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Basic Research in Europe

Different countries favor different systems for the support and organization of scientific work.

David M. Gates

Europe offers an unusual opportunity to observe the support and organization of scientific research conducted by countries differing greatly in their cultural and economic histories. We see in some European countries highly successful research organizations; in some, very brilliant individuals; and in some, very little of either. Perhaps by looking closely at these examples one can learn lessons of use in our own country. Some of the outstanding features concerning the organization and support of scientific research and the general level of scientific activity in the various European countries are discussed in this article.

The Office of Naval Research of the U.S. Navy has maintained for ten years a branch office in London which is engaged in the exchange of scientific information between America and Europe. This office is staffed primarily with university and government scientists, appointed for one or two years, who are on leave of absence from their American institutions. These men, about 15 scientists, are visiting European universities and research institutes, exchanging ideas in almost every field of science. The observations presented here represent an interpretation of the viewpoints expressed by some of these scientists and of my own personal experience.

Great Britain

Most observers agree that the scientists of Great Britain are making first-rate contributions to all fields of science. This must indeed be evidence of good organization, of a sound educational system, and of a stimulating cultural and economic environment. In Great Britain the general responsibility for national scientific policy rests with the Lord President of the Privy Council, to whom two scientific advisory groups report: on the military side is the Defence Research Policy Committee, and on the civilian side, the Advisory Council for Scientific Policy. The DRPC is composed of the chief scientist from the Admiralty, the War Office, the Air Ministry, and the Ministry of Supply. The ACSP has a more diverse representation, from the councils for Scientific and Industrial Research, Medical Research, Agricultural Research, and Nature Conservation. The scientific policy of these councils is determined by their membership, which is composed of eminent scientists from universities and representatives of industry and labor as well. The Research Councils also make grants and award contracts for research to be done at universities and elsewhere, and give fellowships for the training of research workers at postgraduate levels. The principal government organization in Great Britain for dealing with research and its application is the Department of Scientific and Industrial Research (DSIR), under whose jurisdiction come 14 research organizations, such as the National Physical Laboratory. A number of civil departments, such as the Ministry of Power and the Home Office, have scientific staffs and a scientific adviser. Liaison between these departments and the Research Councils is close and informal.

Among the nongovernmental societies which are greatly relied upon for advice and for the dispersal of funds is the Royal Society of London, composed of about 500 fellows who are pre-eminent in the scientific community of the British Empire. A considerable endowment has been built up over the years, and the interest from this supports special professorships and research to the extent of more than $100,000 per year. In addition, the Ministries grant money through the Royal Society for certain special projects.

When Americans think of British universities they usually think of Oxford and Cambridge and are generally surprised to learn that most of Great Britain's 22 universities are more youthful than their own. Prior to 1900 there were only 12 universities in existence there. Since World War II, five new universities have received full recognition. More than 70 percent of the students receive scholarships derived from private or public funds, a situation adding considerable strength to the British educational system. The DSIR alone provides over $1.5 million per year for research scholarships.

The British universities are government-supported and are represented to the government through the University Grants Committee. This committee is the direct link with the Chancellor of the Exchequer, and establishes budgets and policies on a quinquennium basis. In general there has been sufficient money available for research, although most British professors feel that they could use more, and as a result have accepted support from American military agencies. A very few academic research projects are supported by the British military research laboratories.

One gets the impression that there is somewhat greater stability and freedom in the British system for the support of research than in the American system. In Britain the Chancellor of the Exchequer presents his budget to Parliament, usually in March, and Parliament must

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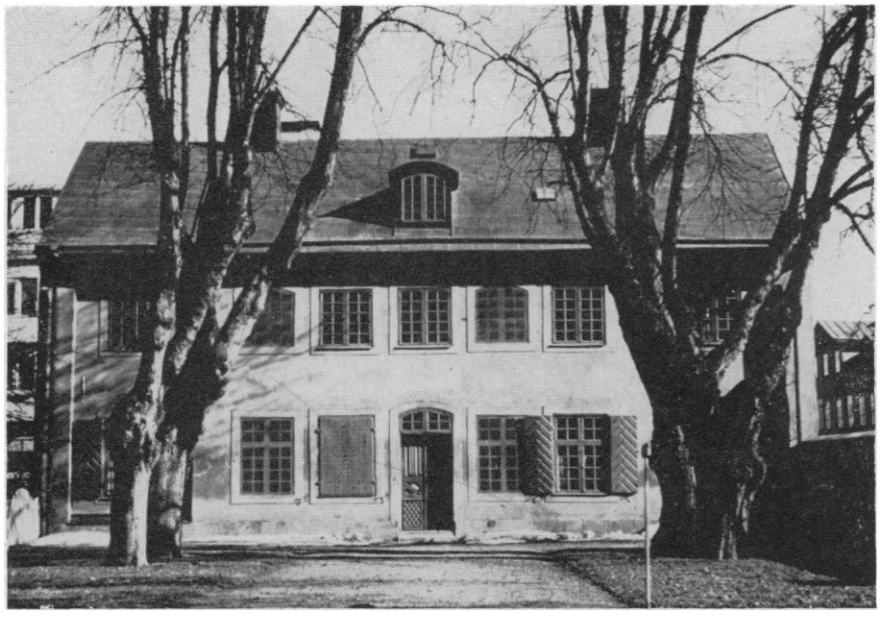


Linnaeus House, Uppsala, Sweden.

either accept or reject it in total. Rejection means a fall of the government. It is in the preparation of this budget and in making reductions in the budget that the Defense Research Policy Committee and the Advisory Council on Scientific Policy play their greatest role; all final decisions must be made by them. The amount of money available for research can be counted on from year to year so that long-range plans can be made with assurance. Manufacturers with government contracts can make their plans for a number of years in advance with the almost certain assurance that the Treasury will live up to its commitments. Greater freedom is achieved by supporting individuals and institutions per se, rather than by supporting specific projects with definite objectives, as is the case in the United States at the present time. Many research institutes and individual scientists in Britain know that so long as they are productive they will receive support on a continuing basis without having to campaign for funds each year or having to submit project proposals frequently to various agencies. Several of the 14 government institutes set up under DSIR receive funds from the military agencies but are almost completely shielded from any political pressures which might tend to divert the effort of the institute into applied research rather than basic research.

A considerable amount of university construction is taking place in Britain today, but this has not made up for the great overcrowding of the universities which took place just after the war. University salaries are low; in fact, a university scientist in Britain is relatively worse off than his counterpart in the United States. The shortage of engineers and scientists is decried everywhere, and there is some criticism of American recruiting in Britain of this precious commodity.

Scandinavia and Finland

Considered as having the highest standard of living of any part of Europe, Scandinavia (comprised of Sweden, Norway, and Denmark) and Finland are held in very high esteem for their scientific pre-eminence. Sweden is outstanding in nearly every scientific field, and its scientific productivity is high, a factor closely related to the fact that Sweden has been successful in avoiding wars and foreign military occupations and has the greatest supply of mineral resources in Scandinavia. Denmark exhibits excellence in the biological sciences, but except for the Bohr Institute cannot be considered as outstanding in the physical sciences. Medical Sciences in Denmark are outstanding, largely because of the Carlsberg Foundation which receives its support from the Carlsberg Breweries. Norway and Finland have contributed very notably in certain narrow areas such as auroral physics, oceanography, and in dental science; however, it is difficult for these small countries to compete in quantity with the larger countries.

In Sweden one is struck by the newness and spaciousness of the academic research laboratories, which can be referred to only as ultramodern and as the finest in Europe, if not the finest in the world. Few American university laboratories are any better equipped. This is consistent with the fact that Sweden maintains the highest standard of living in Europe and has an extremely high cultural standard. Academic salaries have been raised in the last couple of years and compare favorably with those in England.

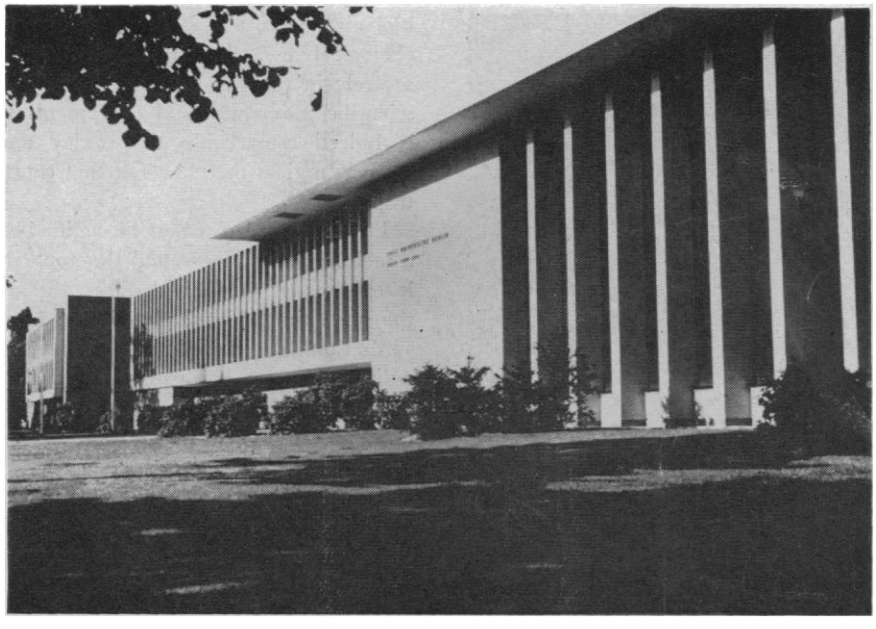
Unfortunately for Sweden, one of her greatest exports is young scientists, a situation created by the lack of opportunity within Sweden and by the strong demand in the United States. The situation is aggravated by a very rigid and formalized professorship structure within each Swedish university. A lecturer who has been at a university for seven years and has not achieved a professorship must go to another university. However, in view of the fact that at the four universities in Sweden there are usually only one or two professorships in any given field, this forces out of the country many extremely competent young scientists. In one or two exceptional instances the king has etsablished a "personal" professorship in order to retain an outstanding man. The system of training scientists and appointing faculty members in Scandinavia is considerably different from that in America, and even different from that in the rest of Europe. There are three principal degrees: *kandidat, licentiat,* and *doktor,* to be interpreted as an M.S., a poor Ph.D., and a very good Ph.D. degree, respectively. The *kandidat* degree is given after examinations have been taken in three subjects, and requires three to four years of study. To obtain the *licentiat* a substantial research paper is required, in addition to advanced study in seminars and independent study. Persons wishing to teach or do research in universities will then study for the doctoral degree, although minor positions are filled from the two lower degrees. The doctoral thesis is of book length and usually takes several years to complete. The position of docent provides the best opportunity for research. There is usually only one docent per department, and the salary is nearly as large as that of the professor. Appointments as docent are made for six or seven years and may not be renewed, which leads to the difficulty mentioned above. When a professorship becomes vacant the position is filled by competition among the docents apply-

ing, the selection being made by a committee of professors from all the Swedish universities.

The four universities are represented to the Minister of Education by the University Councillor, to whom they present their budget requirements. The Minister of Education deals directly with Parliament. Money for new buildings, university salaries, and some research comes through these channels. Additional money for research comes through the efforts of the National Councils for Natural, Technical, Medical, and Agricultural Sciences, which make their pleas to the Ministries of Education, Commerce, and Agriculture.

Research contracts are written between the professor and the council, and reports must be written at the conclusion of the research to describe the results. Any equipment built from contract funds must be made available to other universities or institutes if it is no longer required by the parent laboratory. A very thorough general planning of science in Sweden was made by various committees set up just after the war. The success with which they executed their plans for the scientific research programs in Sweden can be attributed in part to the smallness of the country and to the unanimity with which the committees could operate.

Like Scandinavia, the isolated country of Finland has a high standard of living and a great love of learning; its educational system is one of the finest in the world. Because of its strange language and its location, Finland probably has had less contact with Americans than has any other European country outside of the Iron Curtain. It has four institutions of higher learning, two privately supported and two state supported. Finland is to be all the more admired since, despite the fact that she suffered a great loss of life and property during the Russo-Finnish War and has had crushing economic obligations since then, she has paid off her World War I debts to the United States. In recognition of this, Congress passed Public Law 265 in 1949, which provided that money paid in this fashion should be put into a special account for the support of Finnish educational and scientific activities. The fund may be used for buying American books and equipment and for exchanging scientists between the two countries. At present, approximately $400,000 per year is available for this exchange. Noticeable consequences of this law are that Finland sends a greater proportion of its postgraduate students to the United States for training than does any other European country and that Finnish laboratories now have considerable American-made scientific equipment. On every hand one hears appreciation for this contribution. Seldom has American money abroad been spent more effectively. Although in most fields of research the Finnish contributions cannot be considered outstanding, in certain specific interests they have given exceptionally brilliant men to science. They are well known for their research in x-ray crystallography and in meteorology and are presently developing a good oceanographic program. Many new buildings are seen in Finland, and although at the present time these are not occupied to full capacity, there is every indication that within a few years they will be bursting with activity.



Free University of Berlin, built by the Ford Foundation.

Germany

Germany is behind Great Britain and Sweden only because of the devastating effects of the war and of the Nazi regime. First-rate research is being done in every field except nuclear physics, bacteriology, and physiology, areas affected most strongly by the politics of the war. A great resurgence of high-level research is witnessed everywhere in Germany today. Germany is missing almost an entire generation of scientists, the age group of 35 to 50. Some positions of authority (such as professorships) are held by distinguished scientists who are now elderly and whose contacts with the many excellent younger men are not as close or always as inspirational as is necessary for the greatest productivity to be achieved. Unfortunately, another difficulty exists in Germany because some second-raters got into positions during and just prior to the war; these men are now only middle-aged and are there for many years to come. This situation is not general, and only slightly influences the general picture. There is little doubt that, barring unforeseen economic and political reverses, in another decade German science will rival Britain's in almost every field.

Since many of the German universities and research institutes were heavily damaged during the war, it has been necessary for German scientists to spend much of their time and effort during the last decade on reconstruction. Many of the great Kaiser-Wilhelm Institutes, which were located in Berlin before the war, were destroyed, and their personnel dispersed both west and east. The Kaiser-Wilhelm Institutes have been reformulated under the Max Planck Gesellschaft, and many of them have been relocated at university cities in western Germany. Today there are more than forty of the Max Planck Institutes and another dozen or more under the Kaiser-Wilhelm designation in Berlin-Dahlem in the American zone. These institutes receive their support from the states of Western Germany.

Much of the scientific research in Ger-

many is supported by the Deutsche Forschungsgemeinschaft, which has its headquarters at Bad-Godesberg, near Bonn. This association receives its money from both the government and industry. Membership is comprised of advisers for each field, selected from among the university professors throughout Germany. These committees then pass on the requests for grants from the various universities. Usually rather definite areas of research are supported by the Deutsche Forschungsgemeinschaft; however, the grants are usually given to an institute rather than to individuals. The universities in Germany are state supported, and since some states pay more than others, it is difficult to attract good people to the more poorly paid universities. In contrast to England, there are no fellowships or scholarships for students, and so most students must either come from well-to-do homes or work their way through the university. One state, Hesse, offers a free university education to any student resident in that state who can pass the entrance examination.

Several new German universities have been established since the war, such as the Free University in Western Berlin, which has received a great deal of Ford Foundation support, and the Johannes Gutenberg University in Mainz. In addition, one observes a burst of activity in certain localities. The University of Bonn, which formerly had no tradition whatever in physics or, particularly, nuclear physics, during the last couple of years has received a large sum for establishing two institutes: an institute of physics and an institute of nuclear physics. The latter is starting an extensive building program of laboratories, offices, classrooms, and a 70-Mev synchrotron, the total cost to be about $1.5 million. The physics institute is building a 500-Mev electron synchrotron which is to cost at least as much. In the near future, the University of Bonn will be the best equipped of the German universities for nuclear physics. The funds come from the highly industrialized state of North Westphalia. Other departments in this university are doing nearly as well. Controlled fusion research is being done at Göttingen, Aachen, Munich, and Hamburg.

At the Munich universities alone there are more than 70 inorganic chemists, and it is felt by some that research in synthetic inorganic chemistry is proportionately greater in German universities than it is in the United States. In fluid mechanics, Germany is the country in Europe best organized to carry out basic research. This is done primarily at the *Technische Hochschulen,* which are state supported, at which are located the private research laboratories of some of the professional societies. The situation in the field of solid-state physics is discouraging and reflects all the ills characterizing Germany as a whole. On the other hand, the Siemens industrial laboratories are among the best in Europe.

One sees throughout Germany most departments capably directed by a senior staff and the work enthusiastically developed by the junior scientists and students. In the smaller departments, a single professor may still do all the lecturing and younger men may wait many years for a professorship. Furthermore, one must take special examinations in addition to the Ph.D. degree in order to lecture at a German university. Although there has been a tremendous resurgence of science in Germany, the Germans are still hampered by an inflexible professorial system which has not met the changing demands of recent times. One can say in general that scientific research is adequately supported in Germany today by the federal and state governments, and that industry is making a sizable contribution. The great efforts made by American foundations and by the U.S. Government in collaboration with the German Government during the last ten years have gone a long way toward resurrecting in Germany a healthy intellectual environment.

Meteorological Service Building at de Bilt, Netherlands.

Netherlands

Scientific research in the Netherlands can be typified by the word *quality* rather than *quantity,* and the excellence of the work reflects a high degree of organization and a well-conceived educational system. The Dutch have had to work hard for everything they have, and their obstinacy and perseverance have shown up in an individualism which is unique in Europe. It has often been said that one Dutchman is an individual, two are a committee, and three are an organization. The Netherlands is the equal of Sweden and Germany in the physical sciences, may fall slightly behind in the biological area, and is first rate in psychological research. The Dutch suffered severely in the war and lost heavily in scientific manpower and equipment. It is indeed remarkable that today one scarcely notices the effects of that catastrophe.

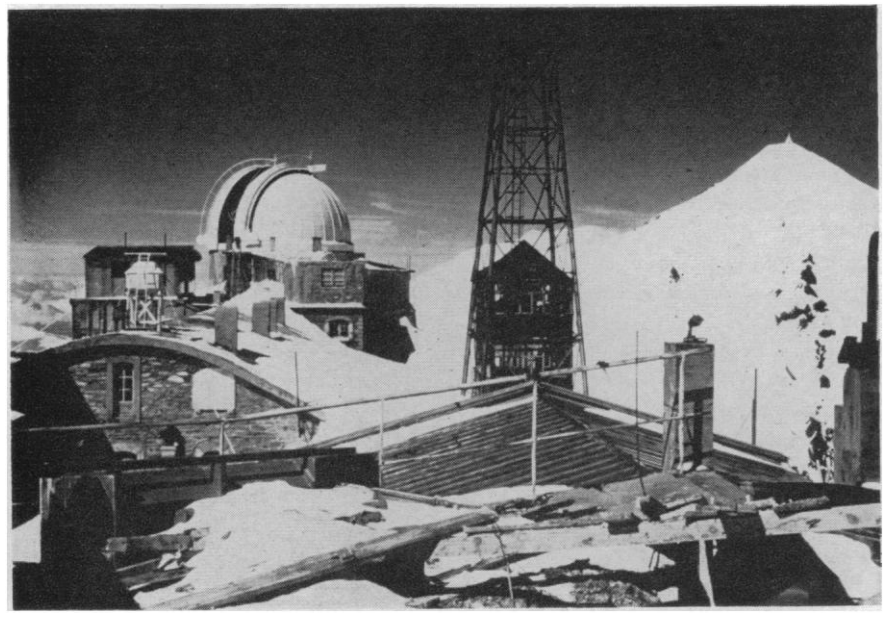
Dutch science can best be typified as a melding of the basic and the applied; it exhibits great individualism and at the same time skillful planning and organization. To exemplify this one need only mention the Philips Research Laboratory, the Kamerlingh Onnes Laboratory, and the Technical University at Delft. The nuclear physics laboratory at Utrecht is run on a five-year plan which is revised every year. The physics department is expertly run through committees, and, in addition, one member of the staff acts as business manager.

Research work in the Netherlands

has been more or less tailored to the needs of the country. The Dutch have been famous for their work in hydraulics, in geodesy, in seismology, in botany (stemming from their plantations in the East Indies), in agriculture, in cyogenics, and in statistical mechanics, and since the war they have been working on the peaceful applications of nuclear energy. Their university laboratories are overcrowded and they decry a lack of trained personnel. Their newer laboratories are elaborately designed to reduce the need for technicians. The lack of scientists stems from the rigors of the Dutch system of education.

There are nine universities and technical high schools in the Netherlands, located in Amsterdam, Rotterdam, Leiden, Utrecht, Delft, Groningen, Nijmegen, and Wageningen. Several of the state universities were founded in the 16th and 17th centuries, while the technical universities were started at the beginning of this century. Though one sees numerous old buildings on each campus, the number of structures erected since the war is impressive. The universities are supported locally by their municipality or state and have an average enrollment of about 5000 students, with a three-to-one ratio of men to women. Students graduating from secondary school are admitted to the university by examination. Often after the first or second year further oral examinations are required. After the bachelor's degree, about three years may be spent in graduate study which culminates in a comprehensive examination. The industries are happy to employ people at this stage, and so, partly for this reason, and partly because of selectivity, only a few students proceed beyond this point to get the Ph.D. The Ph.D. thesis usually takes another three to four years, and so the total time spent in graduate work may amount to six or seven years. The Ph.D. thesis is much more elaborate than the American one, so the recipient of a Dutch Ph.D. may be considered as having had considerably more experience. These factors, along with the possibility of two years of military service, tend to restrict severely the number of Ph.D. candidates. The situation is further aggravated by the fact that industry pays salaries at least 50 percent higher than the universities do.

The result of this system is that in most academic laboratories one finds a professor at the head of an organization containing from 30 to 150 people. The professor will therefore have considerable administrative work within his own department. The academic pyramid is well filled at the very bottom with large numbers of graduate students, but there are too few people in the intermediate ranks between the Ph.D. degree and the full professorship.



Observatory at Pic du Midi, Haute Provence, France.

A number of scientific research institutes which conduct research in almost all fields of science are active. The most noted of these institutes is the Central Council for Applied Scientific Research in the Netherlands, T.N.O. (Nederlandse Centrale Organisatie), located at The Hague, and organized in 1932. This organization has five branches which function as national research councils for industrial, nutritional, health, agricultural, and defense research. There are specific institutes working on programs in each area at the main laboratory at The Hague.

Basic research in the universities is supported through the Foundation for Fundamental Research of Matter and by the Netherlands Organization for Pure Research, Z.W.O. (Stichting voor zuiver Wetenschappelijk Onderzoek i.o.). These agencies are government-supported but receive substantial contributions from industry as well.

France

Most visitors to France agree that the potential of the country for research is considerably greater than her productivity. France is a dilemma and a bit difficult to analyze. Science in France exhibits towering individualism, inspired ideas, and localized brilliance, but seldom reflects a large coordinated program involving teamwork. Three factors have probably contributed most strongly to the fact that French science is not more enlivened today than it is: the overly idealistic approach to the organization of scientific research which took place between the two world wars, the virtual isolation of France by occupation during World War II, and a rather inflexible but highly respected educational system with a great tradition for the arts and literature. French science today lacks adequate support by one or two orders of magnitude. This is a bit surprising when one considers that French scientists have enjoyed positions of great political and social prestige, more so than in almost any other country. France did not receive the stimulus of the war which led to the great cooperative efforts between basic and applied research which took place in the United States and Britain and which have rallied support for science in these countries ever since. Basically, the difficulty in France is an economic anemia resulting from the following factors: (i) wars have drained France of personnel and of scientific and industrial materials; (ii) France is an agricultural country of peasant proprietorship; (iii) for France, Paris is the hub of the universe and acts as an economic drain on the rest of the country.

French science is organized under the Centre National de la Recherche Scientifique. The council of CNRS is ad-

mirably constituted, being composed of several hundred scientists who have distinguished themselves by recent research and who must continue to engage in research. CNRS has a representative on the Commission for the Planning of National Expenditure, which reports directly to the Minister of Finance. Within the CNRS the decisions of the council are carried out by an executive committee which can plan research on a national basis.

One notices in France, more than in any other country, that the scientific laboratories are housed in ancient buildings, remnants of a glorious past. Academic salaries are desperately low, and as a result many scientists must hold more than one job in order to earn a living. For a number of years there were large inequalities between the salaries paid by the Ministry of Education and those paid for professorships by CNRS. This situation has been somewhat corrected in recent years.

Despite the good intentions of CNRS, French science seems to be rampant with personal enmities which are severely retarding its growth, with a neglect, conscious or otherwise, of the provincial universities, and with an overemphasis of some fields at the expense of others. The strong personal feelings may be the result of a rather volatile sociological and political system which allows opinions to be expressed without fear of persecution or ostracism. This is a freedom which has considerably wider bounds in England and France that it has had in America since World War II. Another difficulty is exemplified by the procedure for the appointment of professors at the Sorbonne. Each candidate must have a personal interview with every member of the faculty, an interminable procedure, since there are several hundred faculty members. This procedure also is used for election to the French Academy of Sciences.

The French university faculty organization is still based on the patron system, the professor being responsible for all of those under him and usually dictating the program of research his disciples will follow. This is not solely a French affliction but is a general European characteristic. A departmental staff may consist of a professor, who may or may not teach, an assistant professor, a *maître de conférence* who does most of the teaching and who is held in great esteem, a *chargé de cours* who is not an official member of the faculty, and, finally, laboratory assistants who are entirely involved with research and study. In France, university courses usually are taken without credit, and one's recognition and position come from the esteem in which he is held by his colleagues, based upon knowledge and research productivity. The universities are primarily supported by the national government through the Ministry of Education, which, at the operating level, is reasonably free of the vagaries of French politics.

Institute of Optics, University of Madrid, Spain.

Thinking of French science, one is reminded of the brilliant contributions which have been made to optics, to the study of the night sky, to solar and radio astronomy, to electronics (traveling-wave tubes, carcinotrons, and photomultipliers), to the bathyscaphe for oceanography, to magnetism, to radioactivity, to tropical-disease research, to immunization, and to psychology. From an engineering standpoint, the French system for the distribution of electricity over the country is one of the best. In most cases these are examples of brilliant individual contributions with little mass effort in evidence. Often interest in a subject will wane when its leading scientist dies. Probably the most enviable characteristic of French science is the ability to develop towering individualism and great imagination, a characteristic we must encourage in America.

Italy

Although a creditable amount of excellent research is being done in Italy, there are certain circumstances which tend to reduce the research productivity of Italian laboratories. The universities generally derive support from state and local funds, and money for research from these sources is virtually nonexistent. Research is supported by the Federal Government through such agencies as the National Research Council or the National Institute for Nuclear Physics. The government has set up numerous research centers at universities specializing in different subjects, and much of the notable research is being done at these universities.

Several factors work toward diluting the quality of Italian research; among these are low academic salaries, heavy teaching duties, multiple jobs, large classes (300 to 800 not uncommon) without laboratory work, a doctorate degree the equivalent of a good American master's degree, inadequate research experience in work for degrees, free and easy publication, the existence of too many journals of inadequate standards, the acceptance of quantity rather than quality in publication, and the environment of a country steeped in the cultural traditions of the arts, with little appreciation for the importance of science to modern life. It is generally expected that a good percentage of those getting doctor's degrees will emigrate. A good deal of fine scientific equipment has been supplied to Italy through the Marshall Plan, and the Italian government is making a concerted effort to develop good schools of science throughout the country. Italy is doing first-class work in nuclear physics and in chemical physics, but cannot be regarded quite so highly in most other fields.

Spain

On visiting Spain, one sees some elegant new laboratories and new equipment, but few results. Research funds are controlled largely through the Superior Council for Scientific Research under the Ministry of Education and are distributed to academic institutes in all fields of science, except agriculture. The major disciplines are grouped together into eight foundations, each of which is named after a famous Spanish scientist. Under each foundation come a number of institutes, each of which may be a laboratory but is more likely to be an administrative title to include a number of independent research laboratories.

Research in Spain is beset with many difficulties attributable in part to the poverty of the country. Salaries are low, trained personnel are scarce, outstanding laboratories are rare, teaching loads are heavy, scientific leadership and stimulation are limited, equipment and supplies must be imported, and maintenance and repairs of equipment are difficult. Unfortunately, the situation tends to perpetuate itself. Many of the more imaginative, ambitious, or talented individuals tend to leave the country. There are, however, a few gifted, devoted scientists who are able to make significant contributions.

Because of the low salaries it is customary for most of the academic staff to hold additional jobs. It is very difficult, even at the research institutes, to convince the technical personnel that their job there should receive their sole attention and that they should not try to hold down a second job in the afternoon or evening. This makes it all the more difficult to convince younger scientists that they should dedicate all of their time to research.

Other Countries

Switzerland is somewhat self-contradictory. It is a country of magnificent industrialization but of relatively poor support for basic research in the universities.

Belgium, although good in many areas, is not of first rank in many, although again a few individuals are outstanding.

Yugoslavia is desperately poor, struggling under the handicap of a dictatorship and exhibiting the absence of free enterprise. Here again salaries are so low that almost all of the younger scientists must hold two jobs in order to earn a living. University enrollments in Yugoslavia are somewhat fictitious, since many students enroll, but do not attend classes, in order to permit their fathers to receive the government subsidy which is paid to heads of families with children in the universities. Class sizes tend to be extremely large. It is truly a tribute to some of the devoted scientists in Yugoslavia to see them fighting all odds to build within a system of restricted freedom the type of institution they know in their hearts they must have.

University of Coimbra, Portugal.

Eire is an overpopulated, tragically poor agricultural country with a total lack of organization for research. In the shadow of Great Britain it is a little surprising that more cross fertilization and inspiration have not taken place.

Israel is diametrically opposite, and is the prime example of what an energetic, prosperous, and organized people can do in what is otherwise regarded as an area devoid of scientific achievement.

Science in Austria is tremendously handicapped economically, and although there are many excellent individuals, the country has suffered from virtual isolation since the war.

Eastern Germany also has been in isolation, but has responded somewhat differently. Although it has received no help from the U.S.S.R., and little aid from the West, the momentum of the great tradition in German science has given inspiration through these politically difficult years. In many instances one sees instruments developed in East Germany which are totally unlike those used for the same purpose elsewhere, and which represent the product of truly independent thinking.

Portugal has many of Spain's difficulties in scientific research, but has one considerable advantage. The advantage is the benevolent dictatorship under a constitutional monarchy which allows in Portugal far greater freedom and communication with the outside than will ever be possible under the present regime in Spain.

Comparisons

Perhaps one can learn some valuable lessons to apply in our own country from these observations on others. This is not to say that the European system is to be recommended, or that ours is not good, but it is hoped that we might glean some ideas from the best in theirs in order to add to ours, to achieve the most productive and inspirational research and educational program possible. The following remarks do not always apply throughout Europe, but describe the best features observed in certain specific instances.

In Europe generally, research funds are not project funds but rather institutional funds to be used for research in a broad area. This is an important freedom of action which should be encouraged in America. It greatly reduces the inefficiency of having to make individual detailed proposals and often repeated pleas for support, and of having to submit quarterly progress reports, rather than allowing published results to suffice. The inefficiency associated with project support is often appalling.

Research programs in Europe are

usually thoroughly planned and well conceived before a great effort is expended. This is a situation somewhat enforced by necessity from the more austere budgets in general and by the fact that what is done must be well done in order that further support be forthcoming. The overriding criterion for continued institutional support is probably excellence of work. In the places where really great research is being done the scientists seem to be able to be less concerned with politicking, a disease somewhat associated with project funding.

The teaching load in European universities is usually very light. This allows the scientist the opportunity to do research in a less harried atmosphere. Many American teaching loads are from four to twelve times greater than European and are considerably more arduous per hour. In Europe, examinations are less frequent and are likely to be supervised by only a fraction of the staff, thereby freeing the others for research during these hours. The important point is that in some of the best European universities the scientist is given the greatest possible amount of undisturbed research time, and this time is jealously guarded against any encroachments.

The European science student has been forced by necessity to do more for himself in the way of building up equipment. Certain countries prefer sending their students to Europe for training rather than to the United States because they feel that the students will return home with more fully developed skills than then would acquire here, where they would become accustomed to manufactured equipment. In a country where industrial equipment is available there are advantages in not building everything, and using this time for more productive research. In the underdeveloped regions of the world it is best to have people who can build their own equipment.

The availability of a large number of fellowships in England has had a notable effect on science education and research in that country. This is particularly true at the postgraduate level, where a limited number of students are supported to do research for three to four years without any other obligations to distract their attention. This does a great deal toward giving a good young scientist the momentum he needs for the years ahead in his chosen career. At some European universities this scheme is further developed by appointing exceptional postgraduates to special research positions with a tenure of five years. The results at some institutions have been clearly recognizable in terms of Nobel Prizes and other outstanding awards.

In some of the larger European universities, the professor, as head of the department, has an administrative assistant who takes many of the burdens from his shoulders, by dealing with the scheduling of courses, showing visitors through the laboratories, preparing the budget, and so forth, thereby giving the professor more time for research. In a few European universities each faculty member has a full-time research assistant who is a regular member of the staff. If one suggests that in America teaching loads can't be reduced, that assistants can's be hired, that post graduate fellowships can't be given, there is only a look of incredulity on the face of the European, who remarks: "but America is the richest country in the world!"

One knows that if one were to hire a graduate Ph.D. scientist from some of the European countries one would be extremely unlikely to get a poor product. From a few countries it would be difficult to get an outstanding graduate, not because of a lack of intellect, but because of a deficiency in training. In America the situation is far from uniform. The greatest disadvantage of European graduate programs is the nearly total lack of an organized curriculum, whereas in America we do a great deal in graduate school to make up for an accumulated deficiency in training throughout the secondary and primary schools. For the scientist in America, the deficiency in the arts and humanities is never made up. This should be an important sobering thought to our educators.

Another valuable observation would be the fact that certain geographically small countries, such as England, Sweden and Holland, may well be proud of their distinguished records in science. One wonders whether this situation results in part from the fact that the universities in these countries are few enough in number that they can plan coherently. The needs and interests of all universities can be considered when plans and budgets are made.

In America, with many universities spread over a vast area, it is far more difficult to achieve coherency. Although it is contrary to the current trend toward more federal support for education and science, it should be considered whether or not greater regional or state support is the more desirable thing. This is being done to some extent in such groups as the agricultural experiment stations, certain cooperative nuclear research projects, and so forth, but there is need for a great deal more of this cooperative type of effort. It would indeed be a stroke of wisdom if some of our state legislatures would support to the hilt certain local research institutes in a definite area of research, without the term *project funds* being mentioned and without the need for federal subsidy. The practical solution is probably a combination of both federal and state support.

The scheme in Great Britain for planning of budgets on a quinquennial basis has notable advantages and more inherent stability than the American system. This is probably related to a rather fundamental difference between the constitutions of the two countries, and our system is one that we have to live with. The on-again, off-again support of research in America is a situation which would be extremely unlikely to occur in Britain.

It is difficult to escape the observation that tradition is an extremely important motivating factor in yielding great achievements in academic research. At the same time, tradition can retard progress. This is particularly true with regard to the inflexible faculty organization within the European universities, whereby there may be a single professor in a department who is overlord of all research and instruction within that department. Young men frequently must wait many years before they can teach or receive an appointment with tenure in the university.

Summary

Europe, traditionally the breeding ground for basic scientific research until the 1930's, is only now approaching full recovery from the devastating effects of the war. Great Britain has a more stimulating climate for research, a more progressive graduate-school program, and a more flexible professorship structure than any other country of Europe. Germany still has several years to go before the effects of the war will be obliterated. In most northern European countries, the organization and support of academic research ranges from good to excellent, and a stimulating intellectual atmosphere exists. Germany is rapidly contending for the lead in basic research

along with England and Sweden, which are now in the forefront. The Netherlands is typified by superb organization, and most of the Scandinavian countries are high in quality if not always in quantity of research. France is characterized by brilliant individual contributions but over-all falls far short of her potential for scientific research. Switzerland, a highly industrialized country, is geared primarily for engineering and does not compete as highly on basic research as might otherwise be expected. Italian research is good in certain areas but is plagued by a number of difficulties that retard progress. Nevertheless, there are encouraging efforts being made in Italy to develop some good scientific programs. In the south of Europe the situation is generally discouraging and will continue to be so, except where a few dedicated, brilliant individuals are making good contributions with the meager resources available.

Europe will continue to be a tremendous scientific manpower reserve for the United States, and, despite accusations of proselyting, the fact remains that in many European countries the employment possibilities are not commensurate with the production rate of scientists and engineers. If the universities of Europe would realign the professional structure of their departmental staffs and extend their graduate curricula they would give far more opportunity to young research scientists and make better use of their facilities. America can indeed be grateful to Europe for a great cultural and academic heritage, and one can sincerely hope that close cooperation in science will take place for many years to come.

Note

This article is not an expression of the official views of the Office of Naval Research.

What Is the Economist's Task?

The current recession illustrates his responsibilities as an analyst and as an adviser on public measures.

Gerhard Colm

"The proper attitude in which any economist should review this year's [economic] survey is one of humility towards the failures of his own science" [*Economist* (5 Apr. 1958)].

We have been in a recession for about six months. Although the downward movement has tapered off, signs of a sustained recovery to a satisfactorily high level of activity are not yet in sight. During the last decade most economists have emphasized that the American economy has not become immune to economic fluctuations. They have also emphasized, however, that we now have the legislative and executive machinery established by the Employment Act of 1946 and the know-how to counteract a recession, or at least to prevent a recession from deteriorating into a depression. Are we economists then to blame for the unfavorable economic developments of the last six months? Must we accept the criticism expressed in the quotation from the *Economist*? Or should our defense be that as economists we have a responsibility only for good economic analysis and that the determination of policy is the responsibility of the decision makers, inside and outside the Government? My answer is that the function of the economist extends beyond pure analysis, that the economist can and must contribute to the economic decision-making process. An economist who has been asked to advise a statesman on economic policy cannot confine himself to presenting the findings of pure analysis. For if he does, unintentionally he may give not pure but poor advice.

In this discussion I will examine the relationship of economic research to the current recession problem and to the policy measures which have been or should be taken. In this way we will be better able to judge the responsibility of the economists and politicians for the unsatisfactory economic developments which have been taking place.

In analyzing the multiple role of the economist, I will elaborate a distinction which was suggested by a remark of Edwin Nourse in his book *Economics in the Public Service*.

The economist has to consider a problem such as the recession on four different planes—namely, the planes of (i) economic analysis; (ii) institutional economics or economic engineering; (iii) economic politics; and (iv) economic statesmanship. Let me discuss each of these functions, using the recession problem as an illustration.

Economic Analysis

The economic analysis of the recession, like the analysis of a disease, has three aspects—namely, an analysis of the causes which brought the disease about; a prediction of the likely course of events, assuming that no special cure is administered; and a prediction of the influence which various possible medications could have in promoting recovery.

Causal analysis. An enormous amount of research work has been done, both on an empirical and on a theoretical level, to discover whether or not there is one typical cause of economic fluctuations. If there is a single economic virus which disturbs economic growth and stability, it is elusive indeed and changes its appearance from one economic epidemic to the next. In the present case it was pointed out early last year that the productive capacity of agriculture and industry was growing faster than the aggregate demand for agricultural and industrial products in real terms. This led to growing idle capacity and made it likely that business would reduce future expansion in plant and equipment. In addition to this most fundamental cause of the recession there were a number of contributing factors, such as a curtailment in defense orders, a drop in exports due to world-wide dollar shortages,

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