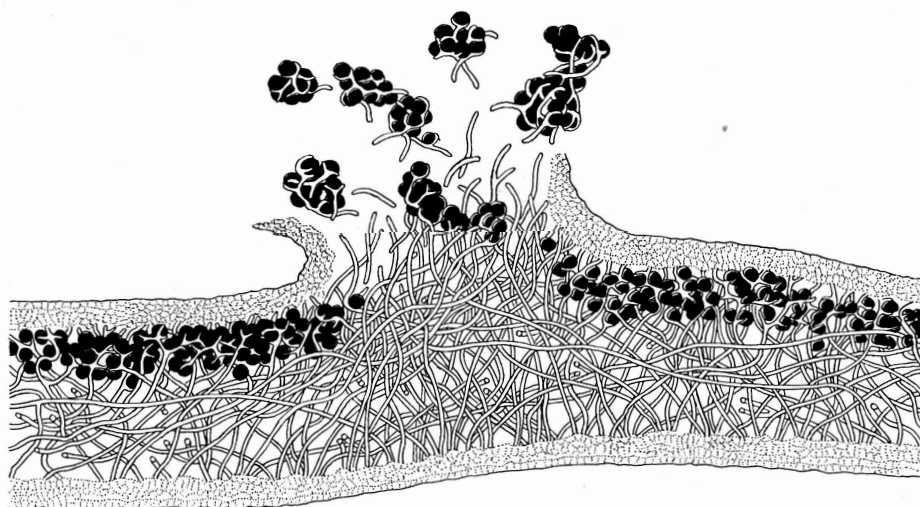
Multifactorial investigations will naturally demand entirely new conceptual and experimental methods, very different from those involving only one variable which have been the stock in trade of experimental science during the past three hundred years. It is widely acknowledged that such methods must be developed in order to bring sociological problems within the scientific fold; but it is less frequently recognized that the need is just as great in the study of biological problems. Some of the most

interesting aspects of life, and perhaps the most important of them, completely escape recognition by the orthodox analytical methods of present-day experimental science.

The case of lichen synthesis illustrates why the experimental method, as usually applied, fails to reveal the creativeness of biological systems. Lichens are constituted by the symbiotic association of an alga and a fungus. They possess complex and beautiful morphological structures, synthesize strange chemical compounds, and exhibit unusual physiological properties which are never found either in the alga or in the fungus growing separately in pure cultures. Furthermore, bringing together the alga and the fungus is not sufficient to form a lichen. Under usual laboratory conditions the alga and the fungus remain separated, and commonly, in fact, one destroys the other. The integration between alga and fungus resulting in true symbiosis occurs only when the two are placed in a nutritionally deficient environment where they cannot multiply alone. Only then does symbiotic association take place. Nutritional complementarity is one of the aspects of symbiosis, and in ways which are not yet understood, it is always accompanied by the creative processes just mentioned.

Lessons from Lichens

Lichen synthesis suggests two lessons to be learned. On the one hand, it illustrates how a particular natural phenomenon can come into being only



In the lichen, an alga and a fungus live in symbiotic association. When together they develop structures, functions, and properties never seen in either one alone. Lichens usually multiply by vegetative reproduction, as shown in the drawing at left.

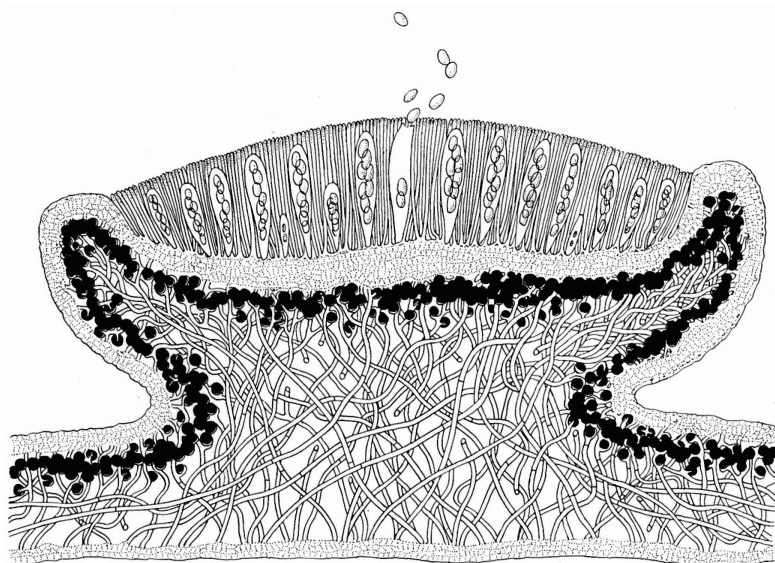
when several unrelated variables are properly manipulated. On the other hand, it brings to light that certain attributes of the alga and the fungus can remain unnoticed, and become manifest only when very special conditions are satisfied. Because lichens were known to occur in nature, there was an obvious inducement to search for the conditions under which they could be produced in the laboratory. But if they had not been known, the detailed analysis of the alga, and of the fungus — the orthodox method of analytical science — would certainly not have led to the recognition of the potential attributes which become realized in the symbiotic state. Lichens thus constitute a living demonstration of the fact that many potential properties of living things cannot be derived from the analysis of their constituent parts, and even when these properties are known to exist they cannot be elicited except through the operation of multifactorial systems.

Modern theoretical biology emphasizes the phenomena common to all living things, the structures and properties of their ultramicroscopic components and of their chemical reactions. But this is not sufficient to learn what makes each particular kind of organism click, be different from others, and respond to stimuli in its own particular way — in other words be truly alive. The reductionist approach is also inadequate for the study of groups and populations.

Crowds respond differently from individual organisms to almost any kind of stimulus. There are forms of behavior, of performance, and of disease that are

determined more by the size of the group and the conditions under which it is placed than by the individual characteristics of each one of its components. The social group is qualitatively different from the sum of its parts, not through any mystical property but simply because its characteristics are determined primarily by the interplay between parts under a particular set of circumstances. Statement of the problem in these terms is not a retreat from science. Rather it points to the necessity of developing scientific methods more sophisticated than those which were found sufficient to study the body machine in the 17th century. More exactly, it implies that the traditional experimental method based on reductionism must be complemented by new integrated techniques.

The body is of course a machine, but the interest that scientists have displayed in the components of the machine has led them to neglect somewhat the obvious truth that life is the response of the integrated individual organism to the forces of the total environment. Science is also part of the living experience, one of the responses of the social group. Most living responses have purposiveness or at least directiveness. In other words, they tend to display processes which end up by benefiting the individual organism or at least the species to which it belongs. This is probably as true of science as of physiological activities. For this reason, I have the faith — admittedly no better documented than the various faiths which have motivated science throughout history — that



Fruiting bodies, the typical structures of sexual reproduction in fungi, are shown in the lichen at left. Both drawings show the round algal cells (BLACK) entangled in the fungal threads. Only if both structures remain together, can a fragment propagate into a new lichen growth.

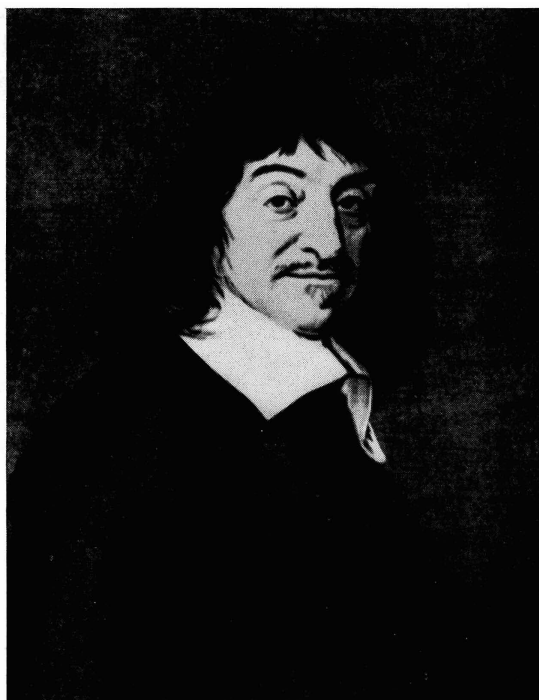
biologists will eventually escape from the spell cast on them during the 17th century. They will continue of course to analyze in their ultimate details the structures and properties of the body machine, but increasingly they will turn their attention to the more complex phenomena of the living experience.

The reductionist and holistic approaches to human problems are well symbolized, it seems to me, in two beautiful portraits of scientists, one by Frans Hals, the other by Rembrandt. The portrait by Frans Hals is a painting of René Descartes, in the Louvre. It conveys the clarity and vigor of orthodox science, confident in the power of its analytical method. The intellectual assurance of the experimenter arises from the fact that he has learned to deal with simplified systems, representing selected aspects of the world rather than total reality. The portrait by Rembrandt is an etching in the Philadelphia Museum of Art, depicting a physician who has just seen a sick person. His attitude, at the same time perplexed and reflective, symbolizes the bewilderment and awe experienced by any thoughtful scientist coming face to face with the problems of the throbbing man in direct contact with life as it occurs in nature. Rem-

brandt's doctor seems hesitant, yet eager to grasp the real meaning of experience.

Frans Hals and Rembrandt have presented in these portraits two complementary aspects of scientific life. Through their vision, science appears as an endless dialogue between two manifestations of human nature. At times, following Descartes, scientists select and arrange phenomena to create formal patterns which are not quite true to life, but fit well in their own mental fabric. At other times, like Rembrandt's doctor, they try to apprehend human problems in all their undefinable, overpowering, but entrancing complexities. It is often a pathetic effort, but one that enlarges human vision and helps biologists to keep in view their ultimate goal. They want to know not only what the body machine is made of, but even more, how the living organism — man in particular — responds to the total environment. We, as biologists, must learn to study living as experience.

A more extended version of this article, presented as the Penrose Memorial Lecture, previously appeared in the Proceedings of the American Philosophical Society. Last December, Dr. Dubos' book, The Unseen World, published by The Rockefeller Institute Press, received the Phi Beta Kappa Award in science.



Descartes by Frans Hals



Amsterdam Physician by Rembrandt

NINETEENTH CENTURY AMERICAN SCIENCE

INSIGHTS FROM FOUR MANUSCRIPTS

BY EDWARD LURIE

*Scientific institutions are themselves
the creative works of men. In the
tracings of these men's lives, we find
insights into the enduring structures.*

I SHOULD LIKE to impart some sense of my own appreciation of the significance of the inner history of American institutions of science and the men connected with them by recounting several experiences from my research. One of my first insights into the importance of means of communication among scientists and intellectuals occurred as I turned over letter after letter in the papers of Joseph Leidy, the noted Philadelphia paleontologist and professor at the University of Pennsylvania. One of Leidy's regular correspondents was the South Carolina paleontologist Francis S. Holmes. Philadelphia, by virtue of the activities of scientists such as Leidy, served as a sort of intellectual link between the scientists of the Southern states and those of the North. As a member of the Academy of Natural Sciences of Philadelphia, and a man well regarded by such naturalists as Louis Agassiz and James Dwight Dana, Leidy was fully aware of the character of research, publication, and scientific interchange in centers like New Haven, New York, Boston, and Cambridge, as well as his native Philadelphia. Such knowledge he imparted to

Holmes, who, relatively isolated in Charleston, devoured it eagerly. Holmes was an investigator of considerable stature. He had published articles describing and analyzing the vertebrate paleontology of his region, and his private collection of fossils was a comprehensive and unique one.

The scientific character of the Holmes-Leidy correspondence dealt, as might be expected, with vertebrate paleontology generally, and fossil teeth in particular, a subject of much interest to each man. But as the political climate of the 1850's became more and more incendiary and divisive, it was clearly difficult for each naturalist to be concerned solely with problems of ancient dentition. They were compelled to lament the political divisions that seemed to drive the sections further apart with the passage of time. Early in 1861, after the election of Lincoln, when the political strife in the nation was reaching its highest pitch, Holmes wrote an especially revealing letter to Leidy. In it, after recounting the war hysteria and the sectional feeling running so high in the deep South, the naturalist ended his account with words that were especially poignant: "Remember yr promise, Leidy," and, reminding the Philadelphian of earlier words, concluded: "no matter what comes 'we are friends forever.'" This plea for the continuance of personal and intellectual friendship and communication despite the harsh intrusion of the cataclysm of political and social upheaval, struck me as symbolic of that need of the scientist for interchange with his colleagues, so essential to the life of the mind. I was curious to discover whether or not Holmes ever

picked up the threads of that scientific existence and personal relationship so rudely torn apart by the Civil War. After serving in the Confederate forces, Holmes returned to the South. I found more letters in the correspondence in the years after 1865. In one letter, Holmes reported to Leidy the sense of bitterness, frustration, and intellectual impotence he experienced as a result of the burning of his library during the war. He tried desperately, out of contact as he was with the world of scientific interchange, to renew his former intellectual existence, and asked Leidy's aid in getting some papers published.

Holmes and the others from the South were not the only sufferers. A number of Northern scientists (like the brilliant Harvard naturalist Theodore Lyman) went off to the war, as did Holmes, and the failure of communication and transportation systems throughout the nation served to divide the rest. The sole agency for national communication in science, the AAAS, was unable to hold a meeting from 1861 to 1868. This breakdown in the interchange of knowledge occurred in those very years when the most significant scientific hypothesis of the period — Charles Darwin's ideas of organic evolution — was being enunciated. The American scientific community as a whole had to wait for almost ten years be-

fore it could debate *On the Origin of Species*.

This sense of the importance of intellectual interchange grew even greater when I came upon a letter in the Dana papers at Yale. As an editor of the *American Journal of Science* and a distinguished geologist, Dana was, even more than Leidy, in a central position in the power structure of young American science. He was also engaged in research and study in marine biology, working on problems of geographic distribution, a subject that had already engaged the attention of Charles Darwin. Dana's talent was revealed to me by the inquiries, which increased in number with the passing months, made of him by Darwin in the mid-1850's.

As I read letter after letter from Darwin to Dana, I became so impressed with the intellectual stature of the Yale naturalist, that I almost overlooked the importance of a letter written to Dana by Benjamin Apthorp Gould, an astronomer. Gould was at that time a resident of Cambridge and an employee of the *Nautical Almanac*, a publication of the Navy Department, under Lieutenant Charles Henry Davis. In November 1856, he wrote Dana:

There is a scheme by some of us in Cambridge after consultation with Bache for the hatching of which you are an essential element. . . . The simple proposal is

Charleston Jan'y 7th 1860
My dear Leidy, Thanks for yr kind letter
I hope you did not think hard of me
for this delay in answering, but the
truth is we are literally in camp &
armed to the teeth, & every thing has
given way to the preparation for war.
These are sad times for our one

Charleston January 7th 1860
My dear Leidy Thanks for your
kind letter. I hope you did not
think hard of me for this de-
lay in answering, but the truth
is we are literally in camp &
armed to the teeth, & every-
thing has given way to the
preparation for War. These
are sad times for our once . . .

Remember yr promise Leidy,
"No matter what comes we are friends
forever!" Faithfully Yours
(P.S. over) Francis S. Holmes

Remember yr promise Leidy,
"No matter what comes we
are friends forever." Faith-
fully yours Francis S. Holmes

[Extracts from letter of
Francis S. Holmes to Joseph
Leidy, January 7, 1860]

this, that once in each year . . . some of us should eat one outrageously good dinner together, persons to be nine . . . together with any others whom they may hereafter unanimously desire. Officers none, excepting Bache to be the chief. This will do as much as the American Association to stimulate, support, and encourage us all, and will taste better.

It was on reading this letter that scattered phrases in the correspondence of other scientists began to take shape for me as a general pattern of organizational development in American science in the years before the Civil War. "There is a clique bound to each others' interests and defense at all times and under all circumstances," was the complaint of a young Philadelphia naturalist in 1857. "They have their men to whom they refer matters and investigations; their intercommunication is constant. I know of all their intercourse in Cambridge and Washington," was another ominous note. Was the "Cambridge-Washington clique" merely an imaginative figment in the mind of a young malcontent who resented the power of men such as A. D. Bache, Dana, and Louis Agassiz? Or was this power being used for special ends and purposes, for the advancement of special interests in science?

I determined to find out the actual meaning behind the seemingly innocent Gould proposal.

Lazzaroni

I began to read the papers of Agassiz, Asa Gray, Bache, Davis, and Benjamin Peirce with more than routine interest. It was not long before the following pattern of organization became plain:

By the mid-1850's these men thought of themselves as a group dedicated to: achieving a larger role for science in American education; professionalizing the discipline so as to make "charlatanism," "quackery," and "old fogeyism" remnants of a pre-scientific past; gaining government sponsorship for a "central scientific organization"; and employing the monetary power inherent in the social status of the Smithsonian, the Coast Survey, the *American Journal*, and the AAAS, to gain their ends. They were forward-looking men who thought of science as a mark of an advanced civilization; they wanted America to equal and even surpass Europe in the social support for science and the creation of institutions to further education and research. By 1853, they had given themselves the name of the Florentine Academy,

changed a few years later to "The Order of Scientific Lazzaroni." The Lazzaroni constituted a cohesive organization that functioned well because it was not subject to cumbersome delays, disputes, and procedures that typified democratic organizations.

Lazzaroni were Neapolitan idlers or beggars. This ironic designation showed how cheerfully this coterie proceeded on their self-appointed mission to dominate the institutions and culture of American science and to move men, states, and nation to achieve their purposes. They were all men of tremendous energy and scientific distinction.

Agassiz's words to James Hall, in a letter of 1849, set the tone for the Lazzaroni of the future:

It becomes a duty for scientific men to do their utmost to prevent the public from being humbugged by pseudo knowledge . . . let the whole number of scientific men come together and vindicate their natural right, a right which benefits the community and which will put an end to the contemptible doings of quacks or those unworthy men of science who consider first their pocket and then their honor.

From 1849 to the Civil War, they worked to establish what they liked to call "The American University." Although they founded the first major astronomical observatory in the nation—the Dudley Observatory, directed by B. A. Gould and managed by a "Scientific Council" composed of Henry, Bache, and Benjamin Peirce—they failed in their specific mission of the 1850's. They publicized notable goals for the future, however—aims realized after the Civil War.

What of their ideal of establishing, in Bache's words, a "central scientific organization" supported by the federal government? To trace the history of this conception in the 1850's and 1860's it was necessary for me to go to Washington and read the manuscripts of such men as Bache and Joseph Henry. Henry was of special interest. He was held in high esteem by scientists everywhere. As Secretary of the Smithsonian Institution, he was in a key position to realize the aim of a national scientific establishment. It is clear that the organization of the National Academy of Sciences by act of Congress in March of 1863 provided just the sort of institution the Lazzaroni had urged for the nation since the 1850's. But what was the role of Henry in this effort, and how did the aims of the Lazzaroni square with the values of social de-

mocracy in intellectual life so dear to men such as he?

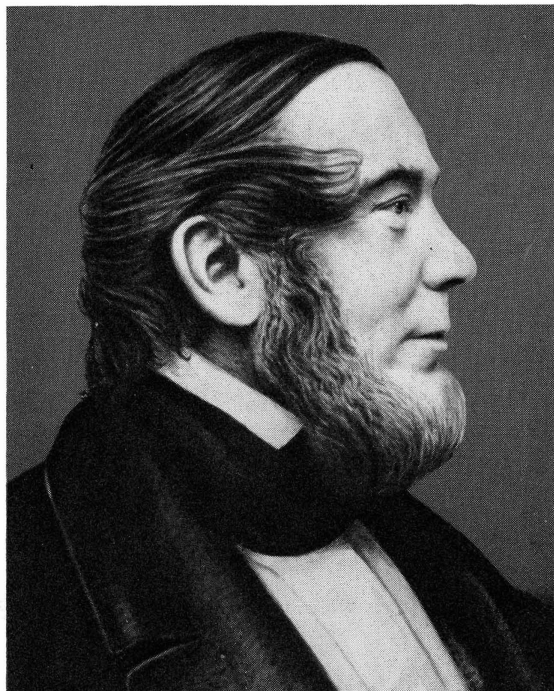
When I asked the Smithsonian archivist if I might see the papers of Joseph Henry, I learned that the fire that had swept the Institution in 1865 had destroyed most of the physicist's private manuscripts. As if to offer some morsel to appease my unsatisfied appetite, the gentleman asked if I would be interested in a diary kept by Henry's daughter, Mary. I would. This small leather-bound book written in a fine hand by a young woman of apparent breeding and intelligence seemed at first uninteresting in its details of the commonplace experiences of home, family, and social existence of the Henrys. But a close reading of Mary Henry's observations taught me much about the cultural relations of the life of science in a changing, crisis-ridden society. What was incomparable in Mary Henry's picture of scientific life in Washington during the years 1861-1870, was her sense of the processes and the politics of decision-making.

Diary

It became plain from my study of the diary that Henry was one of the most powerful intellectual figures in the city. Through the Regents of the Smithsonian, he had access to decision-making in the legislative, judicial, and executive branches of the government. His service on various scientific commissions put him in a position to work for increased utilization of science in the service of national aims, not only in terms of war technology, but in such matters as weather observation. Mary told of these connections.

I was disappointed, however, to find no comment in Miss Henry's diary regarding the manner of organizing the National Academy in 1863, because in this one instance the ranks of the Lazzaroni had been thinned by the absence of Henry. Bache and his coterie knew Henry to be opposed to the idea of a select grouping of governmentally recognized scientists because he felt that it was "at variance with our democratic institutions," and that it would create ill-will among scientists. But, with the aid of Senator Henry Wilson of Massachusetts, Bache, Agassiz, Wolcott Gibbs, Gould, and Peirce proceeded without Henry's knowledge to gain congressional and presidential approval for the Academy, and Henry only found out about the event on March 5, two days after Lincoln had signed the bill into law.

In the light of these events, an entry of January, 1868 in Miss Henry's diary was of more than casual interest: "Professor Agassiz called. While he was here, Dr. Gould came in and told us Father had been elected President of the Academy. The election was unanimous. 'Only one vote for you, Prof. A.,' said Dr. Gould. 'Yes,' said Prof. A. 'I had only one vote which



ALEXANDER DALLAS BACHE

probably came from Prof. Henry as he would not vote for himself.'" These sentences provide a fitting capstone to the early organizational struggles of the Academy to establish itself in conformity with the often conflicting drives of scientific elitism on the one hand, and cultural democracy on the other. Miss Henry's disarming report was in fact a statement that laid bare five years of internal struggles within the councils of American science.

Alexander Dallas Bache, first president of the Academy, had died in 1867, leaving his entire estate of about \$50,000 as a permanent fund for the use of the Academy. While Henry had not believed in the organization, fearing it might be used to promote "personal interest or to the support of partisan politics," he agreed to take the presidency and was in fact the only scientist of reputation who could have rescued the organization from the quarrels, jealousies, and antagonisms that marked its early history, both

within its ranks and in the larger world of American science. Agassiz, with equal national stature, would have been an impossible choice, so involved had he been in the rivalries and disputes of the past. Hence the Harvard naturalist was delighted with Henry's decision to assume control and start the academy off on a new direction. His words epitomized his understanding of the errors of the past and the potentialities of the future: "A better acquaintance with American ways has satisfied me that we started on a wrong track; but since we have at last got an Academy let us make it American as much as we can and try to avoid natural domestic breaches." This was a frank recognition of the resentment of such men as Henry, Leidy, Asa Gray, and William Barton Rogers at the secret way the Academy had been organized, of the ill-feeling on the part of John William Draper, Spencer F Baird, and others, at being left out of the original membership list, and of the antagonism within the Academy caused by the insistence of leading Lazzaroni that the first members take an oath of loyalty to the federal government. In time, the oath restriction was removed, the membership rules liberalized, and by virtue of the wise counsel of Henry, the Academy acquired the ability to function as the primary agency providing scientific advice to the general government. But this end-product of devoted Lazzaroni effort had not been created without considerable personal conflicts. In a letter to Agassiz of August, 1864, Henry brilliantly delineated the im-

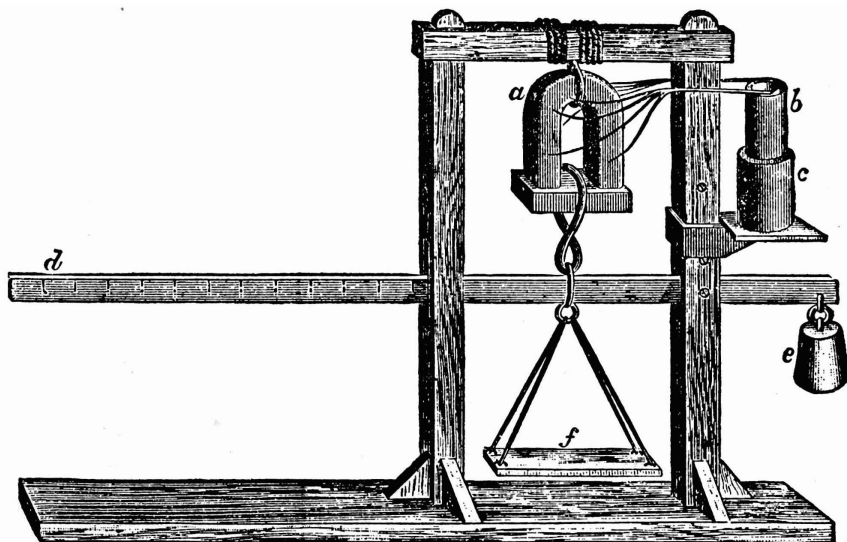
pact of this form of activity upon the scientist dedicated to cultural advancement:

Why trouble yourself so much about the character of American science which can only be improved with the social and political conditions which tend to encourage and develop it? . . . You are formed to lead men by the silken words of love rather than to urge them on by the rough method of coercion. Let me beg of you therefore . . . to first take care of your health and secondly to devote yourself for the remainder of your life to those investigations which have given you so wide and permanent a reputation and in which at every step you can elevate yourself in your own self esteem . . . and afford to look down with complacency on the means to which ordinary men resort to raise themselves into temporary notoriety. It is lamentable to think how much time, mental activity, and bodily strength have been expended among us during the last ten years in personal altercations, which might have been devoted to the discovery of new truths; . . . to the enlargement of the bounds of knowledge, and the advancement of happiness.

But Agassiz, like others of the Lazzaroni persuasion, was incapable of ceasing life as a public man, devoted as he was to activity in the world of affairs.

Copybooks

In the spring of 1864, just a few months before the letter from Henry, Agassiz engaged in a correspondence with Senator Charles Sumner of Massachusetts that revealed the manner in which the politics of cultural organization extended beyond the realm of sci-



Joseph Henry's electromagnet, described by him as "probably . . . the most powerful magnet ever constructed." Around the U-shaped iron bar, which weighed 21 pounds, were wound 500 feet of copper wire in nine separate coils. The magnet was capable of lifting 750 pounds, more than thirty-five times its own weight.

1868

some of them are of a great depth.

23rd Thursday. a rainy day. Prof. called after breakfast. Prof. Guyot left us to our great regret. He has to lecture in Baltimore. Prof. Agassiz called. While he was here Dr. Gould came on to tell us Father had been elected President of the Academy. The election was unanimous only one vote for you Prof. A. said Dr. Gould. Yes said Prof. A. I had only one vote which probably came from the Prof. as he would not vote for himself. Later - Father has come home tired. He has accepted the Presidency as the vote was so unanimous. Soiree, at Senator Morgan's Secretary Randall, Nell went with Miss H. & some of the Gentlemen.

24th Friday. A reception day but I made my escape to the Capitol with Prof. & Miss Horsford to hear Father's paper on Sound leaving Nell & Henry to assist Mother in entertaining the guests. Thus

1868, 23rd Thursday. A rainy day. Prof. called after breakfast. Prof. Guyot left us to our great regret. He has to lecture in Baltimore. Prof. Agassiz called. While he was here Dr. Gould came in & told us Father had been elected President of the Academy. The election was unanimous only one vote for you Prof. A. said Dr. Gould. Yes said Prof. A. I had only one vote which probably came from the Prof. as he would not vote for himself. Later - Father has come home tired. He has accepted the Presidency as the vote was so unanimous. Soiree, at Senator Morgan's & Secretary Randall, Nell went with Miss H. & some of the Gentlemen.

[A page from the diary of Mary Henry]

ence and into that of the humanities and the social sciences. For all the insight into the history of American science I had gained from working at such Harvard depositories as the Museum of Comparative Zoology, I had never, in nearly two years of research there, found the records relative to the history of the museum itself, nor, for that matter, had I found many letters written by Agassiz himself. In 1959, just prior to completing my Agassiz biography, I returned to Cambridge for a necessarily brief stay, in the hope of finding such vital material. Not much of significance turned up until three days before I had to leave, when the assistant to the director of the Museum casually asked whether I would be "interested" in some old letter-press copybooks that had been found

in the bottom of a file cabinet. There were the materials I had looked for so long in vain, the entire "official" correspondence of the directors of the Museum from the 1850's through the turn of the century! Since Agassiz never distinguished his official museum life from his scientific and other personal and professional interests, these were, in effect, the vast body of letters I had sought so long.

I confess that I quite often felt distressed as I read the letter books and found carefully preserved copies of letters which had required diligent searching out in archives in Washington, Philadelphia, or New Haven in the quest for the originals. Not wanting to miss a thing, however, I plowed on, through the days (and nights) remaining to me. And then, eye-weary

and eager to be finished and to begin writing, I found the correspondence with Sumner. It was a most enlightening discovery. It helped me understand how science served as a model in the organization and rationalization of other forms of creative effort in the late nineteenth century.

In 1864, Sumner was a kind of symbolic hero of unionism and abolitionism in America, having suffered personally for his beliefs from a physical disability inflicted upon him in 1856 by Representative Preston Brooks of South Carolina in an attack on the Senate floor. In moral and cultural terms, Sumner shared that concept of social progress that typified the outlook of such fellow New Englanders as Agassiz, Lowell, Longfellow, Emerson, and Whittier. The formation of the National Academy just the year before through the efforts of the senior Massachusetts Senator Henry Wilson, had been an example of the manner in which radical Republicanism, freed from the fetters of southern states' rights opposition, had promoted a wide range of nationalistic, centralizing legislation that placed the federal government in a primary position in economic and cultural affairs.

Academy

By 1864 the National Academy had held two meetings, and despite the skepticism and disapproval shown by some member and non-member scientists, it provided at least a framework for the future contribution of special knowledge in the service of the nation. For the scientists, its organization had meant more than this. Agassiz expressed the feelings of his fellows accurately when he wrote Bache:

To have this organization settled is a great step, and I see first fruits growing from it. The malcontents will be set aside and the institution survive. It has already accomplished one great thing. We have a standard for scientific excellence, whatever our shortcomings may be. Hereafter a man will not pass for a mathematician or a geologist, because an incompetent Board of Trustees or Corporation may give him an appointment. He must be acknowledged as such by his peers, or aim at such an authority that by his efforts and this aim, must be the first sign of his propriety.

It was this spirit of professionalism, this understanding that an *institution* would survive above and beyond the finite aims and disagreements of individuals comprising it, that made men like Bache and Agassiz such modernists in cultural outlook, and

made the things they did so important both in shaping the character of national educational and cultural life in the late nineteenth century, and also in providing patterns for the present.

It is in this context that the Agassiz-Sumner correspondence of 1864 was of such interest to me.

This series of letters revealed that scientist and senator had discussed the formation, under government sponsorship, of two new "Academies." One would represent literature, history, philosophy, and the humanistic disciplines generally, the other would contain members in the "social" sciences such as economics, statistics, anthropology, sociology, and political science. As in the science academy, the humanities academy would restrict membership to fifty individuals; however, an original group of twenty members would elect five new members each year until the full number was reached. In the light of the controversy and acrimony stirred by the way in which fifty scientists had been selected by Agassiz, Bache, and a few others, as the leading men worthy of National Academy membership, this innovation is an interesting example of the effect of such protest. "In this way," Agassiz boasted to Sumner, "you will avoid all objection of clique and nepotism in the first selection of a full Academy, and also the pressure to have this or that gentleman's name added to the list, as the original members may be so chosen that everybody will consider them as the most competent body to choose the best men for the two academies."

What was even more significant was the fact that a scientist, in alliance with a statesman, felt perfectly capable and competent to plan the membership and the structure of federal organizations in the humanities and social sciences. But Agassiz did not think he was acting at variance with democratic means or entering fields of decision-making not properly his own. Rather, he was proud of his organizational scheme, telling Sumner that "any attempt in a private way to fill up the list of the two Academies will . . . be an impossibility, without making great blunders." Just as in science, Agassiz was convinced that "there seems to me to be only one consideration admissible for membership, absolute fitness on the ground of real qualification."

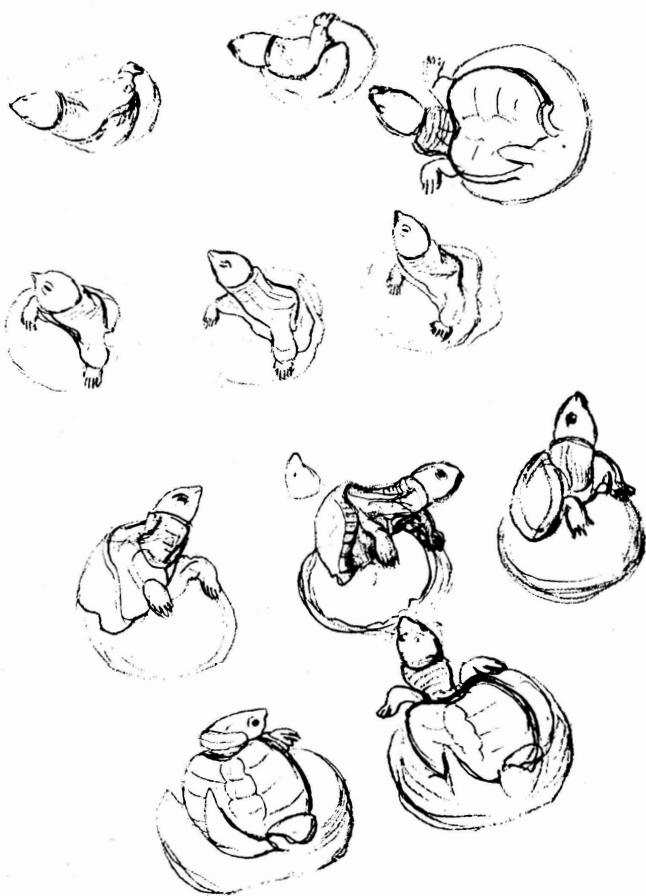
It is instructive to note the qualification represented by the lists Agassiz submitted. In the "Academy of Letters," with only three exceptions, all the

proposed charter members were New Englanders, most living in the Boston-Cambridge region, and most already members of the Saturday Club. The Club was a self-selected body that met once each month at Boston's Parker House, numbered Emerson, Longfellow, Holmes, Lowell, and Agassiz among its leading members, enjoyed a very good dinner, excellent wine and cigars, and engaged in discussion and disputation on matters of poetry and kings, slavery and science. It was the literary and cultural counterpart of the Order of Scientific Lazzaroni and even had its own unofficial publication, the *Atlantic Monthly*, begun in 1858, which was edited successively by different Club members. It is apparent that just as the National Academy of Sciences was the governmental and organizational formalization of Lazzaroni values, the non-scientific academies were to represent the membership of the Saturday Club. A penciled note in Agassiz's hand at the bottom of one of the membership lists reveals the touch of the

statesman of cultural organization. He wrote Sumner, "If you feel no objection to members of Congress," and then appended the names John Pendleton Kennedy, Reverdy Johnson, and Charles Sumner.

This noble dream never did materialize, but the fact that it was taken seriously by each man, and by the Saturday Club membership, impressed me with the necessity of probing more deeply into the entire problem of the relationship of intellectuals to their culture in the years from the 1860's to the turn of the century. As I read these letters, they suggested to me a markedly different style of intellectual activity, a style that had a distinct flavor of modernism, not evident in the cultural history of the earlier nineteenth century. When we walk into a museum and see a reconstruction of the furnishings of homes in colonial America, we feel unfamiliar and uncomfortable with what we see, but in the domestic art forms of the late Victorian era, we can perceive styles that are clearly transitional to and consequently reminiscent of our own. So, too, the style and form represented by the effort to nationalize science, social science, and humane letters has the character of modern intellectual and academic formalization.

Bearing in mind Agassiz's dictum that institutions are created by individuals and survive after them, I began to see such houses of intellect as understandable in terms of the efforts of dedicated men. Agassiz, Bache, John Wesley Powell, Daniel Coit Gilman, and others of that stamp worked to build permanent organizational forms so as to make intellectual life at once more rational, more professional, more efficient, and more deserving of public respect, financial support, and cultural status. It seemed imperative to consider as primary the activities and the values of the *rationalizers* of intellectual life, new men who arose to give voice to and instill a different cultural ethos in this significant movement in national life. Seen in this context, then, the Agassiz-Sumner interchange and the activities of the Lazzaroni appeared all the more intriguing; here were men who, confident of their skill, knew real joy and pleasure in the employment of creative energy to build lasting institutions of intellectual life. That this effort did not result in contributions to knowledge was, in the large sense, a false dichotomy. Who can estimate whether a scientific discovery is, even on an absolute scale of value, any more lasting than the building of a Na-



Sketches by Agassiz

tional Academy? And, in another sense, the discoveries of modern science are made possible and effective through the very institutional framework provided by the organizers of knowledge.

The case of Agassiz himself is an instructive model. In his youth in Europe, he distinguished himself by fundamental work in geology and paleontology, but, with the challenge of American life, the passing years found him more and more absorbed in the social and public relations of science. He served as an organizer of the AAAS and the Academy, an adviser to Henry on Smithsonian affairs, and a Regent of the Institution. He was the single-handed creator of a great research museum at Harvard, and a man who, in striving to establish the great American university in the 1850's, and in advising President Andrew Dickson White on the structure and character of the new Cornell University in the late 1860's, did much to modernize American educational theory and practice with regard to graduate instruction and research.

Institution Builders

Even more significant, perhaps, was the fact that Agassiz's students learned the lessons of their master well and went on to distinguished careers in scientific and academic administration, as well as in teaching and research in the biological sciences. The Agassiz influence carried on well into modern times with the work of men such as David Starr Jordan at Indiana and Stanford; Frederic Ward Putnam at California, the Peabody Museum, the Field Museum, and the American Museum of Natural History; William Keith Brooks at the Johns Hopkins; Burt G. Wilder at Cornell; Alexander Agassiz and Nathaniel Southgate Shaler at Harvard; and Addison Emery Verrill at Yale. The same was true of "Bache's Young Men" of the Coast Survey, and those who came under the influence of Silliman and Dana at the Sheffield Scientific School of Yale. It seems then, that to study the lives of institution builders is not only to learn their acts of individual creativity. This study must also include the manner and style that these dominant, pioneering individuals communicated to their associates and to others who came after them.

I thus found myself beginning to ask new questions regarding such individuals whose lives were intimately associated with institutional history. What was most striking about them, thought of as a group

rather than as single individuals engaging in single acts of accomplishment? It was that compared to intellectuals of an earlier day, these men were dedicated to ideals and values of group activity, of multiplicity, and of a psychology of organizational identification that made their lives meaningful to the degree that they were involved with the forces of institutionalism that bore the mark of their own creativity. It was this that impelled men of the latter nineteenth century to organize and seek professional status for such new social sciences as anthropology and psychology, to gain an increased role for science in the government through such new agencies as the United States Geological Survey and the National Research Council, and to organize and establish such universities as California, Stanford, Chicago, the Hopkins, M.I.T., and Cornell. When such efforts are viewed side by side with parallel activities directed toward the organization and rationalization of finance, industry, political parties, the labor movement, and the religious and philanthropic aspects of social welfare efforts in the late nineteenth century, it is evident how the society we now accept as a matter of course was in fact formed and inspired.

From reading the plaintive words of Francis Holmes's letter I knew that there was a humaneness in the life of science; from reading Gould's invitation to Dana I understood that scientists, like other dedicated men, wanted to make their commitment publicly effective; from reading Miss Henry's diary I was reminded that this effort was a common activity of scientists, and that they were as concerned as anyone else with war and peace, love and death, and the advance of culture. This advance took on a particular cast in late-nineteenth-century America, a form that was epitomized in the Agassiz-Sumner correspondence. I found that the proper study of nineteenth-century and contemporary American science best proceeds when freed from the artificial strictures that define a scientist as an individual somehow different from other intellectuals, and that make a false distinction between the "creative researcher" and the organizer and administrator of knowledge.

This article is adapted from one of a series of lectures on "Science in American Culture," given at the Institute. Dr. Lurie, author of the biography, Louis Agassiz: A Life in Science, is Professor of History at Wayne State University and a Visiting Professor at The Rockefeller Institute.

TEACHING AS A MEANS OF LEARNING

NEXT SUMMER, as in the past five summers, the campus of The Rockefeller Institute will be the setting for a brief but richly rewarding experiment in human relationships. About the first of July, some twenty youngsters from local high schools will come to the Institute for a seven-week course in biology which is organized and taught by the Graduate Fellows.

Not only is the student body recruited afresh each year, but the teaching staff is re-formed anew. This persistent newness gives the summer program its very special flavor, making it a rare and refreshing undertaking.

The school within a school had its beginnings in 1958 when some of the Graduate Fellows expressed a desire to teach. Dr. Bronk gave his instant warm support and, as their plans were formulated, helped them to secure the necessary financial assistance from the Carnegie Corporation of New York. The Carnegie grant maintained the program for its first two years. Since then The Rockefeller Institute has provided the relatively modest sum required, as well as making available laboratory space and equipment. In the person of Dr. Douglas Whitaker, it also stands ready with faculty advice, but only when requested. Each year a group of Graduate Fellows volunteers to select the candidates, plan the course, write the syllabus, supervise the laboratories, and give the lectures. For many of them it is the first chance to teach and it is, of course, for each of them an extraordinary opportunity to test a highly individual approach to teaching.

Each Graduate Fellow has charge of the class for from two to five days. He selects an interesting topic from a representative field of modern biology and



plans a series of lectures, demonstrations, discussions, and laboratory exercises. The specific topics usually change from year to year but they are generally chosen from the same fields. Students who teach for more than one summer often present a new topic each year. The number of Graduate Fellows who teach has tended to increase each year. Last year twenty-one taught.

Michael Ruttenberg, who taught organic chemistry in 1961, was head of the Summer Course Committee in 1962, and has now left the program "to give somebody new a chance." Lawrence Sturman, who taught pathology in 1962, was in charge of the program in 1963. This year the program is under the directorship of a committee headed by Kathryn Holmes. In addition to the biology of whole organisms, as Mrs. Holmes's section was called, last year's program covered such topics as nucleic acid chem-

istry, photosynthesis, intermediary metabolism, psychology, and the structure and function of the cell membrane. In 1963, a choice of some small laboratory projects was offered at the end of the course. Each of several Graduate Fellows worked closely with a pair of high school students for a two-week period. This year, it is proposed to assign each student to an adviser who will work with him personally to help with material he does not understand and with ideas he would like to explore further.

"I don't believe a program like this would work anywhere else," Dr. Sturman said. "Here we all know each other and have plenty of opportunity to talk together and to work things out informally."

Testing the Teachers

From time to time, the Graduate Fellows give their students tests which are designed to find out just how well their teaching methods have succeeded. "All of the boys and girls are very bright," Mrs. Holmes explained, "so we know that they are capable of learning the material as long as it is presented well." In addition, each year the students have been asked to write an evaluation of the course in which they comment candidly, not only on the content of each group of lectures and laboratories, but also on the style and skill of the teachers.

"We learn more than they do," commented Mr. Ruttenberg, in a reminiscent evaluation. "A few of us have done a little teaching before, but often this is the first opportunity to plan a lecture and deliver it in front of a whole class."

"In addition," Dr. Sturman added, "a lot of the Fellows find that it is a wonderful way to review an old subject or to explore a new one. It is an enormous help in organizing one's thinking about a particular field."

One of the most difficult aspects of the program is selecting the students who will be accepted. In 1959, *the first year of the program*, a dozen New York City high schools were simply asked to select students for the course; twenty-seven were nominated and all were taken. In subsequent years, the Fellows thought that students from more high schools should be given a chance to apply. This meant, of course, that some sort of selection procedure had to be instituted. Each year the procedures have varied somewhat. Just how to choose the students wisely and fairly has

come to be as much of an experiment and a learning process as any other aspect of the course.

In January of this year the program was described at a meeting attended by about 300 high school juniors and seniors. Applications were distributed at that time. They contained a form to be filled out by a high school science teacher and five questions which the students were instructed to answer. More than 200 applications were received. In evaluating the applications, the Graduate Fellows have tried not only to judge the originality of the applicants, but also the usefulness of different types of questions.

Last year it was discovered that a group interview could reveal many qualities which were not so apparent in the individual interviews which had been used formerly. The interviews are also useful in indicating which questions on the application form were most revealing. This year, 54 applicants (chosen on the basis of the questionnaires and recommendations) are being interviewed *both* separately and in groups.

"We have learned a great deal from these interviews," said one member of the Committee. "It's a lot of fun to meet so many interesting high school students. We try to make the interviews interesting and enjoyable for the students too." The students eventually selected have a wide variety of individual interests and backgrounds. The Fellows all agree that it is difficult to turn down any of these good students. In this selection experiment they face the problems and doubts which confront educators and administrators throughout the country.

About the Students

This fall, Erich Weinberg and Sanford R. Simon, who were members of the 1959 class, became Graduate Fellows. Mr. Simon has himself signed up to teach in this year's summer session. The reappearance of students Simon and Weinberg is regarded as a happy but unexpected bonus. The summer session is not planned as a recruiting service for the cause of science, but rather to introduce young people to another way of thinking and looking at the world. According to Dr. Sturman, some of the best students from the teacher's point of view, are the ones who do not yet know what they want to be and so are broadly receptive to all new information and new ideas.

No grades are given in the program, just a simple statement that the course was completed.

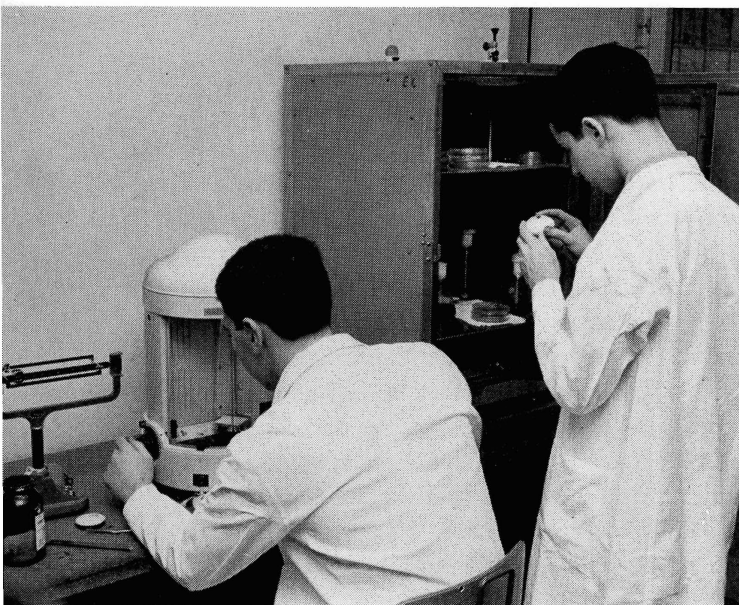
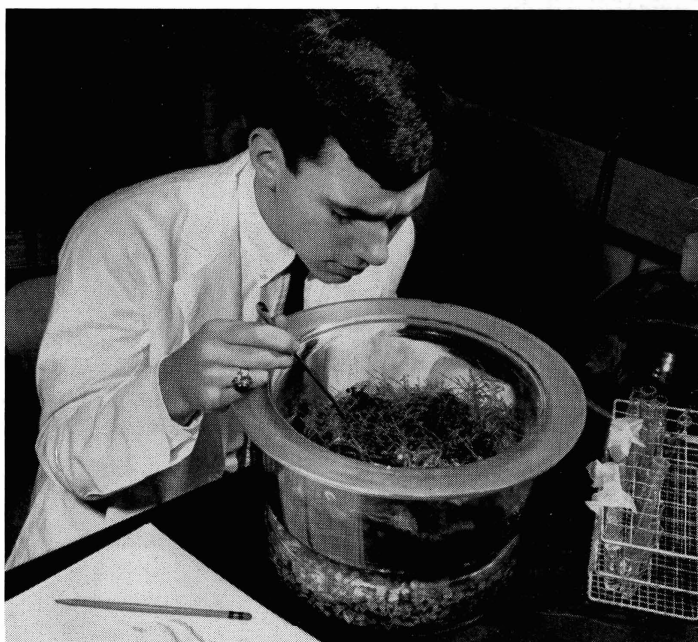
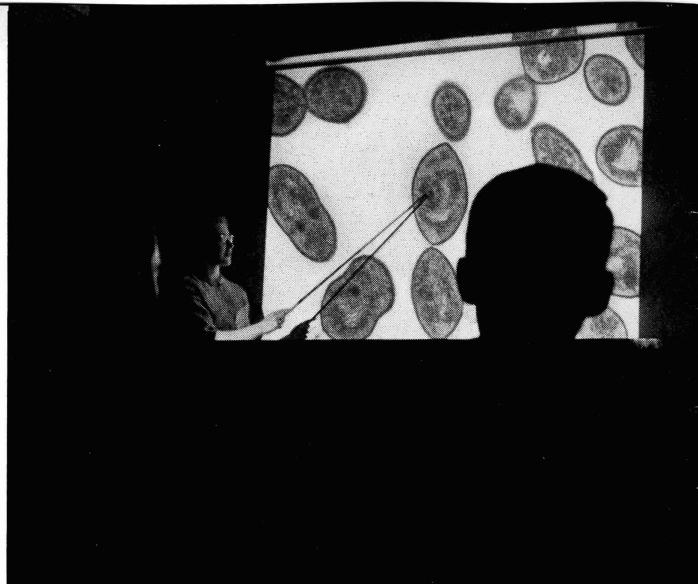
The course moves at a brisk pace, with classes and laboratories from nine in the morning to five or six every evening, and reading assignments besides in a variety of subjects. "I never knew I could work so hard," gasped one of last year's students. "Now I'm not so afraid of college any more."

A Typical Day

In a typical day, a student might spend a morning at a lecture on the Krebs' cycle and an afternoon devising experiments to test the reactions of Hydra to external stimuli, or a lecture on the structure of the cell membrane might be followed by a laboratory study of osmosis. Although a great variety of topics are covered, the instructors try to interrelate the subjects as much as possible and to provide a guiding thread of continuity; last year, for example, the unifying theme was cell physiology.

The consensus of opinion of both teachers and students is that the acquisition of facts is not the most important part of the course. When students are asked what they remember about the course, the response that is given most frequently is "the experience."

One of the students who wrote a formal letter of appreciation said: "It offered a first-hand opportunity to see a scientific community actively at work."



As another one put it: "It seemed like being in another world."

Most of all, the students appreciate their opportunity to work closely with the Graduate Fellows. "They know so much," exclaimed one of them, an impression which is heightened by the knowledge that such a short span of years separates student from teacher.

"What I liked best," one of the students recalled, "was the change that came over one of the Graduate Fellows when he would start to talk about the thing he was working on and that was closest to his heart." Or, as another wrote in his evaluation of one of the teachers: "He was the best of all. I did not always understand what he was saying, but his enthusiasm just spilled over."

NATIONAL ACADEMY OF SCIENCES CENTENNIAL CELEBRATION

The Centennial Celebrations of the National Academy of Sciences during 1963 were of interest to all universities that are devoted to the furtherance of science, the teaching of science, and the relations of science to creative endeavor. The Academy has played a leading role in the dramatic development of science during this past century.

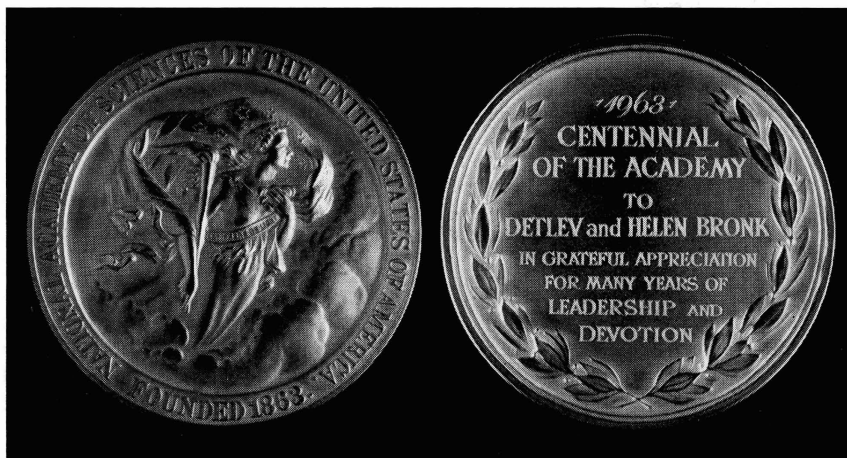
The Centennial Year was of especial significance for The Rockefeller Institute because of the Institute's primary concern with the education of scientific scholars and research and because so many of the past and present members of the Institute faculty have been active in the work of the Academy. Dr. Bronk, Past President of the Academy, was Chairman of the Centennial.

The most significant and colorful event of Centennial Week was the Centennial Convocation. Presidents of academies of science throughout the world, representatives of hundreds of learned societies, and members of the Academy, all in academic costume, together with thousands of guests, assembled in Constitution Hall to honor the Academy and to hear President Kennedy's moving address. Tracing the history of science during the lifetime of the Academy from the days of its founding when "the recognition of the value of abstract science ran against the grain of our traditional preoccupation with technology and engineering," President Kennedy went on to say "we can imagine no period in the long history of the world where it would be more exciting and rewarding than in the field today of scientific exploration . . . I think that never in the short history of this Academy or in the far longer history of science has the time been brighter, the need been greater for cooperation between those of us who work in Government and those of you who may work in far-distant laboratories on subjects almost wholly unrelated to the problems we now face in 1963."

Among the 23 eminent members of the Academy who reviewed the present status of science, envisioned its future, and developed the relevance in unity of all fields of science, were Rockefeller Institute Professors Dobzhansky, Palade, and Tatum. The notable series of addresses dealt with four themes: *History of the Universe*: Origin of the Elements; History of Stars and Galaxies; History of the Solar System; Origins of the Continents, Oceans, and Atmosphere; Origins of Life. *Nature of Matter*: Symmetry and Conservation Laws; Elementary Particles; Structure of Nuclei; The Architecture of Molecules; The Organization of Living Matter. *Determinants and Evolution of Life*: Genetic Determinants; The Differentiation of Cells; Influence of the Environment; Evolution of Living Systems; Physiological and Cultural Determinants of Behavior. *The Scientific Endeavor*: Communication and Comprehension of Scientific Knowledge; The Role of Science in Universities, Government, and Industry: Science and Public Policy; Synthesis and Applications of Scientific Knowledge for Human Use; Science in the Satisfaction of Human Relations.

During a series of brilliant social events, the members, delegates and guests were received one evening by the Chief Justice of the United States in the National Gallery of Art, and during an afternoon in the Pan American Union by the Secretary of State. There was a luncheon given by Dr. Bronk in honor of more than a score of corporations and foundations that have contributed over two and a half million dollars during the Centennial Year to his solicitation for the completion of the National Academy building.

The President of The Royal Society, oldest academy of science; the President of Harvard University, oldest university in the United States; the President of the American Philosophical Society, oldest learned society in this country; and the President of the International Council of Scientific Unions spoke at the Centennial Banquet. On that occasion there was presentation of a unique Centennial Medal struck in gold, to Dr. Bronk and Mrs. Bronk who aided him greatly while he served four years as Chairman of the Academy's National Research Council, five years as Foreign Secretary, and twelve years as President.



NEWS AND NOTES

PHYSICIANS' REUNION

On Saturday, February 1, there was an informal scientific and social reunion for 28 former and present members of the staff of The Rockefeller Institute Hospital who had begun their careers in research in various departments of the Hospital from 1946 to 1951. The purpose of the meeting was to review new trends in medical research and to renew old friendships.

The idea for the meeting arose during conversations between Dr. Edward H. Ahrens and Dr. Harold S. Ginsberg of the University of Pennsylvania. "I was bewailing the impossibility of 'keeping up' in science and in medicine," Dr. Ahrens explained. "The fact that old friends from the Hospital had found their way into many diverse disciplines suggested a possible solution: why not educate each other and have a good time doing it?" Dr. Ahrens wrote to 34 of his former colleagues asking if they would be interested in such a proposal. By January, when the final plans were laid, he had received affirmative responses from an astonishingly large proportion, 28 in all, including one from Denmark and another from Australia. The daylight hours were devoted to brisk, informal, but highly instructive reviews of their current activities in microbiology, immunology, physiology, and metabolic studies. Evenings were spent renewing friendships.

AWARDS

Dr. Edward J. McShane, Visiting Professor at The Rockefeller Institute, received the *Award for Distinguished Service to Mathematics* at the annual meeting this January of the Mathematical Association of America. This recognition is afforded each year for "outstanding service to mathematics, other than mathematical research."

Dr. McShane is on leave of absence from his post as Professor of Mathematics at the University of Virginia. He is well known for his work in the calculus of variations, in the theory of integration in general spaces, and the general theory of limits. In addition to his distinguished research and teaching career, Dr. McShane is a member of the National Science Board of the National Science Foundation and Chairman of the Division of

Mathematics of the National Research Council.

On March 12 Dr. Edward Reich of the Laboratory of Biochemical Genetics received the 1964 Selman A. Waksman Honorary Lectureship Award. This Award, given annually for outstanding contributions to microbiology, was presented at the 13th Annual Banquet of The Theobald Smith Society, the New Jersey Branch of the American Society for Microbiology. Dr. Reich received his Ph.D. from The Rockefeller Institute in June 1962, and is now an Assistant Professor in the Laboratory of Biochemical Genetics.

SOPHIE FRICKE HALL

Sophie Fricke Hall for student residence was dedicated on February 6th following the winter meeting of the Board of Trustees. This is the first building to be erected on the South Campus, an area of four acres now available for an uncrowded expansion of the Institute. The new building is southwest of the first students' residence hall; the two are similar in architectural design.

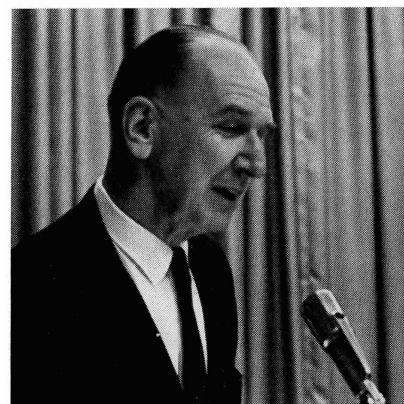
The Hall is named for Miss Sophie Fricke who, on her death in 1958, bequeathed approximately one million dollars to the Institute. Miss Fricke was born in Jersey City of German immigrant parents. Her life was spent in New York as secretary to a number of prominent financiers and businessmen. The wise investment of her systematic savings throughout a long career enabled her to amass the fortune which she gave to the Institute. As Mr. David Rockefeller, Chairman of the Board of Trustees, said in his address at the dedication ceremonies: "Miss Fricke symbolizes much that is unique and great about America: hard work, devoted service, thrift, generous support of institutions which further human welfare."

The building was designed by the architectural firm of Harrison & Abramovitz and was erected by the George A. Fuller Company. On the upper four floors are rooms for as many as 74 students. In addition to single rooms and suites for married couples, there are a few larger apartments for visiting faculty. On the first floor there are classrooms for an elementary school which will be conducted for children of faculty when the

contemplated faculty residence hall is constructed.

Completion of Sophie Fricke Hall marks another important step in the growth of The Rockefeller Institute as a university community which, while sharing the vast cultural resources of New York, retains its individual identity and character. President Bronk emphasized this ideal in his remarks at the dedication: "Sophie Fricke Hall, the earlier students' residence hall, Caspary Auditorium, and Abby Aldrich Rockefeller Hall enable students and faculty and visiting scholars to live together and thus benefit from stimulating discussions and the exchange of ideas in a tranquil environment of natural beauty."

GUEST OF HONOR



Dr. Richard Edwin Shope was the guest of honor at the fourth biennial symposium of the Gustav Stern Foundation, "Perspectives in Virology." The meetings, attended by some 250 virologists, were held in February in New York City.

At the dinner, Dr. Thomas Francis, Jr., of the University of Michigan, described Dr. Shope's many contributions to science: the discovery of the Shope papilloma virus in 1933, the development of a vaccine for rinderpest, his important work on swine influenza and swine pox.

Previous symposia have similarly honored Dr. Thomas Milton Rivers and Dr. Peyton Rous.

Dr. Shope was also recipient of two important awards last spring. On May 31, 1963, he was given the Howard Taylor Ricketts Award by the University of Chicago, a national award for distinguished achievement in medical science. On June 7, Dr. Shope received an Honorary Doctor of Science degree at the State University of Iowa.

COVER PHOTOGRAPH shows the Graduate Students Residence Hall on a wintry day, photograph by Richard Carter. ILLUSTRATIONS: PAGE 2 Culver Pictures. PAGE 5 Standard Oil Co. (N. J.). PAGE 7 Mt. Wilson-Palomar Observatories. PAGE 8, 9 reprinted with permission; copyright © 1963 by Scientific American, Inc.; all rights reserved. PAGE 10 *Descartes* from a painting in the Louvre, Paris; *Amsterdam Physician* from a print in the Philadelphia Museum of Art. PAGE 12 Academy of Natural Sciences of Philadelphia. PAGE 14 National Academy of Sciences. PAGE 16 The Smithsonian Institution. PAGE 18 Museum of Comparative Zoology, Harvard College. PAGE 20, 22, photos by Sam Vandivert.