PROGRESS REPORT

THE NATURAL SCIENCES

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In April, 1933, the division of the Natural Sciences proposed a program which represented a considerable departure from past procedures. This departure consisted, in essence, of a proposal gradually to withdraw, at least in considerable part, from broad support for all fields of the natural sciences and to concentrate along certain functional lines where the strategy of Foundation support could be most effective, where it is most needed, and where it promises the largest social return.

The redirection of a great force, such as that which The Rockefeller Foundation constitutes, is a matter of great import; and not months but years of observation and study are necessary to the wise formulation of plans. The original proposal 915 Pro-5 of April, 1933, the interim report 915 Pro-6 of December, 1933, and the present statement are all to be viewed as progress reports rather than as rigid formulations of policy. Indeed the whole point of making a further statement at this time is the fact that there has been progress in thinking and in plans. This progress has steadily increased confidence in the desirability and effectiveness of the general proposal, and it has, at the same time, resulted in a gradual and still increasing clarification of the objective and of the concrete way in which these purposes may be served. It has become increasingly clear, that by throwing support behind this critical sector the Foundation has the opportunity to play a role of primary importance, bringing about developments which promise to be of quite unprecedented importance.

Both of the previous memoranda set forth, either directly or by implication, the basis of the conviction that the major emphasis should be upon certain fields of modern analytical biology. There is a strong and growing belief, held by many thoughtful scientists - even by many of the ablest specialists in the physical sciences - that the past fifty or one

hundred years have seen the supremacy of physics and chemistry, but that hope for the future of mankind depends in a basic way upon the development during the next fifty years of a new biology and a new psychology. As one views the present state of the world, with its terrific tension, its paradoxical confusion of abundance, and its almost uncontrollable mechanical expertness, one is tempted to charge the physical sciences with having helped to produce a situation that man has neither the wits to manage nor the nerves to endure. One should be critical in distinguishing between basic pure science and the inventive and technological activity that is often incorrectly referred to as science: and yet the fact must be faced that no one hopes or expects that technological advances will not continue.

The challenge of this situation is obvious. Can man gain an intelligent control of his own power? Can we develop so sound and extensive a genetics that we can hope to breed, in the future, superior men? Can we obtain enough knowledge of the physiology and psychobiology of sex so that man can bring this pervasive, highly important, and dangerous aspect of life under rational control? Can we unravel the tangled problem of the endocrine glands, and develop, before it is too late, a therapy for the whole hideous range of mental and physical disorders which result from glandular disturbances? Can we solve the mysteries of the various vitamins so that we can nurture a race sufficiently healthy and resistant? Can we release psychology from its present confusion and ineffectiveness and shape it into a tool which every man can use every day? Can man acquire enough knowledge of his own vital processes so that we can hope to rationalize human behavior? Can we, in short, create a new science of man?

This point of view has recently been realized by various scientists,

philosophers and statesmen; many of the techniques are at hand; but direction, stimulation, support and leadership are for the most part lacking. The Foundation has a unique chance to correlate and direct existing forces and to stimulate the creation of new forces for a coherent and strategic attack. The proposed program recognizes here one of the most inspiring opportunities with which science has ever been faced.

This opportunity is so impressive and so attractive, and the financial implications are so large, that one is tempted incautiously to abandon all other types of operation. The division judges, however, that this is not wise. In the presentation of last April the following budget was presented and approved:

SPECIAL PROGRAMS

Vital Processes			
Institutional and Committee Support (U.S. & Europe)	$500,000		
Fellowships			
U.S. ($35,000)			
Europe	35,000		
Grants-in-aid			
U.S. ($35,000)			
Europe($35,000)	70,000		
Studies	15,000	$620,000	
Earth Science			
Institutional Support (U.S. & Europe)	$200,000		
Fellowships			
U.S. ($35,000)			
Europe	10,000		
Grants-in-aid			
U.S. ($10,000)			
Europe($20,000)	30,000	240,000	$860,000

GENERAL PROGRAM			
Fluid Research		$ 80,000	
Fellowships			
N.R.C. $150,000)			
Europe $ 40,000)		190,000	
Grants-in-aid			
N.R.C. $ 30,000)			
Europe $ 40,000)		70,000	
Publications		90,000	

GENERAL PROGRAM (Cont.)					
Backward Countries					
China					
Fellowships	$50,000				
Institutional	50,000				
Grants-in-aid	10,000	$110,000)			
European		)			
Fellowships	$20,000	)			
Grants	5,000	25,000) ...		$135,000	
Contingent Fund				75,000	$640,000 $1,500,000

At the present time the division would propose the following modified budget:

SPECIAL PROGRAMS			
Vital Processes			
Institutional and Committee Support (U.S. and Europe)	$685,000		
Fellowships			
U.S. ($35,000)			
Europe	50,000		
Grants-in-aid			
U.S. $50,000)			
Europe 50,000)	100,000		
Studies	20,000	$855,000	
Earth Science			
Institutional Support (U.S. and Europe)	$100,000		
Fellowships			
U.S. ($20,000)			
Europe	15,000		
Grants-in-aid			
U.S. $10,000)			
Europe 20,000)	30,000	145,000	$1,000,000
GENERAL PROGRAM			
Fellowships			
NRC $100,000)			
Europe 40,000)		140,000	
Grants-in-aid			
NRC $ 30,000)			
Europe 40,000)		70,000	
Publications		90,000	
Backward Countries			
China			
Fellowships	$50,000)		
Institutional	50,000)		
Grants-in-aid	10,000)	$110,000)	
European		)	
Fellowships	20,000)	)	
Grants	5,000)	25,000) ...	135,000
Contingent Fund			65,000 500,000
			$1,500,000

However great the enthusiasm may be for the program in vital processes, it would be grossly inaccurate to leave the impression that a general study has revealed this as the one program worthy of aid. There are many fields of science that are of high significance to mankind, and which are deserving and needful of support. The officers of this division have found no reason to revise the earlier judgment that second only to the major and compelling interest in vital processes comes the opportunity in earth sciences. There are a variety of reasons, most of which have been expressed before, for this choice.

No other branch of natural science is directly concerned with studying the physical conditions which surround and affect life. This program thus is related in a basic way to the program in vital processes. Certain aspects of research in this field, particularly meteorology, have practical applications of high importance and possible benefit. Work in this field has the whole earth as its laboratory, and much of the research is necessarily of international organization and significance. This fact often makes it difficult to obtain support, but also makes the field a natural one for the Foundation. Research in earth science has received relatively little attention, despite its importance, being somewhat pushed off the stage by the more spectacular researches in atomic and astrophysics. Within the last five years, one of the first, if not the first professorship in geophysics was established in the United States; and two major institutions are now contemplating the same move, although it is significant that there does not seem to exist in this country a suitably trained man for the more important of the two posts. In view, however, of the pressing need in the biological program, it is now proposed to

reduce sharply the present allocation for earth science. For similar reasons there are two reductions in the general program, all of these changes resulting in an increase in the vital processes allocation from $620,000 to $855,000. It is to be hoped that conditions will soon make possible a further increase in this figure, for it has become clear that much larger sums could be used wisely and effectively.

The interim report of December, 1933, listed some of the actual steps taken in the new program since April, 1933. It may be useful to indicate here some details of the plans which are now in process of formulation. The budget mentions five mechanisms: grants-in-aid, fellowships, studies, committee support, and institutional support. The grant-in-aid and fellowship procedures are now well under way. Opportunities of very unusual merit and promise have already come to light, where small sums release men of real ability for more effective research. We have found, for example, one of the leading geneticists of the world who has been using 30% of his own time to wash bottles and feed fruit flies. Approximately seventy-five candidates for fellowships have been before us. This list, now cut to about fifteen, is receiving further study, and some five to ten appointments will be made during the spring months. Perhaps the most significant feature is the fact that several of the men will be enabled through this training to prepare for careers which would not at all be open to them in the absence of this opportunity. It is expected that both fellowships and grants-in-aid will be of increasing effectiveness as the program develops.

One study is now under way. Dr. Alexander Hollaender, a former National Research Council fellow and one of the best informed men in the country

concerning effects of radiation on living material, has accepted a five months' appointment to survey the literature on the applications of electro-optical methods to biological analyses. This study relates to a sector of future program which has not been described before, and which deserves attention here.

An essential purpose of the new program is to focus the delicate and powerful techniques of modern physics, chemistry and mathematics upon biological problems which are closely connected with the understanding and control of everyday aspects of the life of man. For a hundred years physics has been developing the instruments, techniques, and theories of modern spectroscopy. To date this tool has been used, almost exclusively, in atomic physics and astrophysics. A very large proportion of our experimental knowledge of atomic structure and practically all of our experimental knowledge of stars and of the universe has been obtained in this way. It is amazing that such methods were, over a hundred years ago, delicate enough to determine the presence of sodium in the atmosphere of the sun, but that these methods were not used until the last year or two to determine lead in spinal fluid or the metallic constituents of urine. So far, science has largely lacked the interest, time, or ingenuity to apply this tool to the solution of biological problems which immediately concern man. There has been, however, enough preliminary work to strengthen the belief in the biological applicability of methods of emission and absorption spectra; of fluourescent, phosphorescent, and Raman spectra; of magneto optical measurements; and of a number of other closely correlated methods. At the present time the vitamin content of foods and the hormone content of various body fluids and secretions must be determined by long and difficult concentration procedures, followed by very inaccurate and

unsatisfactory biological tests. Vitamins are measured in "rat units" and hormones by their effectiveness, for example, in stimulating comb growth in a castrated rooster. With such tedious and crude methods it is quite impossible to begin the attack on many problems of first importance. What, for example, is the normal variation in the hormone content of urine through the oestrus cycle?

The survey of literature, mentioned above, is a first step in a comprehensive survey of the field. A conference of some ten physicists and biologists will be called presently to discuss the situation and to advise on procedures. One concrete proposal for support is now before us, and five more are under preliminary consideration. Dr. W.A. Sawyer of the International Health Division is planning to include in the research of the Division a study of the application of optical and electro-optical methods to the antigen-antibody aspects of yellow fever and malaria research.

The Foundation has made extensive use of national committees to administer portions of its program. The National Research Council fellowship boards and grant-in-aid committee come in this category, as well as the National Research Council Committee for Research in Problems of Sex and the National Research Council Committee on the Effects of Radiation in Living Organisms. It is planned to make further use of such mechanisms. To clarify thinking, tentative plans have been drawn for six such national committees. It is not likely that more than two or at most three will prove desirable, the fields which seem the most clearly indicated at the moment being genetics, nutrition, and endocrinology.

Fellowships and studies are contributory mechanisms. It is with grants-in-aid and committee support that the actual researches get under way.

It is with department and institutional aid that one finances more significant and longer-term research projects, and builds the larger-scale structure which insures the continuing development of the research fields in question. The survey of opportunities for departmental and institutional aid is now well under way. Large sums are involved here, however, and time and careful study are indicated. A few important opportunities are now under direct study, including general physiology at Stanford, neurophysiology at Washington University, cell physiology at Iowa, genetics and endocrinology at McGill, physics and chemistry of respiration at Michigan, and neurophysiology at Northwestern. A grant for the development of genetics, biophysics, biochemistry and physiology has already been made to the California Institute of Technology.

There are two somewhat disconnected observations which may be made in conclusion.

One field which should receive important emphasis in the new program presents, as yet, something of a dilemma. This is the field of psychology. The officers are enlarging, as rapidly as may be, their contacts with this field. Various alternative plans have been formed for a survey of men, problems and opportunities. Some such survey will probably be under way next fall. The impression has been gained that the major need for research in psychology is in personnel. If a competent survey and judgment bears out this statement, it may well be that this sector of program must be a long-range affair, starting with recruitment and training through fellowships.

The second observation relates to organic chemistry. It was pointed out in the interim report of December 1933 that this program is, for the

present, laying special emphasis on researches which are more or less immediately applicable to human problems. Too great an emphasis on applications is somewhat analogous to the procedure of a holding company which too heavily milks its subsidiaries in order to meet current dividend requirements. Such a procedure may be temporarily justified, but it cannot continue as a sound, long-term policy. And as this program develops it is inevitable and desirable that it dig deeper and deeper into fundamental researches. One such contributory field which is not at present included, but which seems likely to offer a convincing case for inclusion, is the field of organic chemistry. This branch of chemistry is fundamental to all biology, and it is a field which is definitely lagging, especially in the United States. The great emphasis on physical chemistry during the past few decades has attracted the keenest minds away from other branches of chemistry, and there are almost no live and growing centers in organic work. One thinks at once of Dr. Conant, one of the three or four really important organic chemists in this country, and of the fact that no suitable successor to his chair is in sight. It is probable that the older type of organic chemistry has become so infertile that it is inevitably dying out; but there is a great opportunity to assist in the development of the newer type of organic chemistry which makes use of physical chemistry techniques. If this development is not assisted there is a real probability that lack of progress here may shortly prove the limiting factor in the biological applications.

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