12-1966

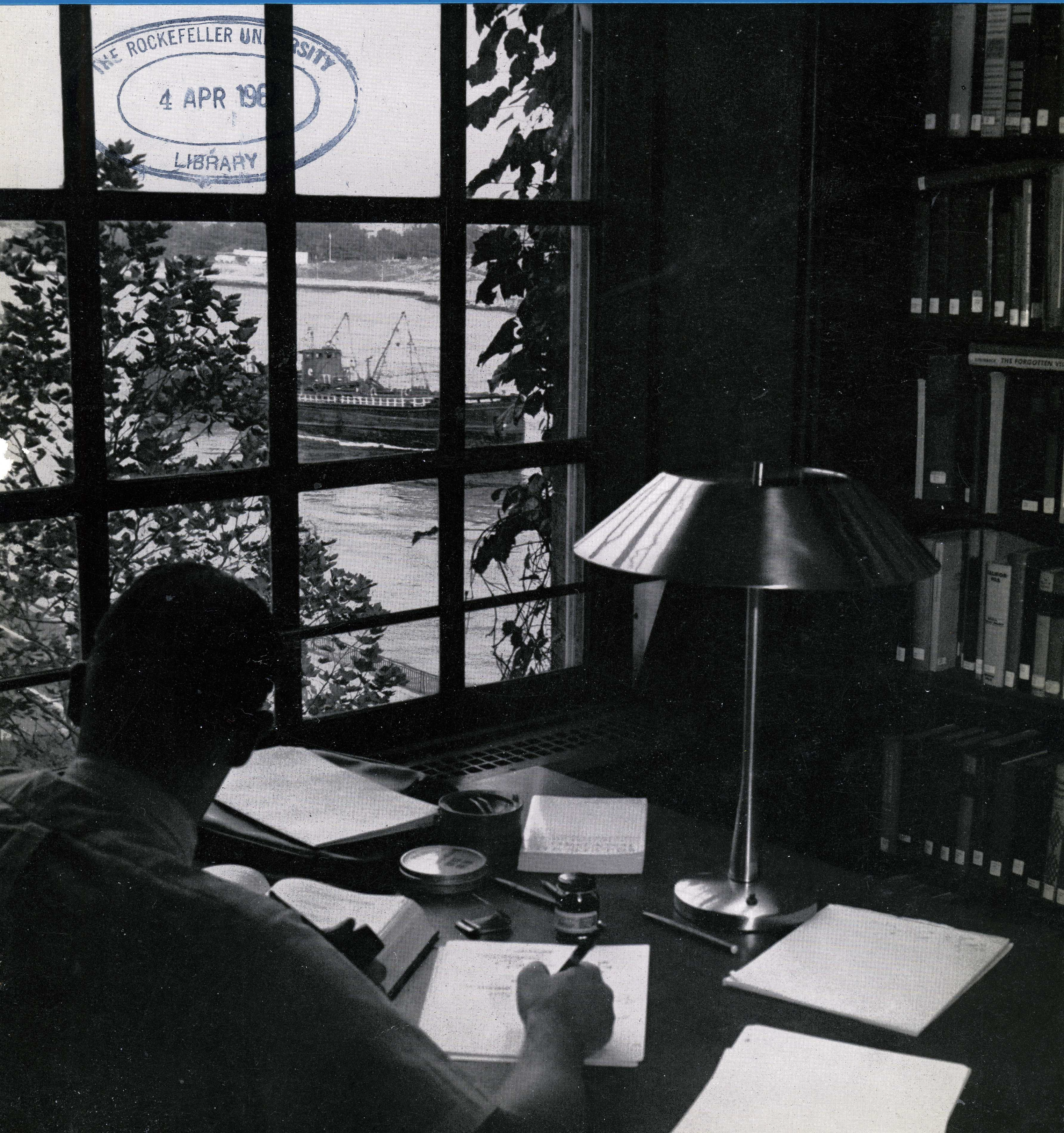
The Rockefeller University Review 1966, vol. 4, no. 5

The Rockefeller University

THE ROCKEFELLER UNIVERSITY

NOVEMBER · DECEMBER 1966

REVIEW



The Rockefeller University Review, Nov.-Dec., 1966. The Review is issued bimonthly. This is volume 4 number 5 [July-Aug. not issued]. Published by The Rockefeller University, Sixty-sixth Street and York Avenue, New York, N. Y. 10021. Second-class postage paid at New York, New York. The price for a subscription for one year is three dollars, single copies sixty cents.

PEYTON ROUS NOBEL LAUREATE 1966

BY FRANK L. HORSFALL, JR.

This is a brief account of the scientific work of Peyton Rous that so richly deserved the Nobel Prize. It was written by Frank Horsfall because he seemed to me to be that one among the host of friends of Rous who is uniquely fitted for the privilege.

It is a traditional policy of The Rockefeller University to accord life-long facilities for study and research to the faculty emeriti. The wisdom of that policy has been dramatically attested by the continued vigor and notable achievements of Dr. Rous during the more than 30 years of his "retirement" that have led during this past year to the award to him of the National Medal of Science, the Paul Ehrlich and Ludwig Darmstaedter Prize, and now the Nobel Prize. Personally, I acknowledge with gratitude the youthful enthusiasm with which he has welcomed and supported the recent rapid evolution of this institution that he has ennobled.

DETLEV W. BRONK

On December 10, 1966, in Stockholm, Sweden, the king, Gustaf VI Adolf, presented the Nobel Prize for Medicine 1966 to Peyton Rous and Charles B. Huggins. Thus, for the first time in several decades two pre-eminent scientists were honored for their contributions to knowledge of cancer by one of the most distinguished awards in existence.

Peyton Rous joined the staff of The Rockefeller Institute in 1909 and has continued as an active investigator there and at The Rockefeller University throughout the intervening 58 years. Although he formally became Member Emeritus in 1945, his researches continue unabated and without diminution. His many scientific publications, some 300 in all, span a period of six decades.

Charles B. Huggins joined the faculty of The University of Chicago in 1927 and has pursued his numerous investigations there during 40 years. In 1951, he became Director of The Ben May Laboratory for Cancer Research of The University of Chicago, a post he still holds.

The Nobel Prize citation for Dr. Rous stated: "for his discovery of tumor-inducing viruses"; that for Dr. Huggins: "for his discoveries concerning hormonal treatment of prostatic cancer."

No Stranger to Honors

Peyton Rous is no stranger to honors and awards. Some nine honorary degrees have been conferred upon him, and he has received some 17 medals and awards. During the past five years, he has received the Gold Medal of the Royal Society of Medicine (London), the United Nations Prize for cancer research, the Paul Ehrlich and Ludwig Darmstaedter Prize (West Germany), and the National Medal of Science, in addition to the Nobel Prize. He is an honorary or foreign member of eminent scientific societies in England, Israel, Ireland, France, Denmark, and Norway. He was elected a member of the

National Academy of Sciences of the United States in 1927.

Dr. Rous received his M.D. degree from The Johns Hopkins University in 1905 and, after a year as resident house officer at The Johns Hopkins Hospital, was for two years instructor in pathology at The University of Michigan. He was appointed Assistant at The Rockefeller Institute in 1909 and by 1920 had advanced to the rank of Member. Rous has said that when he left Johns Hopkins, William H. Welch told him not to stake his career upon so precarious a task as cancer research. As the long record of his publications shows, he became fully committed to studies on problems other than those of malignant disease for some 25 years both before and between the periods when his major contributions about cancer were made.

Writes Classical Papers

Only two years after he had accepted Simon Flexner's offer to join the staff of the Institute, Rous published a now classical paper entitled "Transmission of a Malignant New Growth by Means of a Cell-free Filtrate." He was then but 32 years of age and had demonstrated for the first time that a malignant tumor could be induced by an infectious agent small enough to pass a filter that held back bacteria. His early training and high competence in pathology were crucial to this achievement as they have continued to be ever since. Then, as now, the only decisive evidence for the presence of cancer is that provided by expert examination of affected tissue under the microscope.

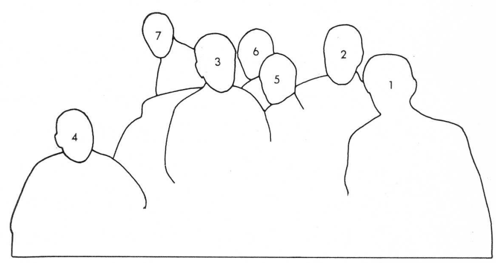
In 1911, only a few viruses had been recognized; the first only 13 years earlier, and so little was known about them that they were considered as mysterious and invisible enigmas. No virus had previously been associated with a malignant tumor. Cancer was, by generally accepted definition, a disease of unknown cause, and it was staunchly believed that it was not related to an infective process. Four years were yet to pass before decisive evidence was obtained by Yamagiwa and Ichikawa that chemical compounds could initiate cancers in experimental animals, and seven years were still to elapse before Lazarus-Barlow provided similar evidence for the oncogenic effects of ionizing radiation.

The state of knowledge concerning neoplastic diseases at that time was wholly uncongenial for this pioneering discovery, particularly since it involved both a chicken tumor which some questioned as being a true cancer and a filterable infective agent of then uncertain nature. The provocative, and now widely held, concept that a virus can cause cancer awakened surprisingly little interest except among those who were inclined to dispute its validity. As a result, for more than 20 years this extraordinary discovery was not regarded as having broad significance.

But much that is now of major interest and importance in this field was clearly presaged in the several remarkable contributions that Rous and his associates, including James B. Murphy, published from 1911 to 1915. Transmission of the malignant chicken tumor to developing chick embryos, both by transplantation and with cell-free filtrates, was demonstrated and thus for the first time it was shown that a virus could be propagated in this immature host. Many years were to pass before the chicken embryo became widely employed for the propagation of other animal viruses. In 1914, three years after the initial report on the chicken tumor as such, an important communication entitled "On the Causation by Filterable Agents of Three Distinct Chicken Tumors," which served to confirm and enlarge the earlier work, was published in *The Journal of Experimental Medicine.*

Develops Blood Preservation

It is not surprising that Rous should have turned away from research on cancer in 1916 and begun work on the preservation of whole blood, a problem which World War I had forced into prominence. He and an associate, J. R. Turner, rapidly developed a practical method of preserving whole blood for transfusions and this was used on the Western Front as early as 1917. The world's first blood bank, built by O. H. Robertson who worked with Rous, was set up in Belgium behind the front lines of the British Expeditionary Forces. For these feats he later received the Distinguished Service Order of Great Britain. With but slight modifications, the original blood preservation procedure was used for huge quantities of blood that were stored for transfusion during World War II, notably when English cities were bombed. It is still in general use in England and in many other countries but is gradually being sup-



Ceremony of the presentation of the Nobel Prizes on the afternoon of December 10, 1966 in the Grand Auditorium of the Concert Hall of Stockholm. Professor George Klein [1] of the Royal Caroline Institute is addressing a group on the orchestra platform about the work of Dr. Huggins [2] and Dr. Rous [3] before they descend separately to the floor of the Hall and receive from the hands of the king, Gustaf VI Adolf, the Prize, the Nobel Medal, and Diploma. Professor Robert S. Mulliken [4] of Chicago has just returned with his Prize for chemistry. Many of the group in the background are previous Prize winners, including Professors Hugo Theorell [5], Arne Tiselius [6], and Alan L. Hodgkin [7] son-in-law of Dr. Rous.

planted in the U.S.A. by freezing the blood with liquid nitrogen.

Because of his interest in the properties of individual cells, Rous sought, with F. S. Jones, a procedure for separating the living cells of tissues. This led to the first demonstration that it could be done by subjecting the tissue to the digestive action of the enzyme, trypsin, a technique which many years later was to become widely used in cell culture investigations. By means of it Rous, McMaster, and Hudack showed that living cells infected with viruses protect these from the antibodies they induce, which reach them only after the cells have died.

By about 1920, Rous had become interested in the

liver and gall bladder. He and his co-workers, particularly P. D. McMaster, made numerous contributions to knowledge of the physiology and metabolism of both organs, including the first demonstration of the concentrating activity of the gall bladder. Later they conducted a series of investigations on the acidity-alkalinity balance of living tissues, on vascular permeability, and gallstone formation.

Returns to Cancer Research

Not until 1932 did he return to cancer research and publish his first paper in 17 years on that subject. This communication was concerned with chemical carcinogenesis, not with viruses and cancer. Two years later saw the beginning of a remarkable series of publications on the virus-induced rabbit papilloma which has continued without long interruption to the present time.

As it happened, Richard E. Shope had recently discovered two viruses which induced benign tumors in rabbits. One of these, the Shope papilloma virus, he gave to Rous, his older colleague and close friend, to do with as he would. It was only one year later that Rous, with J. W. Beard, reported that cancerous changes sometimes developed in the papillomas induced by this virus. After further experiments, they concluded that this mammalian tumor was an "autonomous new growth, purposeless, parasitic, and, on occasion, progressive" and that "the virus that gives rise to the rabbit papilloma must be looked upon as the primary cause of the cancers developing therefrom."

Encounters Extraordinary Difficulties

Extraordinary difficulties were encountered in these early experiments and in many of those which were carried on later. The virus persisted for some while in the cancers maintained by transplantation, as shown by the appearance of a specific antibody against it in the cancer-carrying host; yet it could never be recovered from the malignant tissue and later on every sign of its presence disappeared and nobody could even guess what drove the cancer on. This state of affairs plagues workers with the generality of other cancers for which no actuating cause has been found to the present time.

Not very long after these findings with the cancers derived from Shope papillomas it was widely accepted that a virus could, in fact, induce cancers in a mammalian host. The state of knowledge relative to neoplastic disease had changed markedly since the early days in 1911, and the intellectual climate was such in the mid-1930's as to be not uncongenial for these remarkable advances. Although there were some vigorous disputes, the brilliantly conceived and decisive experiments of Rous and several of his associates, including John G. Kidd and William F. Friedewald, carried the day and finally succeeded in establishing viruses as one of the initiating and activating causes of cancers in animals.

Stimulates Other Workers

Numerous other workers were greatly encouraged and stimulated by these solid findings. During the next 20 years, almost all of the long list of viruses that are now known to be oncogenic in animals were discovered and identified. Furthermore, it was demonstrated that a wide variety of animal species, including avian, amphibian, and several mammalian members, were susceptible to or developed under natural conditions virus-induced cancers.

During his many years of intensive inquiry and experimentation, Rous had numerous associates and co-workers among whom a considerable number went on to develop distinguished careers of their own. More than 30 individual investigators served as co-authors with him on the many publications that have emerged from his laboratory. Some nine associates are identified with the numerous papers published since he assumed emeritus status.

In addition to his very active and continuing work in the laboratory, he has served as an editor of *The Journal of Experimental Medicine* for 46 years. Soon after he was appointed co-editor in 1921, in association with the Director of the Institute, the whole of the task was left to him and he was the effective editor throughout many years. It was he who set the high standards of verbal precision and clear exposition which have been maintained by the *Journal.*

DR. HORSFALL — *who from 1941 was Member, and from 1955-60 Professor and Vice President for Clinical Studies in The Rockefeller University and Physician-in-Chief to the Hospital — has been President and Director of the Sloan-Kettering Institute for Cancer Research since 1960. Dr. Rous has been a member of its Board of Scientific Consultants since 1957 and for several years was Chairman.*

SEEKING SOLUTIONS TO THE PROBLEMS OF POPULATION GROWTH

BY FRANK W. NOTESTEIN

"No organization was ever created from which so much was expected," wrote The New York Times *fifteen years ago in an editorial welcoming the founding of The Population Council. Then there was little awareness of population problems on the part of the public or its leaders, in the United States or abroad. That the situation is improved and this world problem is now yielding to the deliberate application of man's rationality, is due in good share to the innovative and accelerative efforts of the Council, of which the eminent demographer, Dr. Frank W. Notestein, is President.*

SINCE its earliest days, The Population Council has been closely related to The Rockefeller University both through the personal interest of Dr. Bronk and the fact that the University plays host to the Council's Bio-Medical Division. Dr. Bronk, when he was still President of Johns Hopkins, served as one of the advisors to Mr. John D. Rockefeller 3rd in getting the Council organized and launched, and he has from the first been a member of the Council's Board of Trustees as well as of its Executive Committee. The continuing connection between the two institutions may indicate mutual interest in the nature of the problems to which the Council directs its attention.

Readers of the *Review* do not require a discussion in depth of the world's critical problems of population growth. For the planet as a whole, and particularly for the newly developing nations, the critical issues are not those of population size or density or even of the ultimate availability of resources. The problems result from unprecedented rates of population growth, as well as from practical difficulties in the way of slowing those rates of growth.

If we could move smoothly from the pages of the scientific and engineering textbooks into the arenas of action — without intervening social, economic, and political frictions — we would probably be faced with no great problems of poverty for a good many decades ahead. But if there were no friction, we would also have perpetual motion. The problems are not — as they are so often posed — those of some ultimate constraints in an ideal world. They are rather those of moving in a real world from the present position containing a great deal of poverty, illiteracy, and poor health to one that makes possible the sophisticated application of even the existing knowledge.

In broad outlines, present growth rates are easily described, even if the problems they engender are not easily solved. A few decades ago, most of the world had very high birth rates and very high death rates. In a few decades, spectacular reductions of death rates were made possible by control of disease. The process moved with extraordinary speed, because mankind has always preferred health to sickness and life to death. Essentially, there were no problems of ends, only those of the means for their attainment. The worldwide use of antibiotics and insecticides has gained a large measure of control over the vectors of infection and has brought death rates down to levels never thought possible a few years ago. In nation after nation of the underdeveloped world, a newborn baby girl has come to have a better chance of sur-

viving to age 60 than her counterpart early in the century had of reaching age five. In recent decades, death rates in the underdeveloped world have been dropping from three to five times as fast as they fell in Europe in the 19th century. In short, so far as reduction of death rates is concerned, scientific knowledge has moved into social action with remarkable speed.

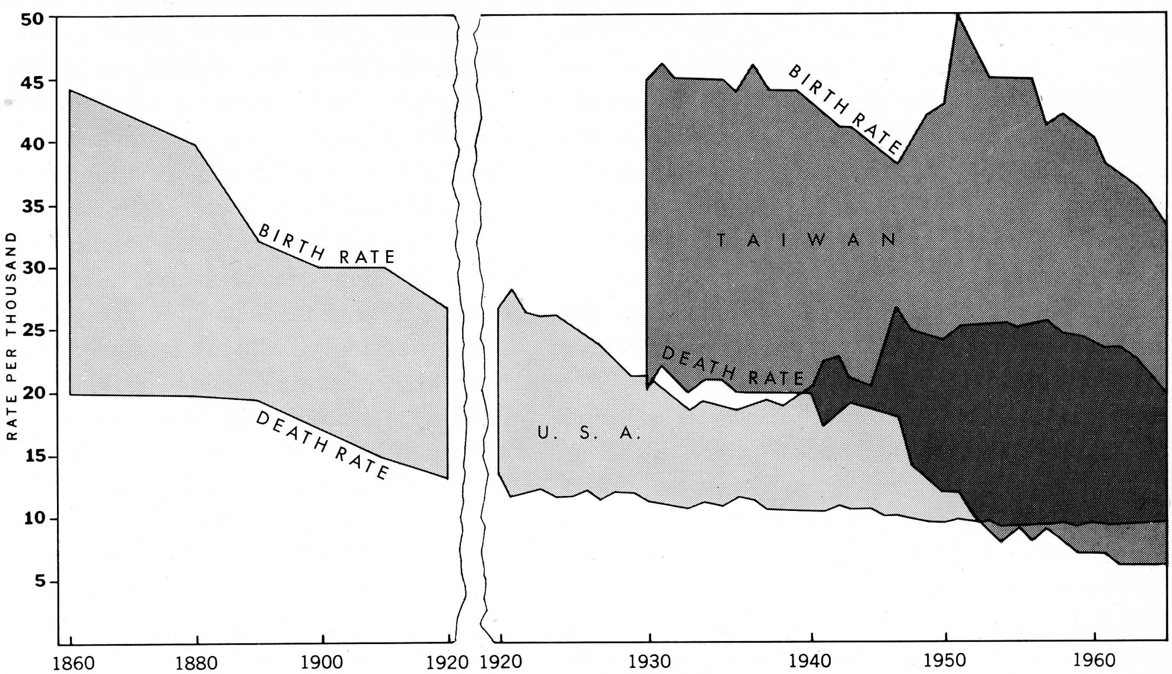
The situation with respect to birth rates is quite different. Here, there are problems of both ends and means. Societies that throughout the ages of high death rates required high fertility in order to insure survival have developed social institutions, educational systems, religious teaching, and moral outlook that support early marriage and abundant reproduction.

In the Western world, birth rates also ultimately fell—under the impact of universal education and urban industrial development. New opportunities focused parental attention on the welfare of the individual child and the prospects available to him, and the population gradually took to birth control—first by folk methods, later by modern contraceptive techniques, plus delayed marriage and abortion.

Meanwhile, birth rates have remained high in most of the underdeveloped world where modernization is only recently beginning to erode the social structures that have traditionally supported high birth rates. Indeed, birth rates in Asia, Africa, and Latin America are generally much higher than they were in 19th-century Europe, thanks principally to early and almost universal marriage. Whereas Western Europe had birth rates of about 35 per 1,000 population in the mid-19th century, few birth rates in the underdeveloped countries today are below 40, and many of them go as high as from 50 to 55.

Such very high birth rates generate very young populations, and since young people are relatively healthy they in turn help generate low death rates under circumstances of even rudimentary health protection. The combination of youth produced by very high birth rates and the control of epidemic disease has brought death rates to extraordinarily low levels. Today, in fact, the lowest death rates in the world are not in the most highly developed countries. Taiwan, for example, has a much lower crude death rate than the United States, and Ceylon has a lower death rate than France or England.

Today the lowest death rates in the world are not in the most highly developed countries. Taiwan, for example, has a lower crude death rate than the United States.



In Europe's 19th-century period of development, populations seldom increased by as much as one per cent per year. Today, very few of the underdeveloped countries have populations that are increasing by less than two per cent per year, and many of the populations are growing at rates of 3 and 3.5 per cent and even higher.

Perhaps I have said enough to suggest that the crucial problem is not size, but rate of growth. It is further complicated by heavy proportions of the total population in the ages of youth dependency. Any population with a birth rate of 40 per 1,000 has more than 40 per cent of its total under 15 years of age.

The process of technological modernization is made enormously more difficult by high rates of population growth. There is no hope of eliminating gross poverty by depending on the traditional economies based on subsistence agriculture. The world's population is already too large for that. If gross tragedy is to be avoided for today's population, not to mention the doubled populations that a few more decades of growth will bring, the only hope lies in the sophisticated use of resources and inanimate energy. But such modernization requires investment in health, education, factories, and equipment. A population growing at three per cent per year has to invest something like nine per cent of its national income just to stay even. Gains in modernization come from investments above that level. Nine per cent is not a high figure for a rich country, but it is incredibly high for populations already living at the margins of subsistence. In short, the processes of modernization are being slowed, and indeed seriously threatened, by a speed of population growth unprecedented in the world's past experience. Hopes for modernization will be much enhanced if it becomes possible to reduce birth rates rather rapidly behind reductions in death rates, to bring growth to reasonable levels.

Unquestionably, it was this situation that gave a sense of urgency to the founders of the Council. Indeed, the initiative for the Council's formation came from a deep conviction on the part of Mr. John D. Rockefeller 3rd that the broad task was to improve the quality of life for the living, and his belief that too little attention was being paid to problems of population in all of their manifestations.

In June 1952 at Mr. Rockefeller's suggestion, the National Academy of Sciences sponsored a conference on population problems at Williamsburg, Virginia. The three-day meeting was chaired by the Academy's President, Dr. Bronk, and it was attended by representatives from demography, medicine, public health, biology, physics, chemistry, mathematics, economics, agriculture, conservation, nutrition, psychology, and public affairs. The discussions resulted in a recommendation that Dr. Bronk appoint a temporary committee which would undertake to establish "an unofficial international council, on a permanent basis."

Founding

As a result of this Committee's work, The Population Council was founded in November 1952, with a gift from Mr. Rockefeller, who became its first President. Mr. Frederick Osborn shortly joined as Executive Vice President, then as President when Mr. Rockefeller became Chairman of the Board of Trustees. Mr. Osborn – in the midst of a busy career as corporation executive, Trustee of the then Rockefeller Institute, and Major General in charge of the U.S. Army's information and educational activities – had found time, beginning in the early 1930s, to devote a great deal of attention to demographic problems, producing among other things two highly professional books on the subject.

Since 1952 the Council has moved from a staff of three people and a budget of a quarter of a million dollars to a staff of nearly 150 persons posted in eleven countries with a budget last year in excess of eight million dollars. It is supported by gifts from Mr. Rockefeller, other members of his family, the Scaife family, The Ford Foundation, the Rockefeller Foundation, the Rockefeller Brothers Fund, the Commonwealth Fund, and a number of other foundations and individuals.

The Council resolved at the outset to approach population problems in an objectively professional manner, or in the words of the Williamsburg Conference, "at a high level of professional competence." At an early meeting, the Board of Trustees laid down the following broad objectives:

To study the problems presented by the increasing population of the world and the relation of that population to material and cultural resources.

To encourage and support research and to disseminate as appropriate the knowledge resulting from such research.

To serve generally as a center for the collection and exchange of facts and information on the significant ideas and developments relating to population questions.

To cooperate with individuals and institutions in the development of programs.

To take initiative in the broad fields which in the aggregate constitute the population problem.

The fact that the Council is a private institution dealing with sensitive subjects in a sensitive world has dictated the nature of its program. It has systematically sought to avoid the role of advocate, believing in the words of the Williamsburg Conference that its most important task would be to "assess the facts as to the populations of the world. . . ." Its major premise has been that each society should seek answers to its own questions in the light of knowledge contributed by modern science. It has sought from the first, through the awarding of fellowships and research grants, to involve students, leading scholars, governmental officials, and international agencies in active roles on the various technical aspects of population work. It has sought to be guided by local sensitivities rather than its own, and to seek the resolution of problems by the advancement of knowledge and the involvement of the professions rather than by hortatory activities.

Demography

The Council's first act when it began operations in 1953 was to launch a program of fellowships at the advanced graduate and post-doctoral levels. Since then a total of 472 Council fellows have studied for at least one year at universities in America and Europe. Fellowships have been awarded to scholars from 57 countries, with most of the fellows coming from nations of the developing world. As they complete their studies and return home, Council fellows carry back with them an awareness of demographic problems which in some instances was not present before. Many former fellows have found opportunities for action as they attained important and influential positions at home. Three Council fellows, incidentally — scholars from Chile, Italy, and Japan — are, at present, conducting research on the campus of The Rockefeller University.

Grants by the Council, as well, have been made with a particular eye to the situation in the developing world. One of the Council's purposes is to help establish and support research facilities and allied institutions inside those nations where the population problem is especially acute. The Council supplied the financial support for the establishment of the three United Nations Demographic Centres — in Bombay, Cairo, and Santiago. The Council supplied the basic financing for population studies units at Seoul National University in Korea, the Population Studies Centre in the Republic of China, Chulalongkorn University in Thailand, the Universidad de los Andes in Colombia, Pakistan Institute of Development Economics, and at the University of Ghana. More than a hundred other universities and institutions in the developing world have been awarded Council grants in support of programs and research in demography, family planning, biology, and medicine.

Biomedical

This is not to say that the Council has neglected the support of research at home. Council funds have been directed both toward specific research projects in American universities, hospitals, and laboratories and toward helping to build institutions that can make effective approaches to population questions whether on the demographic or bio-medical fronts. Council grants have been awarded to most of the important American demographic studies centers, for example, including those at Cornell, Johns Hopkins, and Princeton as well as the universities of California, Chicago, Michigan, and Pittsburgh. The Council's fellowship program has also assisted in the advancement of American demographic studies.

If historically the Council's first emphasis was on demography, the need was clear that the new organization should undertake activities as quickly as possible in the bio-medical field. In 1952 comparatively little was known about the physiology of reproduction; the neglect of this field was to some extent a result of our sexual taboos. It was plain that if more efficient means of controlling fertility were to be developed, a considerable stimulus would have to be given to both basic and applied research. Convinced that The Rockefeller Institute offered the kind of atmosphere in which such research might most suc-

"Family planning is not evil": poster from Pakistan where the Council provides resident advisors to the National Research Institute for Family Planning.

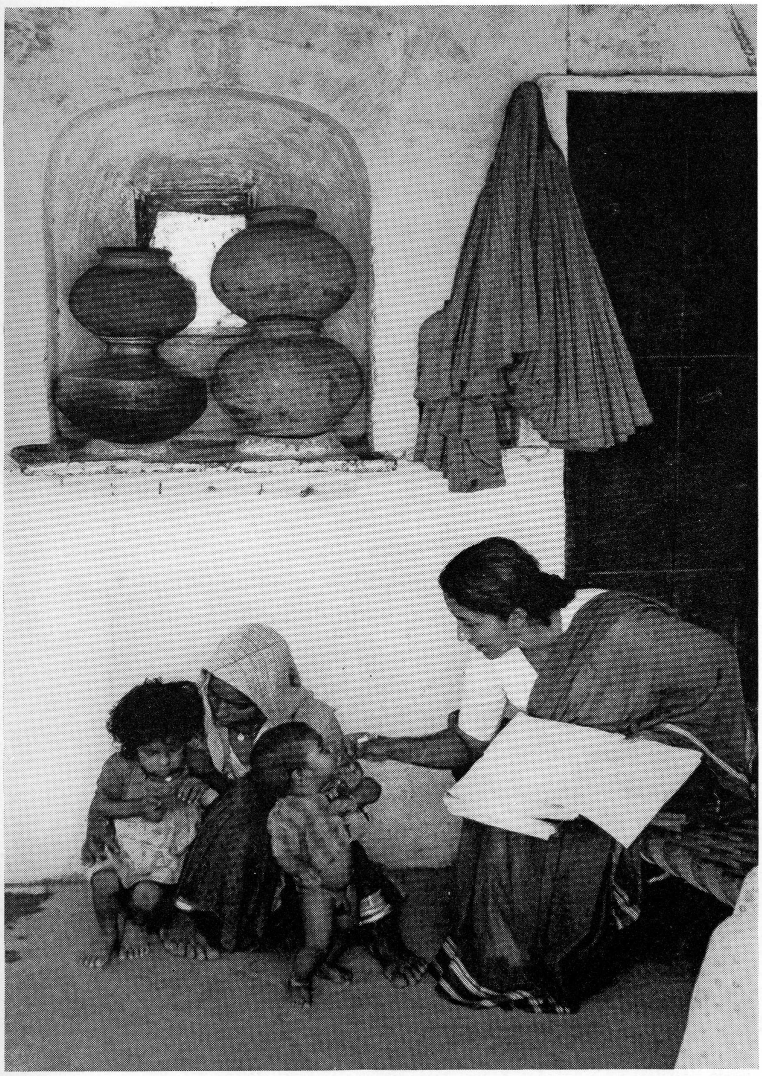
cessfully be carried out, Mr. Osborn went to Dr. Bronk and asked him for space in which to organize the Council's Bio-Medical Division. Since Dr. Bronk's response was favorable, the Council opened a Bio-Medical office at the Institute in 1955 and inaugurated laboratory activities there in 1957. In addition to its own laboratories, the Council has supported extensive research in the physiology of reproduction and in contraceptive technology in laboratories in the United States, in Europe, and in the developing nations. These activities will be described in a separate article by Dr. Sheldon J. Segal, Director of our Bio-Medical Division.

When the Council first began, it directed very little of its attention to birth control. Indeed, the recommendations of the Williamsburg Conference did not even mention the subject. The changing world situation brought the need for institutional support of family planning to the Council's attention. The planning boards and commissions of the developing nations noted with dismay that their best efforts at economic advance were largely consumed by mounting rates of population growth. India was the first country explicitly to recognize the need for reducing its rate of population growth. In 1954, the Minister of Health of the Government of India asked the Council to send advisors to help lay out plans for both population studies and family planning programs. Asked by the Council to undertake this assignment were Dr. Leona Baumgartner, then Commissioner of Health of New York City, and myself, then Director of the Office of Population Research at Princeton University. Our report formed the basis of India's first systematic family planning program. In 1959, after I had succeeded Mr. Osborn as President of the Council, the Government of Pakistan asked for a similar mission. Since then, the Council has responded to additional requests for advisory missions on family planning from the Governments of Iran, Kenya, South Korea, Thailand, Tunisia, and Turkey, and analogous activities have been carried out by staff members in Egypt, Taiwan, and a number of other countries.

In short, a growing awareness of demographic difficulties has gone far toward desensitizing the developing countries to problems of birth control. Indeed, more than half of the population of the underdeveloped world is now living under governments that have adopted explicit governmental policies designed to spread the practice of family planning. The Council has been useful in helping to plan and execute many such programs precisely because we were able to establish the role of the organization as professional and technical—and were viewed abroad as experts rather than advocates.

Signs of Progress

The consequence is that an organization that began in demography at one extreme and biology at the



Indian researcher interviews villagers near New Delhi. The Council's report in 1955 was the basis of India's first systematic planning program.

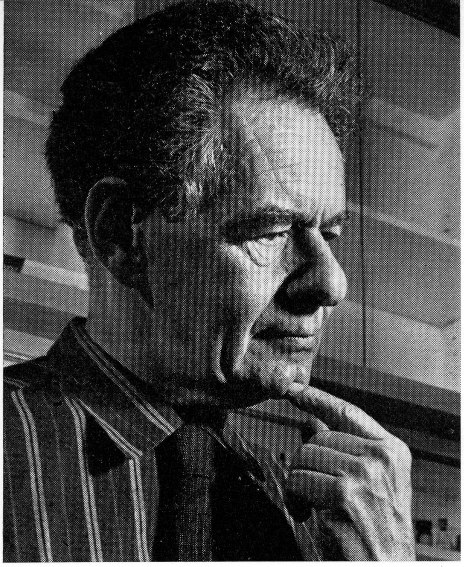
other was forced to develop a new Technical Assistance Division which alone, or jointly with The Ford Foundation, maintains resident family planning advisors to the governments of seven countries. The task is a long way from done. But already hopeful signs of progress are evident in several nations, notably Taiwan and Korea.

The number and variety of applications for grants that the Council receives each year constitute one measure of the immense changes that 15 years have made in the atmosphere surrounding population questions. In 1952, some of these questions could scarcely be discussed in polite society. In those days, applications for grants in support of valid and interesting research projects almost had to be "dug up" by Council officers. In 1966, with a considerably larger budget than it had in its early years, the Council found itself rejecting one perfectly valid application for every grant it awarded.

World Clearinghouse

The demographic crisis itself has been the major circumstance generating the immense interest in population questions that has developed in the past few years. Other circumstances and institutions have played a part, however, not only in generating interest but also in channeling interest in the directions it has taken. And here The Population Council has played a well-defined role growing out of its unique situation as a research and technical assistance organization concerned with *all* aspects of the population problem. This situation has fashioned the Council into a world clearinghouse of knowledge on all questions involving population. The Council, in turn, has furthered this aspect of its work through its translation and publication programs. The Council sends population libraries to interested institutions in Africa, Asia, and Latin America. Council officers participate in international conferences, some of which are sponsored in whole or in part by Council funds.

The largest and most important international conference ever held on the subject of family planning took place in Geneva, Switzerland, in August 1965. Sponsored jointly by The Population Council and The Ford Foundation, the Geneva Conference attracted 176 participants from 37 nations on six continents. As one who attended it, I could not resist letting the gathering remind me how far we had come since the Williamsburg Conference. Some views presented quite seriously at the conference would have seemed impossibly utopian when The Population Council was first organized. Others, notably the contraceptive effectiveness of the intrauterine device, would only recently have elicited scorn, even in a gathering of experts. On the whole, the effect of the conference was to reinforce a sense of optimism that the demographic crisis is, after all, susceptible to the kind of professional approach that The Population Council has formulated in several places in the world, among them the campus of The Rockefeller University.



NATIONAL MEDAL OF SCIENCE TO LIPMANN

PRESIDENT JOHNSON has announced the award of the National Medal of Science — "the highest tribute our government can pay" — to Professor Fritz Lipmann. The presentation will be made in ceremonies at the White House on February 6. Rockefeller University recipients of the Medal in previous years were Professors Dobzhansky, Neal Miller, Rous, and Van Slyke.

The theme of Dr. Fritz Lipmann's lifework is cellular energy — its generation, transmission, and utilization.

A quarter of a century ago, he put forward the illuminating notion of a metabolic dynamo which provides energy to the living cell in usable form. Adenosine triphosphate (ATP) was proposed as the general link between energy generation and energy utilization. In this way, general rules for the biotechnology of cellular energy transmission were formulated. Implicit in this is the concept of the "energy-rich bond," as it presents itself in the ATP molecule and in acetyl phosphate, which Lipmann discovered in 1940. All this conceptual framework is now permanently woven into the fabric of modern biochemistry and forms part of the basic knowledge learned by every student coming into the field. Moreover, since their proposal in 1941, these ideas have underlain all of the magnificent development of metabolic biochemistry which we know today.

In the late 1940's and early 1950's, Lipmann discovered Coenzyme A and revealed its chemical structure. This work gained him the 1953 Nobel Prize which he shared with H. A. Krebs, the discoverer of the Krebs Cycle. Coenzyme A is the long-sought bridge which joins the glycolytic sequence of reactions to the Krebs Cycle. It soon became clear that this singular coenzyme is a carrier of "energized" (i.e., activated) chemical groupings, transmitting this chemical energy to areas of utilization. Dr. Lipmann foresaw, and the work of many others has confirmed, that Coenzyme A plays a vital part in the synthesis of fatty acids, terpenes, steroids, and a multitude of other cell components. It is no exaggeration to say that the discovery of Coenzyme A (and the subsequent development that it triggered) has lit up the field of metabolic chemistry with a dazzling clarity and precision which it could not otherwise possess.

Pursuing his interest in cellular energy, Lipmann in the later 1950's detailed the means by which cells activate the inorganic sulfate molecule for incorporation in polysaccharides and other sulfate derivatives. During this same period, he discovered carbamyl phosphate. This small, energy-rich molecule participates in the fixation of the cellular excretory products, carbon dioxide and ammonia, into the urea molecule, in which form final elimination from the body occurs. Carbamyl phosphate, in other hands, has since come to play a signal role in opening up the vast, burgeoning field of metabolic regulation. It is the substrate for the enzyme, aspartate transcarbamylase, which was among the first enzymes known to be susceptible to feedback inhibition and has been the most extensively studied.

In 1941, Lipmann foretold that protein synthesis would be driven by metabolic energy derived from ATP. This proved to be true. His many friends and former colleagues have just celebrated the 25th anniversary of that landmark in biochemistry by dedicating to Dr. Lipmann the volume, *Current Aspects of Biochemical Energetics.*

LEONARD B. SPECTOR

LUDWIG EDELSTEIN

Ludwig Edelstein was a much-beloved Professor in The Rockefeller University and a friend and advisor of faculty and students. He died on 16 August 1965. In the November-December 1965 issue of The Rockefeller University Review *there was a brief account by George Boas of Edelstein's role as a philosopher. Here is a more intimate account of Professor Edelstein and his personal contributions to The Rockefeller University and the Johns Hopkins whence he came to the Rockefeller. It was written by President Bronk who was his close friend and colleague for fifteen years. It is reprinted from the* Journal of the History of Medicine and Allied Sciences.

COLLEAGUE AND COUNSELOR

BY DETLEV W. BRONK

DURING FIFTEEN YEARS I had the privilege of knowing Ludwig Edelstein as a wise counselor, a loyal colleague, and an affectionate friend.

When I went to The Johns Hopkins University in 1948, I found widespread regret for the recent departure of Edelstein who had been a young Associate Professor of the History of Medicine. Fourteen years before he had brought to Baltimore from Berlin and Heidelberg academic ideals of the kind that had inspired Daniel Coit Gilman when he founded the Hopkins. Edelstein did much to revive "the Gilman tradition" of which he often spoke with deeply felt admiration. Under the wide spread of his scholarly interests he fostered closer relations between the medical institutions and the faculty of philosophy; he was a bridge between the medical scientists of East Baltimore and the humanists of the Homewood Campus.

Edelstein's broad scholarly concerns had lured him away to be Professor of Classical Languages and Literature at the University of Washington, and soon thereafter to a Professorship of Greek at the University of California.

The years of the mid-century were an unhappy time for unyielding advocates of freedom for scholars to voice their thoughtfully reasoned beliefs and convictions. But Edelstein was well prepared for a test of his moral courage and the depth of his beliefs by his devotion to "philosophy, the pilot of life." In his Phi Beta Kappa address written under that title in

his last years, there are these memorable, relevant sentences: "No matter what our convictions, we cannot take refuge behind the dogma that events are inevitable. . . . We cannot escape our responsibility for the events that take place. To some extent, we bring them about, as the moment of decision attests. . . . Reason is not only capable of formulating principles of insight or of action; it is first of all a liberating force, the power to negate. . . . The power to say 'No' in a given situation constitutes our humanity; it is the gift of reason."

Edelstein did indeed say "No" to the Regents of the University of California when they demanded of him and his colleagues an oath that he felt they had no right to ask of scholars who sought truth through reason. And so he was free to accept our invitation to return to the Hopkins in 1950.

At that time we were endeavoring to break down formal barriers between undergraduate and graduate education, to foster research as a means of learning by undergraduates as well as graduates, to cultivate the relevant relations between the natural sciences and the humanities and to synthesize the specialized fragments of each. In this undertaking Edelstein was a leader; to me he gave wise counsel and encouragement. We recognized his dominant role by appointing him the first Professor of Humanistic Studies.

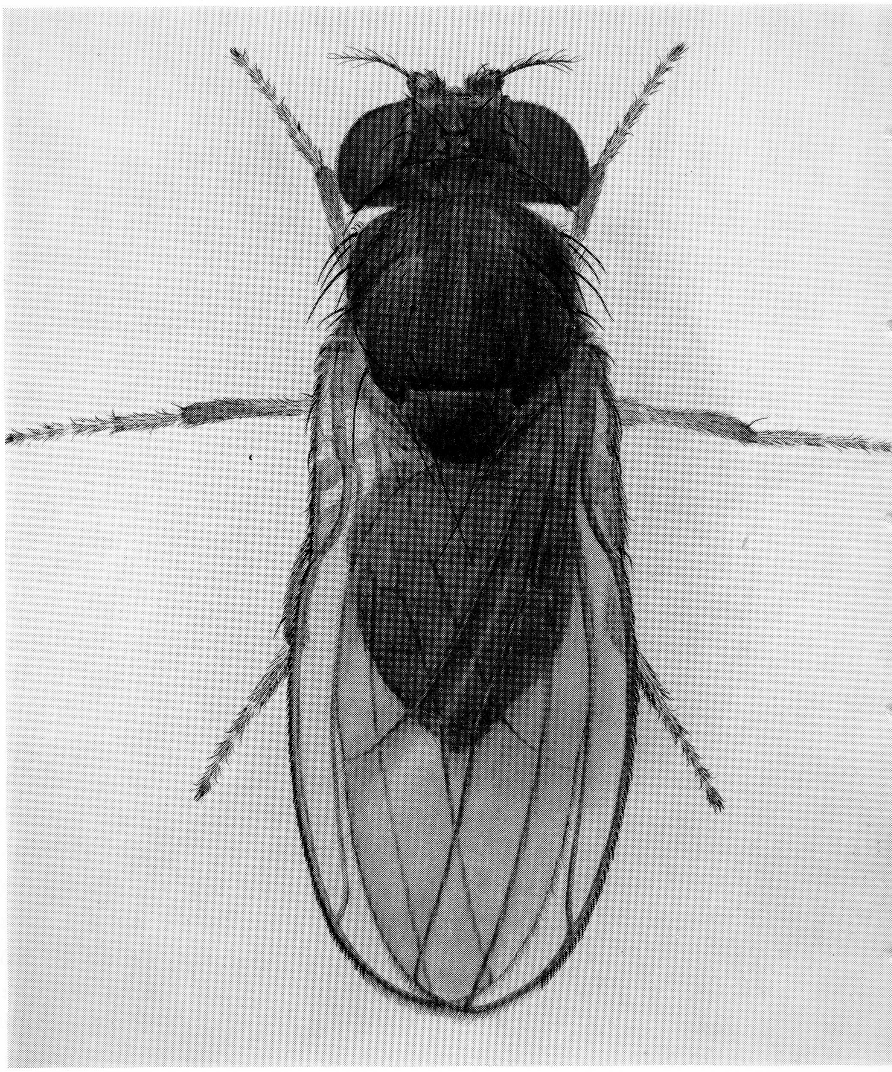
After I went to The Rockefeller Institute to fulfill a goal first set by Gilman and Welch of the Hopkins, I often sought Edelstein's counsel. Over dinner at the Maryland Club, we would discuss the spiritual values of science. Are the natural sciences enriched by the study of history and philosophy? We debated the nature of a community of scholars. Could such a community be justified in the specialized industrial civilization of today? Was it desirable that there be some universities devoted solely to the furtherance of creative scholarship and the preparation of academic scholars? To such questions Edelstein gave strong affirmative response. And so it was natural that he should come to the Rockefeller to further such goals and others close to his heart. But he would not come until the first student scholars were enrolled; as a classicist and historian, he had a deep interest in the nurture of future scholars, for they gave him hope of continuity in the scholarly endeavor to which he had devoted his own life.

I sometimes wondered whether Edelstein would find congenial the environment of The Rockefeller University in which there is close co-mingling of faculty and students without regard for fields of knowledge. For he had been trained in the austere formality of German universities and had spent many years in a professor's relative isolation from students and professors in other fields of learning. I need not have worried. From the first he was the most gregarious of our faculty and was a professor greatly beloved by our students. He chose to live on the campus in a residence hall in which he was mostly surrounded by students. Because he had had the privilege of living the life of a scholar, he valued the opportunity to give direction and meaning to the lives of scores of young scholars he enriched by his counsel and friendship.

Every student spent the first week of his residence at the Rockefeller with Edelstein. The week was devoted to discussion of Greek science, the evolution of science and the significance of science; he gave them a lasting appreciation of the broad relevance of science and its humane values. Future physicists and biochemists and zoologists went on to read Aristotle and Plato with Edelstein and to discuss with him the philosophical implications of social changes fostered by science and its application. Students who had just come from directed and closely supervised undergraduate education learned from him that a scholar's most exacting master and examiner should be himself. Faculty and students found in the teaching and in the life of Ludwig Edelstein the enduring qualities of a scholar.

Edelstein was a giver of gifts; in that he modestly delighted, and for that he is affectionately remembered: wise advice, sympathy, and loyal friendship; fruits because they represented life; flowers because they were beautiful; books because they recorded others' thoughts. The books he gave were especially prized by those who received them because he chose them with studied care so that they would be appropriate to the receiver. His inscriptions always related the receiver to the author or the contents of the book. Sometimes the inscription implied a gentle rebuke or subtle praise. The one I treasure the most is *The Life of Daniel Coit Gilman* in which he wrote: "For the trustee of the Gilman heritage." Edelstein lived for the fulfillment of that heritage.

OF FLIES AND MEN



BY THEODOSIUS
DOBZHANSKY

Dr. Dobzhansky — one of the world's authorities on genetics — received the National Medal of Science from President Johnson in 1965. Last May (Review May-June) the Zoological Society of France conferred on him its medal for distinguished achievement. This article, in which he describes some of those achievements, is a modified version of an address presented to the 74th Annual Convention of the American Psychological Association in September.

ONE OF THE assertions which have gained acceptance by dint of frequent repetition is that science is competent to deal only with what recurs, returns, repeats itself. To study something scientifically, this something must be made representative of a class, group, or assemblage. A single Drosophila fly is of no interest whatsoever. A fly may merit some attention only if it is taken as a representative of its species. An individual person may to be sure merit attention. However, it is allegedly not in the province of science, but of insight, empathy, art, and literature to study and understand a person in his uniqueness.

I wish to challenge this view. Individuality, uniqueness, is not outside the competence of science. It may — in fact it must — be understood scientifically. In particular, the science of genetics investigates individuality and its causes. The singularity of the human self becomes comprehensible in the light

of genetics. You may of course object that what science comprehends is not really a singularity but a plurality of singularities. However, an artist, no less than a biologist, becomes aware of the singularity because he has observed many individual singularities.

Mendelian genetics is a study of differences among living beings. If all members of a species were exactly alike we could do very little, because the most powerful method of Mendelian genetics is to observe differences among individuals in the progenies of parents which differed in some ways. Heredity and variation are two sides of the same coin. Geneticists are always on the lookout for genetic diversity. Variety is said to be the spice of life. It is a staple necessity to geneticists.

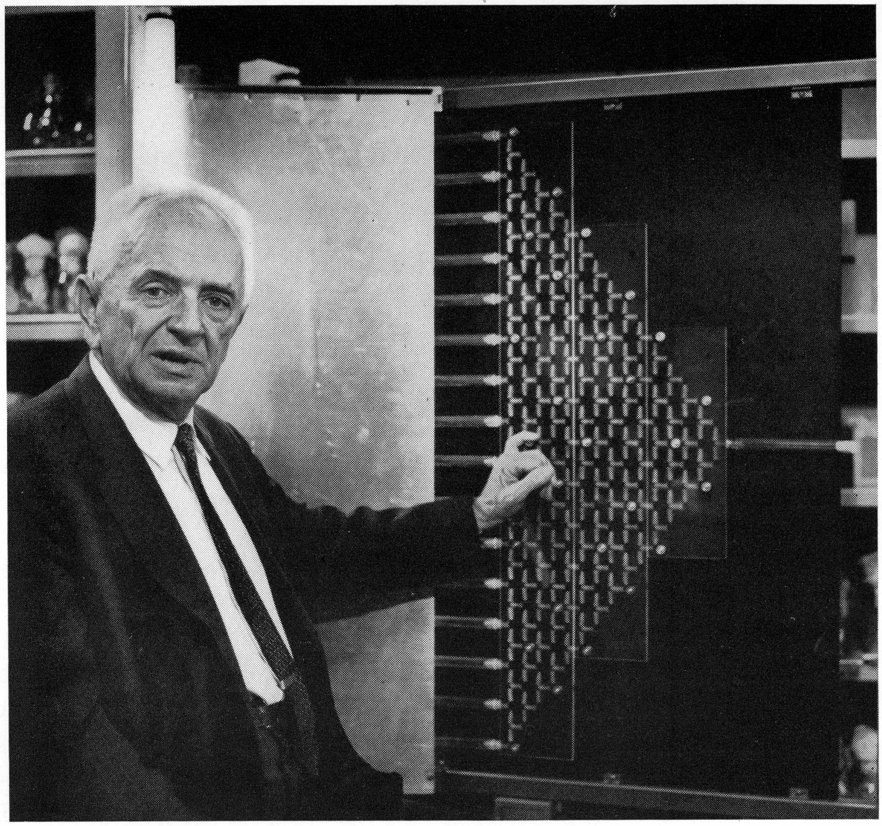
That every person differs from every other person is so obvious that this is taken usually for granted. What continues controversial is to what extent the human differences are due to genetic and in what measure to environmental variations. Though in a new guise, the old nature-nurture problem is still with us. The individuality among flies is rather less evident than human individuality. I do not claim to recognize every Drosophila by her face. The drosophiline individuality is nevertheless easier to analyze, and this analysis helps to throw some needed light on human individuality.

The theory of genetic individuality is simple enough. It stems directly from Mendel's second law, the law of independent assortment. An individual heterozygous for n genes has the potentiality of producing 2^n genetically different kinds of sex cells. Two parents, each heterozygous for the same n genes, can give rise to 3^n genotypes among the progeny, and parents heterozygous each for n different genes may produce 4^n genotypes. To be sure, not all of these genotypes are equally probable, because the linkage of genes in the same chromosome limits their independent assortment. Linkage disequilibrium delays but does not prevent eventual realization of the genetic variety. More important is the problem how large is n, that is, for how many genes an average individual is heterozygous, or how many genes are represented each by two or more variants in the populations of a species, such as man or a Drosophila.

Theoretical arguments cannot settle these questions. I can cite here only the brilliant work of Lewontin and Hubby[1] of the University of Chicago, as an example. Since the total number of genes is unknown, but is surely too large to have the whole set examined one by one, Lewontin and Hubby have decided to study what they believe is a random sample of genes. They chose a battery of enzymes that can be detected by electrophoresis in single individuals of the fly, *Drosophila pseudoobscura.* Some of these enzymes did and others did not show detectable genetic variations. The authors came to the conclusion that an individual fly was heterozygous for on the average between ten and fifteen per cent of the genes in their sample. The numbers of kinds of genes in a sex cell can hardly be less than 10,000; an average fly may then be heterozygous for a number of genes at least of the order of 1000.

Do these results have any bearing on man? Although man is not an overgrown Drosophila, he must have at least as many genes as Drosophila has. If the degree of heterozygosity in man is anything like it is in Drosophila, brothers or sisters are quite unlikely to inherit from their parents the same genes. The likelihood that any two unrelated persons are genetically identical is practically nil. Only identical twins may be genetically identical, since they arise by asexual division of a sexually produced fertilized egg. Even there the possibility of mutation and of cytoplasmic difference must be reckoned with. Human nature is, then, not unitary but multiform; the number of human natures is almost as great as the number of humans. Every person is unique, unprecedented, and unrepeatable.

The demonstration of the genetic uniqueness of individuals only opens, rather than solves, the problem as far as the behavioral and social sciences are concerned. There seems little point in belaboring the truism that behavior as such is not inherited. Only genes can be inherited, in the sense of being handed down from parents to offspring. Even so, I have mostly division products — true copies of the genes I have inherited from my parents — rather than these genes themselves. The skin color is not inherited either, because the skin pigment is not carried in the sex cells. However, I am yet to meet anybody who would contend that one's genes have nothing to do with one's skin color. Human, as well as animal, behavior is the outcome of a process of development in which the genes and the environ-



Dr. Dobzhansky demonstrates Hirsch's classification maze

ment are components of a system of feedback relationships. The same statement can be made equally validly with respect to one's skin color, the shape of one's head, blood chemistry, and somatic, metabolic and mental diseases.

Some authors question the existence of problems of genetics of behavior, distinct from genetics of anything else. They are right only inasmuch as there is not likely to exist a special brand of DNA concerned with behavior, different from that in other kinds of genes. The problem is more subtle. It is the problem, or rather problems, of the genetic architecture of behavioral differences. We want to know how many genes are usually involved in such differences, the magnitude of their effects, the nature of their interactions, the parts played by mutation pressure, hybrid vigor, environmental heterogeneities, and by all forms of natural selection in the formation, in maintenance, and in normal and pathological variations of behavior. In this sense, the genetics and the evolution of behavior may well be different from, let us say, the genetics and the evolution of blood chemistry, or of metabolism, or of chromosomal polymorphism, or of concealing colorations, or mimetic resemblances. And in this sense, which is the only meaningful sense, the genetics of behavior — especially the experimental genetics of behavior — is not yet even a fledgling field, although it has recently begun to chirp rather lively.

In this article I can discuss only one example of a study of genetics of behavior, that made by my colleague B. Spassky and myself on phototaxis and geotaxis in *Drosophila pseudoobscura.* Hirsch and his students[2,3,4] have constructed a classification maze [see photograph] and selected populations of *Drosophila melanogaster* which were clearly positively and others negatively geotactic in their behavior. They showed furthermore that the genetic basis of this behavior was polygenic, the three large pairs of chromosomes all influencing the result. Hadler[5,6] made a similar maze for selection for phototaxis [see photographs] and succeeded in obtaining positively and negatively phototactic strains of *Drosophila melanogaster.* Dobzhansky and Spassky[7] using Hirsch's maze selected positively and negatively geotactic strains of *Drosophila pseudoobscura.* Their starting population was polymorphic for some inverted sections in the third chromosomes, and one of the variant chromosomes proved to favor negative geotaxis, while chromosomal heterozygosis favored positive geotaxis.

The results of newer experiments on selection for

positive and negative phototaxis and geotaxis in *Drosophila pseudoobscura* are presented in the two figures shown here on page 20.

Is it, then, the heredity which makes a Drosophila walk towards lights or darkness, climb up or descend? Even with flies, not only with men, the situation is more complex than that. From the effects of the selection in the first generation, the heritability of the photo- and geotactic responses can be calculated to lie between 0.11 and 0.21. This is somewhat oversimplifying the issue, but one can say that, as a first approximation, the genetic component of the behavior of the fly in our mazes is only 11 to 21 per cent, while random chance and environment is responsible for 80 to 90 per cent. Nor is this all. Taking the data for the first 15 generations of selection as a whole, we can compute the so-called realized heritability, that is to say the efficiency of the response to the selection. This turns out to be very small:

Selection		*Phototaxis*	*Geotaxis*
Positive	Females	0.100 ± 0.009	0.028 ± 0.006
	Males	0.101 ± 0.008	0.021 ± 0.007
Negative	Females	0.091 ± 0.013	0.024 ± 0.011
	Males	0.063 ± 0.010	0.034 ± 0.009

In other words, a prediction of what the selection could accomplish in 15 generations, based on the initial heritability figure, would be a gross overestimate.* There are several factors responsible for this situation, among which I shall single out the one which seems most interesting.

In our first experiments we made selection in three populations of *Drosophila pseudoobscura* during 18 generations for positive and for negative geotaxis. After the positive and the negative populations have diverged about as much as the populations shown here in the geotactic scores, the populations were split each into two. In one member of each pair the selection was reversed, i.e., a population formerly selected for the positive was now selected for a negative geotaxis, and vice versa. In another subpopulation the selection was relaxed, i.e., the subpopulation was propagated without selecting either the positive or the negative individuals. The selective gains obtained through 18 generations of the original selection were almost erased in 6 generations of the reverse selection. The simple relaxation of the selection resulted in a loss of about half of the selection gains.

A partial, or even complete, loss upon abandonment of selection of what had been gained by previous selection is a phenomenon well known to breeders of agricultural plants and animals. Lerner[8] has called this the genetic homeostasis. Very simply, the average height, weight, speed of maturation, and many other characteristics of a population which are determined by cooperation of numerous polygenes, are held by natural selection at levels near-optimal for the population in the environments in which that population usually lives. When a breeder selects towards higher or towards lower levels of certain characteristics, he does so for his benefit, not necessarily for the benefit of the animal or the plant in its original environments. In other words, the artificial selection is often pitted against natural selection. As the artificial selection progresses it becomes more and more frustrated by natural selection. When the artificial selection is stopped, natural selection is given an opportunity to undo what the artificial one had gained; and reverse selection is highly effective because the artificial and the natural selections then work in the same direction, in alliance rather than in opposition.

Evolutionary Plasticity

Biologically, adaptively, this is an excellent strategy for evolution to follow. It combines high adaptedness to the existing environmental conditions, with high adaptability to environmental changes. The populations, though neutral on the average, contain also positive and negative genetic variants. The availability in the populations of this genetic variance confers upon them evolutionary plasticity. A change in the environment that favors a positive or a negative photo- or geotaxis makes the population respond rapidly by adaptive genetic changes. Such responses might occur also in a genetically uniform and homozygous population, but they would be much slower. They would have to wait for the occurrence of mutations. These mutations would have to produce genetic variants which were unfavorable in the old but adaptive in the new environments. The rapidity of the genetic adjustment is, however, not

*A more detailed account of this work, entitled "Effects of selection and migration on geotactic and phototactic behavior of Drosophila" will appear in the *Proceedings of the Royal Society*, Series B, Biological Sciences.

the whole story. A genetically polymorphic population not only responds adaptively to environmental challenges, but in so doing it does not, so to speak, burn the bridges for retreat. It is hedged against the contingency that the environmental change to which it is adapting may only be a temporary one. If it is indeed temporary, and the original environment returns, the population can readapt itself speedily, by returning to its former genetic composition.

Irreversibility of Evolution

And yet genetic homeostasis does not stand in the way of permanent, irreversible, progressive evolutionary changes. If a new environment or a new way of life endures, a new genetic system becomes stabilized. This genetic system will be buffered against the vagaries of the new environments, but no longer able to retrace its steps to the conditions of the bygone age. If these conditions returned, the species would probably become adapted to them in some new way. One of the most interesting lessons that evolutionary biology teaches us is that there may be many more than a single method to eke out a living from an environment. Major evolutionary changes are irreversible and unrepeatable.

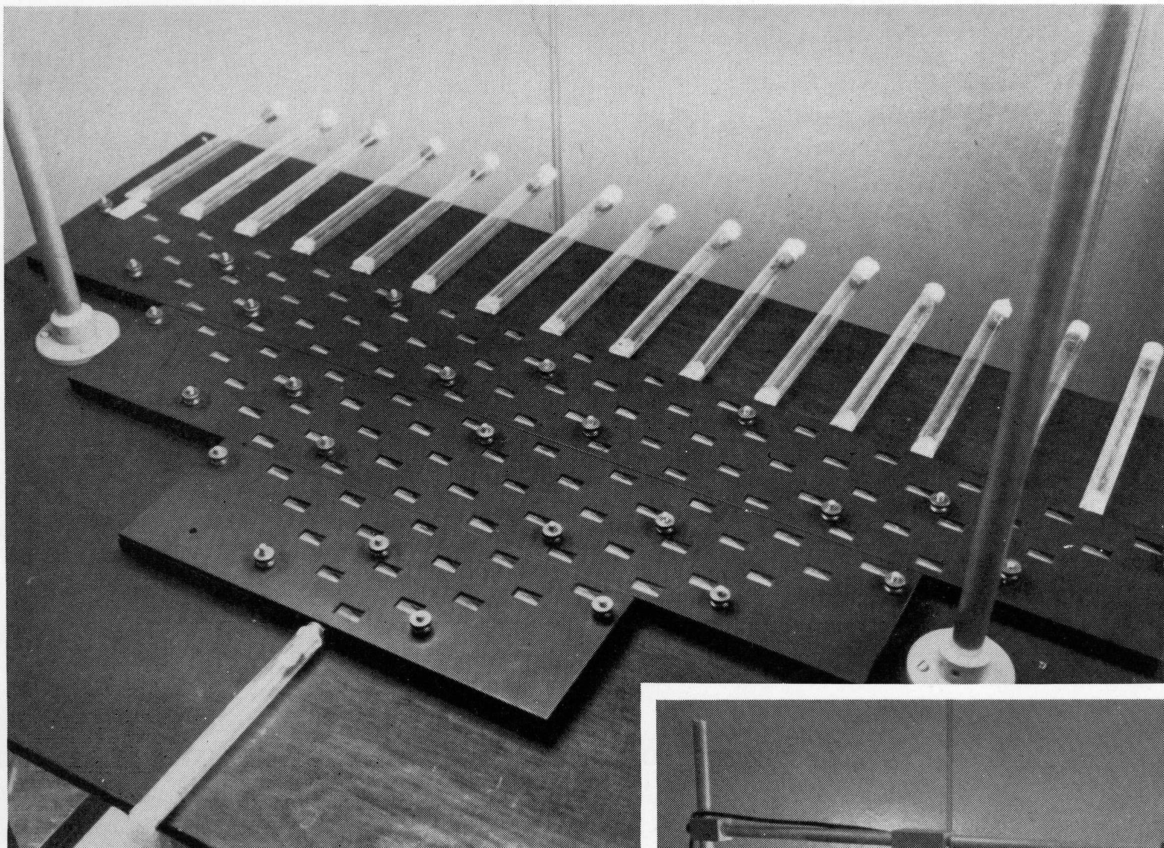
This point is so central that it must be reiterated: Man is not just an overgrown Drosophila. We reject the belief that man is nothing but an animal. Yet he is, among other things, also an animal. Like Drosophila, he is a sexually reproducing, outbreeding species, and his populations are abundantly provided with genetic variability. The genetic diversity affects all kinds of traits — morphological, physiological, and behavioral. The discrete, clear-cut, and usually pathological genetic variations of behavior, such as the so-called Mongoloid idiocy or phenylketonuria, need not be considered in the present discussion. The genetic variations among healthy persons are no less interesting, though much harder to study. The same situation exists also in Drosophila: sharp, easily distinguishable, and poorly viable mutants of classical genetics, versus slight, quantitative, polygenic variations. The difficulty, in human as well as in Drosophila genetics, arises because in the phenotypic variance of the second kind of traits the genetic and the environmental influences are intermingled.

Neither in the most highly selected, nor in the unselected, photo- or geotactic lines of Drosophila is the behavior of an individual rigidly determined. We have seen that the heritability of these behavioral traits is rather low. Whether at a given point of the maze an individual climbs upwards or downwards, takes a light or a dark passage, is in part a matter of environment, or simply of chance. The evidence is nevertheless conclusive that the genotype does bias the choices. Some flies are inclined to walk more often upward and others downward. Are the behavioral traits in human populations also conditioned by genetic variations? I shall be among the first to insist that the evidence is incomplete, and that more data must be collected. Yet the existing evidence, for a variety of traits ranging from I.Q. measurements to smoking habits, indicates that at least some genetic conditioning is involved, of course relatively more for some traits and less for others.

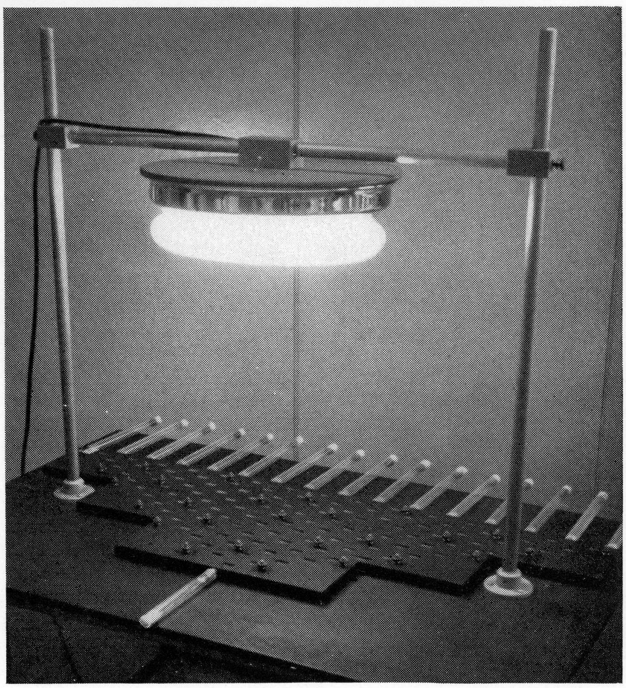
It is no secret that the study of the genetic conditioning of human behavior is hampered by the emotional reactions which this issue elicits in many people. Some wish to give an aura of scientific respectability to their race and class biases. Differences in material well-being and in social position are represented as just and necessary outcomes of the genetic differences. Others cling obstinately to the old tabula rasa theory. Man is a product of his environment and social conditions, and his genes are simply irrelevant. I submit that, irrespective of your preconceptions, modern biology makes it necessary to state the problems of genetic conditioning of behavior in terms rather different from the traditional ones. This is because one of the most significant changes in the biological theory in the recent decades has been a shift from typological to populational models and concepts. This conceptual reformation has been discussed with admirable clarity and discernment, particularly by Simpson[9] and by Mayr[10], making it possible to state what is essential for us here very briefly.

Types versus Populations

To a typologist, what is real and important is the species or the race to which an organism belongs. Differences among individuals of the same species and race are, of course, too obvious to be denied. A typologist regards them, however, as merely a kind of troublesome noise in the biological system. He tries, as it were, to recognize the melody obfuscated by the noise; he seeks to identify, classify, and name



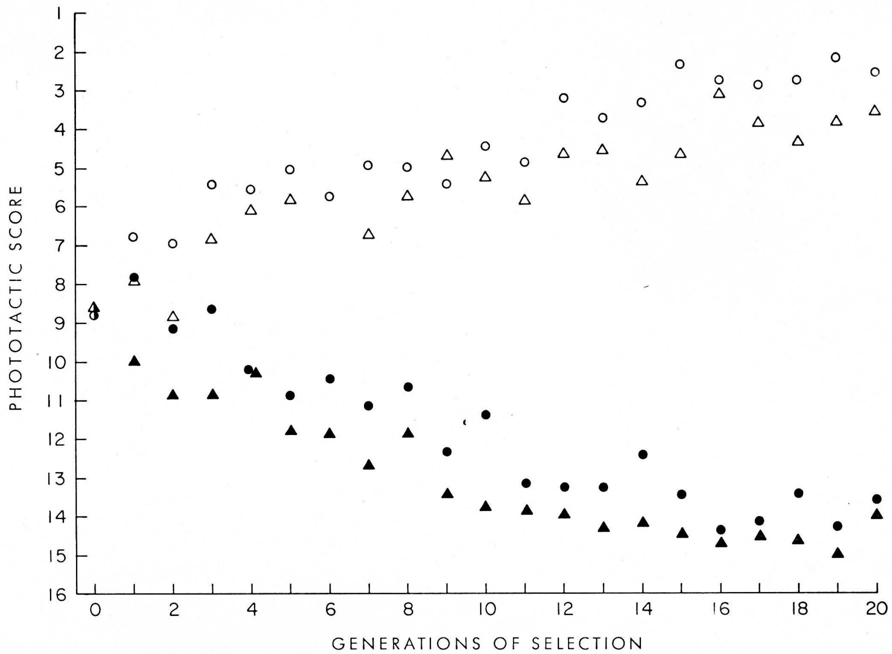
Hadler's maze



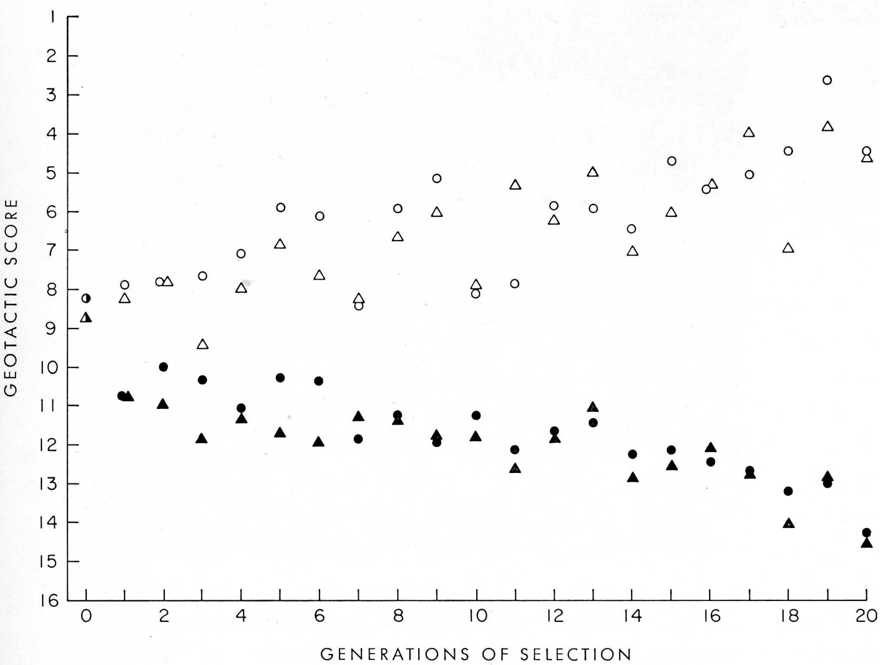
the species and the races. He hopes that once he can determine to which species and race an individual belongs, that individual is thereby adequately described.

A populationist, on the contrary, regards the individuals and their diversity as the prime observable reality. The biological validity of species and races is not thereby refuted (although some extremists try to do just that, in my opinion ill-advisedly). Species and races are, however, derivative from individuals, not the other way around. Species and races are Mendelian populations, reproductive communities of sexually reproducing organisms, forms of adaptive ordering of systems of individuals, evolved because they have made the evolutionary feedback processes between the organisms and their environments most efficient and successful.

Man in the street is a spontaneous typologist. To him, all things which have the same name are therefore alike. All men have the human nature, and an alleged wisdom has it that the human nature does not change. All Negroes are alike because of their negritude, and all Jews are alike because of their jewishness. Populationists affirm that there is no single human nature but as many human natures as there are individuals. Human nature does change. Race differences are compounded of the same ingre-



WHAT MAKES A DROSOPHILA CHOOSE LIGHT OR DARKNESS, CLIMB OR DESCEND?



The ordinates show the phototactic or the geotactic scores, i.e., the averages of the 16 terminal tubes of the mazes into which the flies distribute themselves. On the geotaxis maze the tube No. 1 is the uppermost and No. 16 the lowermost; on the phototaxis maze No. 1 is reached by 15 choices of light passages and No. 16 by 15 choices of dark passages. The selection is made by running through the maze 300 females or 300 males; the 25 most positive, or most negative, individuals of each sex are selected to be the parents of the next generation. The initial populations in our experiments were photo- and geotactically neutral on the average. Or, to be more precise, these initial populations had positive, neutral, and negative individuals in such proportions that the average scores were between 8 and 9 (an average of 8.5 is exact neutrality). After 19 generations of selection, the positively phototactic line had average scores 14.4 and 15.0 for females and males respectively, the negatively phototactic line 2.2 and 4.4, the positively geotactic line 12.9 and 12.9, and the negatively geotactic line 4.5 and 4.7. The frequency distributions overlap only slightly in the middle, i.e., only few flies of the selected strains end up in the terminal tubes Nos. 8 and 9.

MALE: ▲ positive △ negative
FEMALE: ● positive ○ negative

dients as differences among individuals which compose a race. In fact, races differ in relative frequencies of genes more often than they differ qualitatively, one race being homozygous for a certain gene and the other lacking it entirely. The extremists who deny that races exist are disappointed typologists who have discovered for themselves the gene gradients between race populations. They fail to understand that such gradients elucidate the nature of race as a biological phenomenon; the facts warrant the conclusion that Platonic types of races do not exist, not that races do not exist.

Compounded Genotypes

The typological and populational operational approaches are characteristically different. A race of typology is described in terms of means or averages of height, weight, cephalic index, intelligence, etc. Populationists regard variances at least as important as means. Genetic variance characterizes not only the status but also the evolutionary possibilities of a population. The Drosophila populations with which Hirsch and his colleagues as well as ourselves began our experiments were photo- and geotactically neutral on the average. Yet the experiments have shown that the average neutrality did not mean that all individuals were neutral. Selection has attested the presence in the populations of genetic elements for positive and negative photo- and geotaxis. This does not quite mean that the original populations contained individuals as sharply positive and negative as are individuals of the selected strains. Natural and artificial selection do not act as simple sieves which isolate genotypes which were there before selection. Selection creates novelty, because it compounds genotypes the origin of which without selection would be altogether improbable.

All human beings have certain universally recognized rights because they are members of the species *Homo sapiens*. Members of other species do not have the same rights. Cows are sacred to Hindus, but even in India cows are not treated exactly like humans. An imaginative French writer, Vercors, has given a thought-provoking discussion of legal and other problems that might arise if a hybrid of man and some anthropoid species were produced. Anyway, membership in a group, be that a species or a race, does not define all the characteristics of individuals. The notion that it does is implicit in race pride, exclusiveness, and bias.

Racists busy themselves attempting to scrape up any kind of evidence that race X has a lower mean I.Q., or smaller mean brain volume, or greater emotionality than race Y. How large is the genetic component in such differences is questionable. The partitioning of the genetic and environmental variances obtained through studies on monozygotic and dizygotic twins cannot be used as a measure of the genetic and environmental components of the group differences. The basic assumption of the twin method is that the environments of the co-twins are uniform. This is obviously not true when different social classes, castes and races are compared. Even if we had much more complete data on twins than are actually available, this would still leave the question of the magnitude of the genetic component in the group differences wide open. The argument that about one-half of the interracial variance in I.Q. must be genetic because this appears to be so among co-twins is a misinterpretation when it is not an intentional obfuscation.

Plasticity of Human Behavior

To say that we do not know to what extent group differences in psychological traits are genetic is not the same as saying that the genetic component does not exist. It is a challenge to find out. If individuals within populations vary in some character, be that blood grouping, or stature, or intelligence, it is quite unlikely that the population means will be exactly the same. What matters is how great is the intra-populational variance compared to the inter-populational variance. This is different for different characters. Skin pigmentation is individually variable in probably all races, but the interracial variance is evidently larger. Although precise data are not available, it is at least probable that the relation is reversed for psychological traits. In simplest terms, the brightest individuals in every class, caste, and race are undoubtedly brighter than the average in any other class, caste, or race. And vice versa — the dullest individuals in any of these groups are duller than the average of any group. There are sound biological reasons why this should be so. Very briefly, in the evolution of mankind the natural selection has worked, nearly always and everywhere, to increase

and to maintain the behavioral plasticity and diversity which are essential in all human cultures, primitive as well as advanced.

True enough, an individual taken from a population with a higher mean of some trait, say a higher intelligence, has a higher statistical probability to possess this trait more developed than an individual from a population with a lower mean. When we select Drosophilae for stronger or weaker photo- or geotaxis, we generally breed the high and the low selection lines separately. Mr. Spassky and myself have some experiments in progress, however, in which pairs of populations exchange migrants in every generation. The migrants are selected for high or for low photo- or geotaxis or for some other genetically conditioned trait. This may be considered to represent to some extent an experimental simulation of social mobility in human populations. The preliminary results of these experiments are, at least to us, fascinating. Genetically selective social mobility seems to be a powerful evolutionary agent.

"Infinite Diversity"

A day may conceivably come when mankind will embark on some all-out eugenical breeding program. This day is not yet in sight, because mankind has not reached a level of wisdom when it could decide with anything approaching unanimity what combination of genetic qualities the ideal man should have. It is rather easier to agree what qualities he should not have. As for positive ideals, we can only recommend that a diversity of tastes, preferences, abilities, and temperaments should be preserved and perhaps even increased. Anyway, when we consider the social implications of the human genetic diversity we are not usually preoccupied with eugenical breeding programs. The genetic diversity is, for example, most relevant to educational problems. The students are, however, selected for study, not for stud.

Insofar as the genetic component is concerned, the intelligence, or temperament, or special abilities of the parents have little predictive value for these qualities in an individual child. This does not mean that such genetic components do not exist, as some authors have overhastily concluded. It means two things. First, the heritability is fairly low, as it is low in the photo- and geotactic behavior of our flies. In other words, the environmental variance is high, and in man the parent-offspring similarities in behavioral traits may well be due more to the cultural than to the biological inheritance. Secondly, one cannot too often be reminded of the fact that we do not inherit the genotypes of our parents but only one half of their genes. The genes do not produce their effects in development each independently of the others. The genes interact; the genetic "nature" of an individual is an emergent product of the particular pattern or constellation of the genes he carries. This is often the reason why a child is sometimes so strikingly dissimilar to his parents in some traits, even if the environment is kept constant.

How can I summarize the contents of this article, which is itself a summary of thinking concerning a variety of issues? Perhaps the best way is to say that genetics bears out John Dewey's emphasis of "the infinite diversity of active tendencies and combinations of tendencies of which an individual [human] is capable."

This article appears in a somewhat different form in the American Psychologist *for January 1967 and is reproduced with the kind permission of the American Psychological Association, Inc.*

REFERENCES

1. Lewontin, R. C., and Hubby, J. L. A molecular approach to the study of genic heterozygosity in natural populations. *Genetics*, 1966, *54*, 595-609.
2. Hirsch, J. Individual differences in behavior and their genetic basis. *In:* E. L. Bliss *Roots of Behavior*, Harper, New York, 1962, pp. 3-23.
3. Erlenmeyer-Kimling, L., Hirsch, J., and Weiss, J. M. Studies in experimental behavior genetics. III. Selection and hybridization analyses of individual differences in the sign of geotaxis. *Journal of Comparative and Physiological Psychology*, 1962, *55*, 722-731.
4. Hirsch, J., and Erlenmeyer-Kimling, L. Studies in experimental behavior genetics. IV. Chromosome analyses for geotaxis. *Journal of Comparative and Physiological Psychology*, 1962, *55*, 732-739.
5. Hadler, N. Genetic influence on phototaxis in *Drosophila melanogaster*. *The Biology Bulletin*, 1964, *126*, 264-273.
6. Hadler, N. Heritability and phototaxis in *Drosophila melanogaster*. *Genetics*, 1964, *50*, 1269-1277.
7. Dobzhansky, Th., and Spassky, B. Selection for geotaxis in monomorphic and polymorphic populations of *Drosophila pseudoobscura*. *Proceedings of the National Academy of Sciences*, 1962, *48*, 1704-1712.
8. Lerner, I. M. Genetic homeostasis. Oliver & Boyd, Edinburgh & London, 1954.
9. Simpson, G. G. *Principles of animal taxonomy*. Columbia University Press, New York, 1961.
10. Mayr, E. *Animal species and evolution*. Harvard University Press, Cambridge, 1963.

THE ROCKEFELLER UNIVERSITY NEWS

Albert Lasker and T. Duckett Jones Awards

GEORGE E. PALADE

Professor George E. Palade received two of the highest awards in biological research in November: the $10,000 Albert Lasker Basic Research Award and the $6,500 T. Duckett Jones Memorial Award of the Helen Hay Whitney Foundation. The awards cited Dr. Palade's extraordinary series of original and fundamental contributions to knowledge of cell structure and function, and the clear path he has provided to productive research for a new generation of electron microscopists.

President Bronk and the Nation's First School of Engineering

DR. BRONK has been elected Chairman of the Board of Trustees of the Rensselaer Polytechnic Institute and a Life Trustee of that institution.

Rensselaer was founded in 1824 as the first school of engineering in the country and for many years was the only school of civil engineering while the United States Military Academy at West Point trained military engineers. It now has more than 4,000 undergraduates and 1,000 graduate students on a 250-acre campus with 50 buildings. In recent years, R.P.I. has greatly broadened the scope of its curriculum and has become a leading "technological university."

Dr. Bronk's acceptance of Chairmanship of the Board was due to his deep interest in the social role of science that he believes to be a major function of engineers. As President of the National Academy of Sciences and the National Research Council, he became impressed by the growing importance of engineers as partners of scientists in the applications of knowledge for the furtherance of human welfare. Because of that concern and his early training as an engineer, he was a member of the committee of the Engineers Joint Council that formulated plans for the National Academy of Engineers, in the creation of which Dr. Frederick Seitz, now President of the National Academy of Sciences and a trustee of The Rockefeller University, has played a leading role.

Dr. Bronk continues as trustee of The Johns Hopkins University, the University of Pennsylvania, and Bucknell University, as well as The Rockefeller University and as a member of The Board of Visitors of Tulane University. He has often said that he prefers to devote his leisure time to university trusteeships rather than to serve as director of corporations as many university presidents do.

Genetics and Behavior

BY CARL PFAFFMANN

THE ROCKEFELLER UNIVERSITY and Russell Sage Foundation were joined by the Social Science Research Council in sponsoring a conference on Genetics and Behavior held in Caspary Auditorium on November 18 and 19. This was the second in a series of meetings on Biology and Behavior [*Review,* Nov.-Dec. 1965] designed to foster the dialogue between the biological and social sciences.

Genetics, especially modern genetics, is having increasing influence on the scientific study of infrahuman and human behavior. An important consequence is a growing concern among social and biological scientists with the ethical, social, and legal implications of recent advances in genetics. This is reflected in the establishment of a committee by the Social Science Research Council on the Biological

Basis of Social Behavior. Prominent among the Committee's areas of study is the field of behavior genetics represented by Professor Dobzhansky and others.

In his evening address at the Genetics Conference held in Caspary Auditorium, Professor Dobzhansky noted that many social scientists have since the 1930's questioned the relevance of genetics to understanding social and cultural processes in human societies. "But," he went on, "some straws in the wind indicate that attitudes are changing on both sides of the biology-sociology fence. To say that man is an animal is true, but this is only part of the story. Biologists must recognize that man is a great deal more than an animal, or at least that he is a very special kind of animal. And more and more social scientists accept that human nature is not a constant . . . there are about as many different human natures as there are persons living." Dr. Dobzhansky then went on to review some of his own recent experiments in population genetics [see page 14 of this issue].

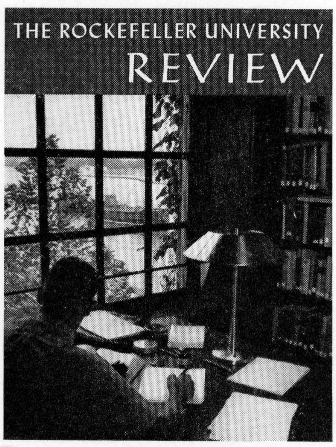
The morning session of the first day was concerned with the nature and development of intelligence and the degree to which genetic factors could be delineated in psychological tests of ability, intelligence, or personality. It was concluded that intelligence is not a unitary factor but a bundle of independent abilities which could reflect hereditary factors to varying degrees. Normal development requires both normal environment and normal genetic make-up, and the permissible variation in genetic make-up or in environment is very small. The next session on genetics and the study of social interaction brought out that the behavior of the organism is the result of both genotypic and environmental influence working in a continuous interaction. The old nature-nurture dichotomy is not only false but misleading. The growing individual is capable of being altered in various ways and it is of interest to ask whether there is a genetic basis for differences in susceptibility to environmental influence on different behavior traits.

Another session took up the broad problem of population control and social selection in animals. A number of examples showed that arthropods and vertebrates of many kinds were capable of regulating their own numbers by a process in which social selection occurs. Periods of very intense social competition in certain animal societies result in the selection of individual organisms for social fitness. In the closing general session it was pointed out that earlier attempts to apply genetic or biological concepts to the interpretation of personality traits, behavioral characteristics, and sociological phenomena, had not been especially successful. Now, increasing research in ethology and behavior genetics reemphasizes the role of the genome relative to environmental influences in the living organisms' behavioral patterns.

Thus the conference focused on: the technical aspects of attempts to determine the role of genetic factors in intelligence and personality (including behavior disorders); the interaction of genetic and environmental variables at various stages of growth and development of the organism; and the relevance of behavioral factors in population control. An important point emerging from this discussion is that the incorporation of genetic thinking into behavioral science has waxed and waned over recent years in large part because of a changing intellectual climate in both disciplines. A major shift in this climate is now taking place and we can expect a more active concern for genetics in the behavioral sciences over the next few years. Contemporary biologists emphasize interaction between the organism and the environment and no longer embrace a simplistic genetic determinism. Social scientists — who study primarily environmental factors — likewise are shifting from a simplistic determinism. The continuing interdisciplinary study of biology and behavior is one of the great challenges for research today.

Animal Navigation and Communication

EACH LECTURE of the now traditional four-day Christmas series for high school students, was well attended — a tribute both to Professor Donald R. Griffin who gave the lectures and to the youngsters themselves. The subject this year was "Animal Navigation and Communication." Skillful interweaving of visual material characterized Dr. Griffin's presentation, which included a superb film by Kenneth Roeder showing the evasive maneuvers of moths sensitive to the echolocating sounds of oncoming bats. A prize of $500 will be awarded to the high school student who writes the outstanding essay on animal navigation and communication; there will be three second prizes of $300 each. Like the lectures, these prizes are supported through the generosity of Mrs. Anita Oser.



THE COVER shows the northeast alcove of The Rockefeller University Library, overlooking the East River, with a Graduate Fellow in the foreground. Photograph by Joseph Barnell.

ACKNOWLEDGMENTS: PAGE 3 photograph by Norris McNamara—Nancy Palmer Agency. PAGES 6 and 9 chart and photograph courtesy of The Population Council. PAGE 10 photograph courtesy of The Ford Foundation. PAGE 11 photograph copyright © by Philippe Halsman and reproduced with permission. PAGE 14 watercolor by Edith Wallace. PAGES 16, 19, 20, and 23 by The Rockefeller University Illustration Service.