Scientific Research: The Case for International Support

Financing of science at a supranational level is a stringent requirement for the vast majority of countries of the world.

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In the last 20 years, although the world has remained politically divided, major scientific enterprises of an international nature have been launched and often successfully completed. It will suffice to recall the activities of the International Council of Scientific Unions, the European Center for Nuclear Research (CERN), EURATOM, the International Geophysical Year, the Committee on Oceanographic Research (SCOR), the Committee on Space Research (COSPAR), and an innumerable series of lesser projects involving the participation of laboratories and scientists of more than one nation. The subject of the organization of science at the International level has become popular in recent years; we can refer to several useful discussions on the topic, such as those of Pierre Auger (*1*), Eugene Rabinowitch (*2*), and Jean-Jacques Salomon (*3*).

We have witnessed since World War II the establishment of a variety of scientific international activities, such as worldwide organizations, regional laboratories, and bilateral agreements, and their virtues and drawbacks have often been under scrutiny. I will not, therefore, discuss in detail these recent experiments in international scientific cooperation, but rather examine whether such cooperation is only a useful addition to ordinary scientific practice or a stringent requirement for countries of different size, population, and cultural development. Following the example offered by American granting agencies, especially in the field of biology, I present a case for the international support of scientific research. It is indeed primarily to the field of biology that the following considerations may apply.

Types of Nations

The dimensions of a nation in terms of area and number of inhabitants, its economic conditions in terms of gross national product and average income, its cultural tradition as expressed by prevailing ideologies, existing school systems, and academic structures—all these factors and others that I discuss later—are relevant to its scientific production. These aspects alone, however, are not a sufficient basis for assessing the actual level of scientific research and training in any one country, since this level represents the end result of a complex interaction among social, economic, and political elements. Nevertheless, one may draw some generalizations that are significant for the subject under discussion.

Scientific talent is dispersed, and there are no reasons for believing that it is concentrated in any one nation. Probably the gene frequencies for excellence in science are statistically fluctuating around a common mean within the whole human population. Indeed, examples of exceptional achievements can be mentioned for every country that has benefited long enough from scientific contacts, nor is there any evidence that planned or haphazard selection for higher scientific abilities has occurred in any country. On the other hand, talents and abilities of scientists represent a very valuable—possibly the most valuable—natural resource for each nation and for the whole human race. It would accordingly appear desirable to study which methods and procedures are likely to produce the most efficient use of these resources. Such study should not be carried out *in vacuo*, in a theoretical human population of size x with a gene frequency for scientific talent z, but rather with reference to present conditions in different nations.

For the sake of simplicity, existing nations can be classified under four headings: (i) large and scientifically advanced countries; (ii) large countries not scientifically advanced; (iii) small and scientifically advanced countries; (iv) small countries not scientifically advanced. By a "large" country I mean one having a population close to or over 200 million; by a "small" country I mean one having a population less than 100 million.

Countries of type i are only two: the United States and the Soviet Union. The proportion of their money which is invested in research and development and the resulting grandiose effort for rapid development of science and technology have probably brought these two countries beyond the inflection of the logistic curve, so that a plateau in growth may soon be reached (*4*). Even in these two countries, however, only a relatively small fraction of the available scientific talent has been tapped, according to the evaluation of D. J. de Solla Price (*4*); even if it does so at a slower pace than in the recent past, scientific development will continue in these countries for years to come. While both countries, especially the United States, can claim at present to possess the leadership in many fields of research, such excellence does not extend over the whole horizon of science. Moreover, leadership in science, as in other human activities, is a temporary blessing. For these reasons, also, these privileged nations do benefit from international cooperation: their size, wealth, and talent are not adequate insurance against the risk of early decrepitude and decadence in science, should they embark on a policy of intellectual autarchy.

There are two countries of type ii: India and China. Only relatively recently have these nations become conscious of the significance of science and technology for their lives and futures and started investing in these fields. The enormous intellectual potential of these major Asiatic countries will be realized in the coming decades, probably with spectacular results. In the course of time China and India

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may reach a stage similar to that now represented by the United States and the Soviet Union, but even then international cooperation will be necessary, for scientific autarchy, even for a very large nation, means inevitable stagnation and decadence. Especially at the present stage very close contacts with more advanced research centers are necessary for these countries if they are to diminish the risk of wasting their efforts.

Even though it is much smaller than China or India, Japan can be taken as a paradigm of the introduction and development of science, in the modern sense of the word, into a previously untouched country. Until 1868 Japan had lived in complete isolation from the products of western thought, and in 1869 it welcomed the introduction of the concepts and methods of science. The first step was to import foreign scientists and teachers and to send promising young Japanese abroad to follow university courses and to work in research laboratories. A small group of the new Japanese scientists took it upon itself to develop physics, chemistry, biology, and other fields of science in Japan, and shortly thereafter growth of science became exponential. "The explosion of science into an underdeveloped country can, then, if serious effort is made, be much faster than into one in which science is already established"—to use Price's words (*4*). In the two great countries under discussion the process is under way now. If international cooperation was essential at the very beginning, it is not any less significant at later stages. After the establishment of a few native scientists and university teachers, there is bound to be a period during which, for any single discipline, only one or a very few competent people are available in the country, and in consequence their authority within the country is likely to grow out of proportion to their position in international science. Senility and infallibility may set in sooner under such circumstances than in a country where science is of long standing and where for every field there are available many specialists, competing for scientific and academic recognition. For countries like China and India a continued and frequent exchange of scientific personnel and information with more advanced countries will therefore be absolutely essential, so that excessive authority will not be bestowed upon elderly scientists and local efforts will not fall out of step with the advance of science elsewhere.

In this respect one consideration should be added, because it has to do with current trends in the kind of help that advanced countries are offering to young scientists from developing countries. Western scientists who visit universities and laboratories in some of those countries find young and well-prepared scientists showing the signs of depression and frustration because, after having worked successfully in the most advanced research centers of the western world, they cannot establish effective research at home, for lack of modern equipment and other facilities. It therefore appears highly desirable that, in order to avoid such waste of talent and money, foundations and similar agencies limit their support to a smaller number of fellows from developing nations and use what is left over to offer more extended assistance to individual young scientists, including help after their return to the home country. Such programs would prove once more that international cooperation is essential to a healthy growth of science throughout the world.

Countries of type iii, small and scientifically advanced, are to be found especially in Europe. The antiquity of national cultural traditions, the diversity of languages, the local university customs steeped in the past, and a kind of ill intended nationalism, which has been rampant until recently in many European countries and unfortunately is still clearly identifiable in some, have caused the Old World to lose its leading position in many areas of science. Problems concerning the growth of science in European countries have recently been discussed in *Science* (*5–9*), and I will not therefore go into this subject. But I wish to add a few considerations, of a sort that are probably more easily expressed by a person like myself who looks at such problems from within than by an observer, however acute, analyzing the problem from outside. In the 12 countries of western Europe 260 million people live and by and large enjoy a fairly high level of education; furthermore, they share the glory of living in what was the cradle of modern science; finally, they are the immediate descendants of those Europeans who, until a few decades ago, had the almost absolute monopoly of scientific knowledge. Why is it that they have lost their leading position? The reasons are certainly numerous and not easily identifiable. But it is clear that the political division of the Continent, the history of internal strife, and reluctance to relinquish obsolete nationalistic pride have played a significant role in determining the present situation. In one particular field, at least, a common European enterprise has been so successful that similar ventures are now being considered for other fields of science: I refer to the European Center for Nuclear Research (CERN) in Geneva (*7, 9, 10*). But even today active research centers in Europe have better contacts with similar American institutions than among themselves.

It seems to me that international cooperation for countries of type iii is essential for the healthy growth of their research efforts and that such cooperation should take various forms, not necessarily only that of the establishment of large research centers, such as CERN. Their cooperation is justified primarily by the consideration that the minimum size of a machine or of a laboratory with certain facilities exceeds the resources of any one of these countries.

There are two main reasons why I think that science should be supported at an international level, especially in the case of groups of relatively small contiguous nations. The first is that modern nations invest large amounts of public money for the development of science and technology. Such large expenditures require justification in the eyes of citizens and legislators. Accordingly, government agencies whose job is to spend money for science submit their proposals primarily in terms of "programs"; that is, they try to justify large expenditures by indicating the reasons for studying certain problems, the procedures that should be followed for such study, the availability of specialized personnel, the kind of apparatus needed, the necessary sums, and so forth. Now, one may ask: What is the optimum size for a program of research? The answer is that the scale of operation should be as large as possible, preferably worldwide, but at least on the scale of large countries (types i and ii) or of blocks of smaller countries. It should be so, because every reasonable and sound program, whether in fundamental or in applied science, requires competence in a large number of diversified areas, which is not to be found in any single nation of type iii. Insofar as financing is linked to programming in scientific research, it needs to be international in nature.

The second reason for support on an international level is that, if it is carried on at the national level, government agencies rely on the advice of committees for the elaboration of scientific policies, the assignment of priorities, the preparation of investment programs, the evaluation and approval or refusal of research proposals, the assignments of grants and fellowships, and so forth. Because of the steadily increasing specialization of science, such committees are less likely to be competent the smaller the country and the smaller the number of national scientists and laboratories. Moreover, within the national framework the competent appraisal of laboratories and their projects can be made by a majority or at least a large fraction of the scientists in charge of these laboratories. Human nature being what it is, they will inevitably form a "cake-division committee" and will, in most cases at least, freeze out any newcomers or, indeed, anyone who does not belong to the union and is without sufficient power to bargain with it. It is too dangerous in these circumstances to rely on the idealism of people whose interests are at stake. Such considerations may not apply to countries of type i, but, in many areas of science at least, seem to be important for countries of type iii. One may therefore conclude that for type-iii nations some kind of mechanism for the evaluation and financing of research programs at a supranational level is essential if scientific quality is to be insured. We will see later what mechanisms can be envisaged.

Countries of type iv, small and not scientifically advanced, are presently the most numerous and are scattered over all continents. They share the same limitations and risks already pointed out for countries of types ii and iii. Their only hope of success in developing their scientific programs lies entirely, now and in the future, in close international cooperation.

Modes of Action

From such reasoning it follows that international cooperation in science is useful in any case but is a stringent requirement for the vast majority of countries of the world. Possible exception can be made for the United States and the U.S.S.R., where the size of the population and the present high level of competence may allow substantial progress through national agencies; but even here there are advantages to be had from the give and take between nations. What might be the best *modus operandi* for such cooperation?

Large-scale international cooperation in science requires the investment of substantial amount of money over relatively long periods of time. Only governments can ensure funds of this type, and for this reason international projects result from agreements signed by governments or government agencies. As Salomon has recently pointed out (*3*):

> Experience has shown that governments will not undertake large-scale combined action and set up scientific organisations (or extend the competence of some existing organisation to cover scientific questions) except when prompted by one or more of the four following motives—only the first of which is *purely* scientific:
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> 1) the research is to be devoted to an essentially extra-national subject (meteorology, oceanography, etc.) [examples: the Antarctic Treaty, the International Geophysical Year, the International Years of the Quiet Sun, the International Biological Program];
>
> 2) it requires expenditure which no country could meet from its own resources (nuclear research, space research, etc.) [examples: CERN, the European Space Research Organisation, the European Launching Development Organisation];
>
> 3) the scientific activities in question are believed to contribute to some wider economic or military project for which the countries are pooling their efforts [such as EURATOM];
>
> 4) participation in this form of scientific cooperation is likely to enhance or maintain the international prestige of the individual countries. [It would be easy to quote examples but it would not be charitable.

There are, however, no reasons why governments should limit collective action to the above types of scientific projects. The primary justification for the international financing of science lies in the astonishingly quick growth in the number of scientific disciplines, the corresponding multiplicity of competences required to adequately plan and evaluate any scientific project of some significance, and the inevitable limitation of abilities and experience within a single nation. The need for such financial intervention at the supranational level becomes the more acute the smaller the size and the lower the scientific production of a nation. As King (*11*) puts it:

> The basic overhead of science has to be met separately by each state (in Europe), with the result that there is much useless duplication and subthreshold effort. The situation is much the same as if, in the United States, each state of the Union were to attempt individually to provide the whole apparatus of the contemporary scientific effort.

To the four motives listed by Salomon, therefore, a fifth should be added (and actually this should be the least controversial of all): Governments will agree to concerted action when the number of specialized research workers within the nation is too limited to staff committees (always subject to rapid turnover) which are asked to elaborate scientific policies and evaluate research proposals in the ever increasing number of specialized scientific disciplines.

As I have attempted to show previously, this condition exists in practically every country. It would be to the advantage of every nation if supranational mechanisms for financing research projects to be carried out at the supranational *and at the national* level were put in operation. Obviously it would be difficult, if not impossible, to persuade governments to pour all their funds for science into a worldwide or a regional agency; but it seems reasonable to expect that they might be willing to participate in international or supranational enterprises that would act not in place of but as a complement to existing national agencies, particularly in those fields of science that require the convergence of a large number of different competences.

A particular experience in the field of international cooperation can be brought to bear on my thesis. I refer to the very significant and generous aid offered by U.S. federal and private granting agencies, particularly in the fields of biology and medicine, to foreign scientists and laboratories, especially in Europe and South America. It is my firm opinion that such experience of the past, even if unidirectional, provides a very useful model, to be followed on a wider scale and in many directions, for facilitating the development of scientific research and the training of highly specialized scientists, particularly in advanced countries of average and small size (population of about 50 million or less), but also in larger ones when their standard of scientific production is still markedly lower than that of the two great powers, the United States and the U.S.S.R.

The earliest and most outstanding example of American generosity in this area is that of the Rockefeller Foundation. The granting of fellowships began with a few appointments during World War I and then grew gradually so that by 1925 several hundred fellowships were being awarded each year. By 1950 well over 6000 individuals from 75 countries had held fellowships. The fellowship directory of the Foundation lists the names of practically all the leading scientists of the United States and Europe, especially in the fields of biology and medicine. Also a large number of grants have been given to individual scientists or laboratories: there is hardly any biologist of distinction who has not received at one time or another some support from the Rockefeller Foundation. I fully agree with Consolazio's statement (*5*):

> This record of the Rockefeller Foundation is one of which Americans should be exceedingly proud. It also demonstrates the value of the grant-in-aid system of supporting science. Rockefeller foundation funds have always been in very short supply. They have always been employed as catalysts, and the high points of European science attest to the past effectiveness of the system.

Since the last World War the largest direct contributor to the development of European biology has been the United States government. In 1963, the National Institutes of Health made 530 grants, totaling about $8 million, to scientists in western Europe and the Middle East. In accordance with the laws governing NIH, research grants are awarded on a competitive basis, applications from the United States and from overseas competing for the same funds.

Other federal agencies, such as the National Science Foundation, the Atomic Energy Commission, the National Aeronautics and Space Administration, the Department of Agriculture, and the Department of Defense, have also supported European science, especially biological and medical research. As Grant, Hutter, and Metzner point out (*8*): "The proportion of the total support of biomedical research provided by the U.S. Government has sometimes been as high as 20 percent in certain European countries."

While such generous support has certainly been very significant in monetary value for the recovery and the development of laboratories in Europe during the last 20 years, it has been especially effective because of the way in which such funds have been awarded. One could ask the question: Suppose that each European country during the last 20 years, instead of accepting American support, had invested an amount of money equal to that offered by American agencies to their biological laboratories, and that the funds these countries actually spent for the same purpose were added to this money; would be the results, in terms of scientific productivity and excellence, have been the same? I think that one can answer quite assuredly, no. There are two primary reasons for the lower efficiency of administering funds for science at the national level, in Europe at least: (i) "No European country awards as much as a third of its total funds for biomedical research by a competitive project-grant mechanism. Instead, most of these funds are distributed in a general subsidization of departments, or total underwriting of institutes" (*8*). (ii) The evaluation of the research projects and of the results obtained, if ever seriously carried out at all, is made by committees appointed from a total population of scientists too small to ensure adequate competence in every specialized discipline, as I have pointed out when discussing small, scientifically advanced countries. Projects that were submitted by European scientists to American granting agencies were treated by procedures designed to meet the needs of a much larger scientific community, with the double advantage that the granting committees were more competent and that the projects had to survive more stringent competition, since awards are made solely on the basis of the scientific excellence of the project, regardless of the nationality of the applicant.

This example of American support of European biology should be taken, I think, as the model for the establishment of a supranational, worldwide, or regional fund for the support of science. Investments made by individual nations would give higher returns than equal amounts of money administered at the national level. Recently, within the area of the "small Europe" or the "Europe of the six" a promising start in this direction has been made by EURATOM, whose Biology Division has launched in the last few years a program of support of biomedical research in Belgium, France, Italy, the Netherlands, and West Germany. A pilot operation following procedures similar to the American ones does already actually work, and, it appears, with significant results (*12*). Unfortunately the budget for biology of this European agency is only a minute fraction of the total, and, even worse, if cuts have to be made it is biology which is likely to become the victim of politicians and administrative officers. It is therefore questionable whether such programs will be continued and expanded in the future.

Another venture in the same direction, which would interest most of the Western European countries and Israel, is the European Molecular Biology Organization (EMBO), which aims to establish a European fund for the support of modern biological research in existing research institutions and universities and to found a large centralized laboratory. It is far from certain that European governments will be willing to back this venture financially. I think, however, that we can make a good case for it, just by mentioning an actual example. Of the members of EMBO, 29 are from France, 15 from Italy, 27 from the United Kingdom, and 25 from West Germany. Suppose that in their respective countries these persons were the best qualified for evaluating research projects. How could such a small group perform efficiently an operation that requires knowledge of the many disciplines that converge toward molecular biology? How would it be possible to have a rapid turnover in the membership of granting committees under present circumstances? How would it be possible to avoid the risk of the "cake-division committee"? Wouldn't these goals be attained and risks avoided if the support of the development of molecular biology in Europe were to be handed to supranational committees that could carry out their work in a much more efficient way?

Science, at the level of the person who works in the laboratory, knows no national boundaries. But at the higher organizational level, that of the large institution or of the university, the crippling effect of power politics sets in and jealousy develops. When we come to centralized governments, in most cases at least, officers are reluctant to give up even the tiniest amount of national sovereignty. The major success of experimental scientists has been in showing the world that one can take a rational approach toward natural phenomena and dispel nefarious superstitions and prejudices. It is the duty of today's scientists, when their influence within societies is increasing, to show by concrete examples that it is to the immediate advantage of the nation, financially as in other ways, to forget nationalistic attitudes. When the battle for the supranational or international support of scientific research has been won by the laboratory scientist, a major step also will have been taken toward the establishment of trust between nations.

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News and Comment

NSF: Friendly Reorganization Plan and Hearings Impending in House Indicate How the Agency Has Grown

Among the federal agencies created to help the United States cope with revolutionary changes in the postwar world, the National Science Foundation has operated on a considerably smaller budget and with less drama than, for example, the Atomic Energy Commission and the National Space and Aeronautics Administration in their public activities and the Central Intelligence Agency in its nonpublic ones. But NSF was born amidst great expectations, and now as it approaches its 15th fiscal year of full operation and is requesting a budget of more than half a billion dollars, with, for the first time, a seemingly fair chance of getting it, the Foundation is attracting an increased measure of attention and scrutiny.

President Johnson recently sent Congress a reorganization plan which would make two changes in the advisory and administrative apparatus of NSF in recognition of growth and change. And on 22 June the subcommittee on science, research, and development of the House Science and Astronautics Committee is scheduled to begin hearings designed to accomplish the first comprehensive review of NSF activities since the agency was established in 1950.

Broad-gage congressional hearings on agency operations and performance often are relatively unproductive, since committee members and their staff seldom have a detailed knowledge of agency operations, and such hearings not infrequently become a guided tour of the trees by agency officials without a view of the forest ever really being gained.

To avoid this, the science, research, and development subcommittee, which is chaired by Representative Emilio Q. Daddario (D–Conn.), is holding a preliminary series of briefing sessions with staff members who have been gathering information and will suggest fruitful lines of inquiry. Figuring prominently in these preparations is a report titled *The National Science Foundation: A General Review of Its First Fifteen Years** produced by the Science Policy Research Division of the Library of Congress' Legislative Reference Service (LRS). Prepared at the request of the committee, and turned out in a relatively brief time, the report is strong on facts and figures and sparing in its analyses of problems and in qualitative judgments. It does, however, raise policy issues that beset NSF and federal science in general, and does inject praise and blame, primarily by quoting from the official record. The report is particularly useful in putting the development of NSF in historical perspective, and the comprehensiveness of information on budget, personnel, and program development indicates that NSF cooperated cheerfully on the project.

In its early years, NSF was an agency with grandiose goals but relatively meager resources. The act which created the Foundation said it was being established "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes." From the beginning, NSF devoted itself to efforts in three major areas—support of research, manpower development (science education), and improvement of scientific information services.

At the outset NSF was dwarfed as a patron of research—even of basic research—by such mission-oriented agencies as the Department of Defense and the Atomic Energy Commission. By the mid-1950's, however, the Foundation was playing a significant role through the support of graduate education and was making an original contribution with its early programs to improve science teaching and encourage science-curriculum revision.

The Foundation had also been given the responsibility of encouraging the formulation of a national science policy and of evaluating scientific research programs being carried on by other federal agencies. It is generally agreed that the Foundation fell short of its sponsors' hopes in the matter of policy making, evaluation, and coordination.

That NSF was least successful in these efforts was not surprising in an

* Available from the Committee on Science and Astronautics, House of Representatives, Washington, D.C.