only conventional chemistry carried out under complicated conditions gives grounds for optimism, since it limits the boundaries of the problem. However, it also imposes a limitation on what might be expected from fundamental catalysis research. Most fundamental catalysis researchers do not rest their hopes on a single dramatic discovery which will make it possible to predict in detail the best catalyst for any specific reaction. The idea that catalysis researchers work with this goal in mind is as unrealistic as the idea that workers involved in practical catalysis development select constituents for catalysts by throwing darts at the periodic table. Although the fundamental catalysis researcher does not expect to advance ahead of general chemical knowledge, he does hope that he will not continue to lag behind. Infrared spectroscopy has provided a significant step toward closing the gap.

References and Notes

1. A. M. Buswell, K. Krebs, W. H. Rodebush, *J. Am. Chem. Soc.* **59**, 2603 (1937).
2. S. Brunauer, P. H. Emmett, E. Teller, *ibid.* **60**, 309 (1938).
3. M. R. Basila, *J. Phys. Chem.* **66**, 2223 (1962).
4. N. G. Yaroslavski and A. N. Terenin, *Dokl. Akad. Nauk SSSR* **66**, 885 (1949); L. N. Kurbatov and G. G. Neuimin, *ibid.* **68**, 341 (1949); ———, *ibid.* **85**, 1103 (1952).
5. R. S. McDonald, *J. Am. Chem. Soc.* **79**, 850 (1957).
6. J. H. de Boer, *Z. Physik. Chem. (Leipzig)* **B15**, 281 (1932).
7. H. P. Leftin and M. C. Hobson, Jr., *Advan. Catalysis* **14**, 115 (1963).
8. According to Beer's law, $\log I_0/I = kc$, where I is the transmission of the band peak, I_0 is the corresponding transmission of the background, k is the absorption coefficient, and c is a measure of the number of absorbing molecules in the beam path.
9. C. E. O'Neill and D. J. C. Yates, *J. Phys. Chem.* **65**, 901 (1961).
10. M. Courtois and S. J. Teichner, *J. Catalysis* **1**, 121 (1962).
11. R. P. Eischens and W. A. Pliskin, *Actes du Deuxième Congrès International de Catalyse* (1961), p. 789.
12. R. P. Eischens, S. A. Francis, W. A. Pliskin, *J. Phys. Chem.* **60**, 194 (1956).
13. R. P. Eischens and W. A. Pliskin, *Advan. Catalysis* **10**, 1 (1958).
14. L. H. Little, N. Sheppard, D. J. C. Yates, *Proc. Roy. Soc. London* **A259**, 242 (1960).
15. For present purposes a satisfactory indication of changes in band intensities may be gained by visual comparison of the bands in Fig. 4. However, quantitative intensity comparisons should be made on the basis of Beer's law (see *8*). To compare intensities the bands are replotted as $\log I_0/I$ versus wave number and the areas of the replotted bands are compared. The 8-fold increase was measured in this way.
16. D. J. C. Yates and P. J. Lucchesi, *J. Chem. Phys.* **35**, 243 (1961).
17. R. P. Eischens and W. A. Pliskin, *Advan. Catalysis* **9**, 662 (1957).
18. B. P. Susz and D. Cossimatis, *Helv. Chim. Acta* **44**, 395 (1961).
19. C. H. Amberg and D. H. Seanor, paper presented at the 3rd International Congress on Catalysis (1964).
20. R. A. Gardner and R. H. Petrucci, *J. Am. Chem. Soc.* **82**, 5051 (1960).
21. A. Nergaranian and M. C. Markham, *J. Phys. Chem.* **67**, 2679 (1963).
22. P. B. Weisz, *Advan. Catalysis* **13**, preface (1963).

Biomedical Science in Europe

Because of differences in their philosophies, Europe and America have much to offer each other in science.

R. P. Grant, C. P. Huttrer, C. G. Metzner

Modern science was born in Europe. Here, for 500 years, biological and medical research grew, and here its leadership has been, unchallenged by any other part of the world until the past generation. World War II was catastrophic for European science. In certain countries as much as 60 percent of the scientific manpower was lost—fled, killed, or exported. Hospitals and universities were destroyed. Virtually only a tradition was left intact. Now, nearly 20 years later, European science is approaching reconstitution, and its eminence is reemerging.

A rectangle in the middle of the map of Europe roughly outlined by lines connecting Rome, London, Stockholm, and Vienna has been the stronghold of European science. Here economic recovery has been most complete, cultural contact closest, and scientific restitution most rapid. In this article we attempt to study the patterns of scientific recovery in this part of Europe. This is an appraisal from an American point of view, in which developments in Western Europe are contrasted with those in the United States, for these two are the largest scientific communities in biomedicine.

European Scientific Community

The 12 countries of Western Europe (*1*) form an area barely one-fourth the size of the United States. Yet, 260 million people live there, as compared with 180 million in the United States. Together, they have 123 medical schools (the United States has 87), and in 1961 they turned out about 15,000 doctors, slightly more, per million of population, than the United States.

The relative size of the biomedical-research manpower pool in the two communities is difficult to determine. In 1960 the number of full-time medical faculty members in the United States was more than three times as large as the number in Western Europe. But the United States moved much more rapidly toward full-time staffing of its medical schools than Europe did. Furthermore, biomedical research is not confined to universities and medical schools in Europe, as it tends to be in the United States. For example, in Western Europe there are nearly 100 major "institutes" devoted to biomedical research which are independent of, although often situated near, universities. Some of them are government-owned and operated—for example, the Istituto Superiore di Sanità in Rome, which employs a thousand scientists and technicians. Others are mainly government-financed but are operated independently of the government or universities—for example, the 44 Max Planck institutes of West Germany, which together employ a thousand scientists. Still others are private, such as the Pasteur Institute of Paris, the Carlsberg Foundation in Copenhagen, and the Nuffield Institute in London. When we add the number of scientists in these institutes to the number on full-time staffs of the medical schools, we find that the biomedical manpower pool in Western Europe is very nearly as large as that in the United States.

But herein lies the largest single

The authors are affiliated with the European Office of the Office of International Research, National Institutes of Health, U.S. Public Health Service. The European Office is in Paris.

problem for European science. This is *not* a single community, even scientifically. The 12 nations included in this tiny portion of the world represent 12 vying cultures, and their peoples speak nine different languages. At its best, nationalism promotes pride in a country's achievements: Holland has her Boerhaave and Christian Huygens, England her Harvey, Germany a Virchow or a Koch, Sweden a Tiselius, France a Claude Bernard, and so on. At its worst, nationalism has fostered the warfare that has repeatedly swept across this part of Europe.

Today, the forces tending to pull European nations together are mainly economic. Surprisingly, science is not prominent among them. It is widely acknowledged that CERN (the European Center for Nuclear Research), the largest European scientific collaborative effort, is primarily the result of financial imperatives (the costliness of this type of research and its potential for industrial development) and secondarily the result of the intrinsic benefits of collaboration among scientists. Efforts to create an organization parallel to CERN in biological sciences (CERB—European Council for Biological Research) have not so far received much encouragement from European governments, perhaps because the financial imperatives do not generally apply to basic biologic research. Likewise, the various compacts among European nations on coal and mineral resources, atomic energy, space research, telecommunications, and so on, though they sometimes contain provisions for basic and developmental research, are born mainly of economic factors. The Common Market agreement has led to the establishing of more than 200 confederations to coordinate various commercial and professional interests among the signatory nations. Not a single one is primarily scientific. One of the original goals of the Common Market was to promote the free flow of professional medical personnel among member nations. This year, 6 years after the signing of the Treaty of Rome, the rectors of universities of member nations will meet to discuss a first step toward this goal, the equivalence of medical licensure.

To be sure, the vast expansion of private industry in Europe has led to a certain amount of internationalization of research. In the biomedical field such pharmaceutical companies as Phillips-Uphar in Holland, Bayer in Germany, Lepetit in Italy, Rhone-Poulenc in France, and firms in Switzerland and other countries (including the United States) have each created networks of factories and research laboratories throughout Europe as well as in North and South America. There is a considerable flow of scientists and technologies within these networks, but the internationalization remains mainly in the domain of competitive private industry.

Within the biomedical scientific community itself there are early but unmistakable signs of a search for a "European" identity. The International Brain Research Organization (IBRO), under UNESCO sponsorship, while an international, world-wide organization, has done much to coordinate European efforts in brain research, and a similar organization in cell biology, the International Cell Research Organization, has recently been established. There are also increasing examples of collaboration among European scientists. Within the past 5 years collaborative efforts in cancer chemotherapy, perinatal morbidity, tuberculin effectiveness, geographic pathology of heart disease, and so on, have brought European scientists together, often in collaboration with American scientists. In another pattern, small informal European "clubs" in such fields as endocrinology and pulmonary physiology have begun to appear, as an answer to, if not a protest against, the huge international congresses which, so far, have been nearly the only occasions when a European biomedical scientist would meet his colleagues from other countries. Finally, international research institutes, staffed by scientists from various countries (mainly European), are beginning to appear. For example, in basic biomedical fields, there are two in Naples—one in marine biology, the other in molecular genetics—which are mainly supported by the Italian Government but also receive support from other countries (including the United States). Another, in molecular biology, is in process of organization, sponsored by nearly 200 scientists from various European countries and Israel.

The Role of Language

Science depends upon the written word, and this is a major reason why a single biomedical scientific community has had difficulty in emerging in Europe. Western Europe may be divided into four groupings according to the language used for communicating science. The four languages are English (which tends to be the scientific language for the Nordic countries and Holland as well as for Great Britain), French, German, and Italian. No one of these four languages has been so conspicuously stronger than the others scientifically as to become a "voice" for biomedical scientists of other European nations. Nor is one of them likely to become such a "voice," because in many fields this role has already been assumed by American journals. The United States, with a scientific community larger than the four European groups combined, is served by a single language. With so many scientists to draw from, certain American journals have attained a scientific quality and authority that few European journals can match. Several have become the international voice for their field, a position they have strengthened by adding prominent scientists from abroad to their editorial boards. *Nature* in London and *Experientia* in Basel are perhaps the only European biomedical journals which regularly attract contributors internationally. As a result, European scientists often aim for publication in American journals rather than in their national media when they wish to reach an international audience.

The absence of a single "voice" for European scientists in a given field is paralleled in the professional societies. Just as among the 3000 biomedical journals listed in *Index Medicus* there are only two which carry the word *European* in their title, so there are only five officially listed "European" societies in biomedical fields; yet there are more than 70 "International" or "World" biomedical societies and hundreds of national and language-group biomedical societies in Europe. Perhaps the recently established European Federation of Biochemical Societies will set a pattern for European biomedical science in this regard.

Not only has the European scientist little opportunity to see himself as a part of a regional scientific community but he has no ready way to learn of more general scientific developments in neighboring countries. Great Britain is the only European country which provides in its biomedical journals editorial comment and news on academic and political developments in science similar to the comment and news offered in the American journal *Science*. And there are no European "forums" (and few national ones) for open discussion of broad aspects of biomedical sciences and education such as the American scientific community has in the American Association for the Advancement of Science, the American Association of Medical Schools, the Federated Societies, and so on. As a result, European governmental science administrators usually know more about developments in the United States than about developments in other European countries, and many European scientists know their American colleagues far better than they know their colleagues in other countries of Europe.

A potentially important unifying agency for European biomedical sciences is the European office of the World Health Organization (WHO). Although the European nations are among the largest contributors to the general fund of WHO, the European Regional Office receives the smallest budget of any of the six WHO regions (*2*). At present, all research conducted under WHO auspices is handled in Geneva. The European Regional Office, with its central offices in a handsome building in Copenhagen, uses its limited funds to promote conferences and training courses in public health problems common to its member nations, which include Russia and the European satellite nations. Its budget and its charter have so far not permitted it to play a role in coordinating European developments in biomedical research or in undergraduate and graduate medical education. Many hope it may grow in this direction, for the need is becoming greater and greater, as national support of science increases in the 12 countries.

A regional pooling of biomedical research and training resources has been attempted among the Scandinavian countries. In 1953 the Nordic Council was established, an interparliamentary advisory agency of Denmark, Finland, Norway, Iceland, and Sweden. Its purpose is the discussion of common problems which have no military or political implications, for, while Denmark and Norway belong to NATO, Sweden does not, and Finland is uneasy in its relation to Russia. The council has been especially active in medical matters. It created a Postgraduate School of Public Health in Gothenburg to serve the five nations; it has coordinated the arctic research activities of the member nations into a single organization, launched a common drug-evaluation agency, set up a science information exchange center, and established equivalent medical licensure for its member nations, which allows doctors licensed in any one of the five countries to practice in the others. Stimulated by the efforts of the Nordic Council, the national medical associations of the member countries have met together in recent years. This, in turn, has led to the establishment of joint refresher courses for physicians, pooling of resources for specialized residency training, and so on. While each nation continues to foster professional literature in its own language, English has been adopted as a second scientific language by all five nations, and all Scandinavian professional journals now use the language.

There is another reason why greater pooling of biomedical resources will be needed in Western Europe. Seven of the 12 economically advanced countries have five or fewer medical schools. With so small an annual output of candidates, these countries cannot expect to maintain excellence in all biomedical fields, and certain more advanced and costly fields of research must remain undeveloped. The United States, on the other hand, has the output of 87 medical schools to choose from, and it appears from published National Institutes of Health data that there may be 12 to 15 candidates in advanced training for each senior academic position which becomes open. This degree of winnowing for excellence is impossible to achieve in even the larger European countries.

As a result, international selection of senior staff is becoming more and more frequent in the smaller European countries. In 1963 Holland appointed to its science faculties seven professors who were nationals of other countries (two Italians, three Americans, one Swiss, and one German). In the Scandinavian countries, by common agreement, when a professorship becomes vacant in one of the countries it is advertised in the appropriate professional journals of all the others; anyone who believes himself qualified may apply, and nationality is not a major consideration in the final appointment.

The Administration of Science

Every advanced country now has one or more governmental agencies for the surveillance and support of science (*3*). This is primarily a response to the economic and industrial importance of science. The Organization for Economic Cooperation and Development (OECD) (*4*) has underscored the significance of science for national economics by conducting a major, exhaustive survey of the scientific and technologic resources of all its member countries. In 1963 OECD sponsored the first international meeting of Ministers of Science, or their equivalents, from all 20 of its member countries. That economic and industrial factors are the principal forces behind the forward surge of science in the Western world is evident from the fact that at least 80 percent and often 90 percent of the governmental budget for research in these countries is devoted to engineering- and industry-related research. Biomedical research, which has few industrial implications beyond pharmacology, receives quite a small part of national research budgets. In the United States, where the percentage of gross national product invested in research and development is the highest in the world, biomedical sciences receive 7 to 8 percent of the national science and technology budget.

While all countries have governmental science agencies, the organization of the agencies varies from country to country. Nevertheless, the governmental science agencies of Europe have certain features in common which distinguish them from U.S. agencies.

In the first place, the word *science* has a much broader meaning in continental Europe than it has in the United States or Great Britain. Virtually all fields of academic scholarship—philosophy, theology, history, archeology, philology, and so on—are considered "sciences" in these countries, and the organization of governmental science agencies reflects this broader definition.

Perhaps nowhere else is this broad interpretation reflected in the organizational structure to the extent that it is in Italy. There the National Research Council (Consiglio Nazionale delle Ricerche, or CNR) divides its authority and budget among ten committees, each representing a different "science." But the committees differ in size, each having as many members as there are "fields" in that science. For example, the law committee has only four members, but biology-medicine, the largest, has 24 (a zoologist, an anatomist, a geneticist, a cancer expert, and so on). To assure a completely democratic situation, not only is every "science" and every "field" given representation in the CNR but all of Italy's 2200 professors of science take part in nominating and then electing the 114 committee members. A single small committee appointed by the government and responsible directly to the prime minister apportions the funds among the ten committees, which have virtually complete authority within their domains.

In Holland, on the other hand, the primary aim has been to bring the research interests of private industry, of the government, and of the universities into a single pattern. Being a tiny country with limited research resources, Holland saw a need to protect research programs in basic science in the universities in the face of rapid growth of industrial research. Her solution is to have two agencies—one [Organisatie voor Toegepost-Natuurwetenschappelijk Onderzoek (TNO)] for "applied" research and the other [Zuiver Wetenschappelijk Onderzoek (ZWO)] for "pure" research; TNO supports clinical and public health research in addition to engineering and industrial research, while ZWO supports a wide range of scholarship in the humanities as well as biology, basic medical research, natural sciences, and so on. The two agencies are organized quite differently in order to encourage participation of industry in TNO. For example, while ZWO is entirely a governmental agency responsible to the prime minister, TNO is administratively independent of the government. Private industry is represented on its governing board, and a large portion of its budget comes directly from industry. Most countries of Western Europe have more machinery for including the scientific interests of private industry in the structure of their governmental science agencies than the United States has.

A still different pattern is seen in the United Kingdom and, generally, in the Scandinavian countries. Here, as in the United States, the word *science* is more narrowly defined, to embrace only the so-called "natural" and "biologic" sciences. As a result, in the United Kingdom and the Scandinavian countries the surveillance of medical science tended to emerge more directly from the government's concern with health matters than from its concern with education, as was the case in other countries on the continent. Accordingly, in the United Kingdom and the Scandinavian countries there is a body to guide biomedical research, generally called a Medical Research Council, which is more independent of other science-supporting agencies than are corresponding agencies in the non-Scandinavian countries on the continent.

It might seem cumbersome for the governmental science agencies of the non-Scandinavian continental countries of Western Europe to concern themselves with philosophy, archeology, law, and so on, in addition to natural and biological sciences. But as a German educator pointed out, "sometimes it is useful for a physicist or a medical scientist to have to defend his budget before a committee which includes philosophers and historians."

Methods of Financing Research

Another striking difference between U.S. and European machinery for supporting biomedical research is found in the funding method. The NIH (which is by far the largest single source of funds for biomedical research in the United States) in 1963 distributed over 75 percent of its total funds by a competitive project-grant method (*5*). It is difficult to obtain exactly comparable data from the various countries, but it appears that 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. Often these institutes are administratively within the government, and most of them are independent of universities.

Why is competitive project-support so little practiced in Europe? One reason is that establishment of the strong, fully subsidized research institute antedated the development of governmental machinery for financing research in most parts of Europe. In addition, the European professor has always had more power over the activities and financing of his department than his counterpart in America has had.

But there is another, more important explanation. In small countries with small populations of scientists a committee of "experts" selected to judge competing applications would often include most, if not all, of the scientists working in that field. The "conflict of interest," which occurs even in large countries when the consultants are themselves grantees, makes a competitive grant system impossible in a small country and difficult in even the larger countries of Europe. Departmental and institute subsidization avoids this problem by, in effect, basing the awards on the scientific stature of the director or professor rather than on the merits of individual projects.

The virtual absence of competitive grant mechanisms in Europe is responsible for one of the serious problems confronting European biomedical research: it is difficult for the young but experienced investigator to develop an independent research program or pursue his own research ideas. He is usually totally dependent financially upon his professor or institute director, and therefore often obliged to follow prescribed research paths. In addition, in virtually all European countries the opportunities at academic echelons corresponding to the levels of assistant professor and associate professor are extraordinarily scanty. These two circumstances conspire to create a bleak and frustrating career prospect for the young biomedical scientist in Europe. This is especially true in French- and German-speaking countries and in Italy, and in these countries the restlessness and agitation for reform by the young and middle generations of biomedical scientists are most manifest.

But a nation, to move forward in science, must have the advice of its scientists, even though they are themselves supported by the agency they are advising. Most European countries have found a way out of this dilemma by a mechanism which varies little from country to country and is little used in the United States. In effect, when the agency decides that a particular field of research should be examined for possible expansion, it gathers all the experts in that field together, gives them an annual budget, tells them how long funds will be provided, and gives them full authority in expending the funds. Usually, the special committee has periodic, combined business-scientific meetings and submits an annual report on its scientific and administrative progress in that field. The scientists, in effect, guide their own subsidization in a fashion calculated to exploit rather than avoid their double interest. The scientist not only gives advice but, now, shares some of the responsibilities for the agency's effectiveness. The "actions concertées" of France's Délégation Générale à la Recherche Scientifique et Technique, the "Schwerpunktprogramme" of the Deutsche Forschungsgemeinschaft in Germany, the "Imprezzi" of Italy's National Research Council, and, to a lesser degree, the "Research Groups" of the British Medical Research Council (MRC) are all variations on this approach, which is everywhere looked upon with enthusiasm in Europe.

Independent Research Institute

Government subsidization of large research institutes not affiliated with a university is perhaps most fully developed in West Germany, France, and the United Kingdom. Fully 50 percent of the biomedical research in these countries is carried out in institutions with no administrative and often little functional attachment to a university.

The oldest and, in many ways, the most successful system of such institutes is that operated by the Max Planck Society in West Germany. An outgrowth of the Kaiser Wilhelm Institute, which was established at the turn of the century, it now includes 44 independent institutes, embracing a wide diversity of humanistic and experimental sciences, 18 in biomedical fields. Generally, a Max Planck Institute is built around an individual of outstanding accomplishments rather than around a field. When a director dies or leaves, the character of the institute often radically changes to accommodate the scientific interests of the new director. Each institute is self-governing, its director having complete responsibility for its internal affairs and receiving a block budget each year from the society to cover all activities in his institute. The system is supervised by the society, of which all institute directors are board members. Although the society was originally privately financed, now more than half the society's funds come from the government, but it has lost none of its autonomy.

France moved in the direction of non-university-affiliated research institutes for quite different reasons, shortly before World War II. Many who recognized that French science was falling behind science elsewhere in Europe attributed this lag to the oppressive top-heaviness of the French universities. In an effort to solve the problem by creating something new rather than renovating what was old, the Centre National de la Recherche Scientifique (CNRS) was formed, to by-pass the inbred academic system. With a tightly centralized organization (perhaps the farthest removed from the Italian "democratic" method of any of the systems of Western Europe), CNRS has undertaken total subsidization of scientists both inside and outside the universities and a vast laboratory-construction and institute-creating program, which is still expanding. At present it operates 43 institutes and employs nearly 4000 scientists and technicians, covering all areas of science, broadly defined. With most of its funds going to natural sciences (biomedical sciences received less than 10 percent of the CNRS budget in 1963), the CNRS has played an important part in France's efforts to become a nuclear power.

While the CNRS has been a major factor in the resurgence of French research, its creation has been costly to France in other regards. Since the CNRS research centers are independent of the universities, the educational system has been neglected, and nowhere is this more apparent than in medicine. A far-sighted plan for reorganizing medical education (the first major reform in more than 50 years) was accepted by the French Government just prior to President de Gaulle's ascent to power, but it has made slow progress. To illustrate the magnitude of the problem, in 1963 there were more than 4000 freshmen medical students in the University of Paris—certainly one of the most overwhelmed medical educational establishments in the world.

Creation of the CNRS also left a gap in the field of medical research. In 1947 the National Institute of Hygiene (INH) was established under the Ministry of Health for the support of medical-school and hospital-based research. Its budget is roughly one-tenth that of the CNRS. It resembles CNRS (and other European agencies) in that most of its funds are used for its own institutes and laboratories, now numbering over 60. Earlier this year INH was reorganized, and it is hoped that this will bring about a resurgence of French medical research.

In the United Kingdom, also, overall subsidization of departments and institutes is a major method of research support by the government. For example, in 1963 the British Medical Research Council devoted 75 percent of its budget to 83 "Research Units," which are financed by, and administratively attached to, the MRC. The Research Units have a total staff of 3000, including 800 scientists. Most of the units are located in or near universities, and to this extent the contact and flow between the two types of institution are somewhat better than in Germany. Like a Max Planck Institute, an MRC unit generally has been built around a man rather than a research field. The British MRC has a modest competitive grant program; it awarded less than 300 grants during 1963.

The reason for the emphasis upon independent research institutes in Western Europe is partly historical. European universities and medical schools grew from loose aggregations of otherwise independent and autonomous professors, and the professors have, up to the present, resisted the development of administrative structures above them. In most parts of Europe the deanship of a medical school and the rectorship of a university are rotated posts of little power, while in the United States they are the fulcra of the administrative structure. The European professor has always been much more powerful than his American counterpart, and the fullest expression of his power has been to have his own relatively independent institute.

But the American approach of interdependent departments and a strong central administration in the medical school, a system already well developed in Sweden, is beginning to appear in other parts of the continent. The new medical school of the University of Bochum will be Germany's first experiment with departmental structure subordinated to a career dean. This is also to be the pattern in Italy's new medical school in Rome, Sacred Heart. (This is Italy's only "private" medical school; it is being financed by the Vatican.) The large "Clinical Research Center" complexes being built in Berlin, Munich, Leiden, Middlesex, and elsewhere are also new to most countries of Europe (though not to the Scandinavian countries) and demonstrate a growing recognition that departmental autonomy is incompatible with modern medical research and education.

While the days of the "powerful professor" are certainly numbered in Europe, the concept of research institutes independent of the universities is not. At their best, these are interdisciplinary aggregations of full-time senior scientists of essentially equal rank in a collaborative atmosphere, freed from administrative duties and from undergraduate teaching, concerned only with research and graduate training. The trend in Europe is toward more, not fewer, of these. European scientists point out that the needs and goals of medical research do not always fit with the needs and goals of undergraduate medical education. For example, the outstanding recent British contributions in molecular genetics came from MRC units which were established several years ago, long before genetics figured prominently in medical school curricula. And many feel that the remarkable strength of the Pasteur Institute in Paris in basic biomedical research is the result of the aggregation of so many senior scientists in related basic fields, an aggregation that no medical school could justify for purposes of undergraduate teaching.

The Plight of the Universities

With such a large proportion of funds going to autonomous, independent research institutes, how is university and medical school research supported in these countries? In France, both CNRS and INH subsidize departments and laboratories within the teaching establishments, the university paying only the professor's salary. It is intended that these units shall gradually become totally absorbed within CNRS or INH, the "irrelevant" undergraduate teaching responsibilities of the unit's scientists being thus reduced and finally eliminated, while the scientists remain within the academic atmosphere. Whether this will in time lead to two faculty populations, one (paid by CNRS and INH) devoted solely to research and graduate teaching and the other (paid by the Ministry of Education) solely concerned with undergraduate teaching, remains to be seen, but this is an acknowledged possibility.

In Great Britain and Germany a similar anxiety is expressed in many quarters—that the investment in relatively independent research institutes is creating two populations. But the fear is not that it creates a split into teaching and a nonteaching faculty but, rather, that it creates two vying populations of researchers. Both Germany and Great Britain have governmental agencies for the support of university and medical school research which are altogether independent of the agencies supporting the research institutes. In Great Britain, the University Grants Committee makes 5-year block awards for total university research needs; only a small part of its funds are available for competitive award to individual scientists in these institutions. In Germany, the German Research Association (Deutsche Forschungsgameinschaft) fills this role. Since education is a state rather than a federal responsibility in Germany, the Deutsche Forschungsgemeinschaft is relatively independent of the federal government; instead, representatives from each state sit on its board. It is altogether independent of the Max Planck Society. It receives funds from the federal government, from the ten states, and from private industry. In 1962 it made about 3000 grants to university scientists, about 20 percent of them in biomedical fields. The awards are made by a modified competitive mechanism. Total departmental subsidization is frequent, and the academic rank and scientific prominence of the applicant are important bases for award.

In the United States there is much concern within and without governmental circles about the effects of large-scale government support of research on the educational purposes of the universities and medical schools. This problem has not yet loomed very large in Europe. Sweden is perhaps the only country that has confronted the educational and manpower problems involved in training biomedical researchers and academicians. But the problem "research versus teaching" will certainly be no easier to solve in Europe because of the great emphasis on unaffiliated research institutes.

Government Philosophies of Research

Within the past few years four European countries have established Ministries for Science—Italy, France, Germany, and Great Britain. In Sweden, the recently created Science Advisory Council has nearly the same status as a Ministry. In all instances, the Ministry has no direct operating control over expenditures by government science agencies, and has a small science budget of its own, or none at all. It appears that it has mainly an advisory function, with major responsibilities for coordinating governmental, industrial, and university research. But the Ministry has perhaps an even more important role in that it brings the voice of responsible science into the highest echelons of national thinking. Which is cause and which effect may be debatable; nevertheless, in general it is true that those countries which have had strong governmental science organization have moved more rapidly toward adequate financing of science. The "voice" of science in government is relatively strong in Sweden, West Germany, and the United Kingdom. In Italy, Denmark, Switzerland, and Austria it has, so far, been much weaker.

Government support of science has been increasing rapidly in all economically advanced countries of Western Europe, having more than tripled since 1950 for the region as a whole. At present all 12 of the more prospering countries appear able adequately to support what might be called the "basal metabolism" of their scientific communities. Especially impressive is the capital investment in science in Europe. Everywhere, magnificent new laboratories and medical school buildings have arisen. Total transplanting of entire university and medical school complexes is under way in Göttingen, Utrecht, Liège, London, Freiburg, and many other cities. But everywhere one hears the rueful observation that it is generally easier to get governmental funds to build a new laboratory than to equip and staff it for optimal research. The architecture of European science is being modernized much more rapidly than its organization.

So far, none of the European countries has broadened its science-support philosophy to include international or even regional European needs. This is partly because none feels it has yet reached the level of providing optimally for its own scientists. To be sure, each makes its annual contribution to WHO, UNESCO, and CERN, and each has fellowship-exchange agreements with other countries. The science agencies of France, Great Britain, Belgium, Holland, and Germany support biomedical research in dependencies and former colonies. The Deutsche Forschungsgemeinschaft has made significant contributions to the support of research in Israel. All European countries have provided consultants and staff to assist less advanced countries in developing health and research resources. But no European country has machinery whereby a foreign scientist (European or otherwise) can apply for financial support, and none have specific programs which might encourage their scientists to collaborate with scientists of other countries.

Role of the United States

The United States has played an exceedingly important part in the recovery of European science since World War II. No aspect of American culture has been more warmly received in Europe than its biomedical research and educational innovations. American participation has taken two forms; one is financial and the other might be called conceptual.

In the immediate postwar years, the Marshall Plan channeled large amounts of U.S. money into industrial and municipal reconstruction, which indirectly helped tremendously to restore Europe's academic and scientific life. The Rockefeller Foundation early recognized the desperate need of the universities for direct help. In the 20 years since the war it has made more than 1500 biomedical research grants, totaling nearly $20 million, in western Europe (including Hungary, Poland, Yugoslavia, and Czechoslovakia). During the same period it provided more than 500 fellowships for young European scientists for study in the United States. Many other American private foundations and private interests have contributed funds for European academic recovery.

But the largest direct financial contributor to the recovery of European biology and medicine has been the United States Government. The National Institutes of Health made its first research grant to a European scientist in 1948, and in the years since then NIH support of European research has steadily grown (*6*). In 1963, NIH made 530 grants to scientists in Western Europe and the Middle East, totaling about $8 million. This was nearly half of NIH's total support for biomedical research overseas, apart from grants to WHO, the Pan American Health Organization (PAHO), and other international organizations. Since 1954, the Department of Defense has been another important American source of support of basic research in Europe. The three military arms of the Department of Defense (Army, Navy, and Air Force) together awarded over 450 grants or contracts to European scientists in 1963, totaling about $6 million, of which one-fifth was in biomedical sciences. Other U.S. agencies, such as the Atomic Energy Commission, the National Science Foundation, the National Aeronautics and Space Administration, and the Department of Agriculture, have also supported European scientists, often in biomedical fields. 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.

The U.S. support has often been crucial in sustaining European scientists during the period of their nation's economic recovery. But the United States, by serving as a training resource for young European scientists, has provided another type of assistance which may, in the long run, be even more important. Many graduate European physicians seek internship and residency training in U.S. hospitals. In 1962 about 1500 European physicians took the examination of the Educational Council for Foreign Medical Graduates, required of all noncitizens before they are accepted for clinical training in accredited U.S. hospitals. Even more significant, perhaps, is the number of young Europeans who are accepted for research training in American laboratories, for from this group come a large proportion of Europe's present and future scientific and academic leaders. In 1962 over 1000 young scientists from 35 different countries received biomedical research training in the United States, supported by fellowships or traineeships from NIH. Additional hundreds were supported by other American sources or by their own nations. The vast majority of these young scientists must, by U.S. law, return to their country of origin when the training is completed.

While the financial contribution of the United States has helped sustain European biomedical science, the training programs are helping to transform it. The young Europeans have learned more than technologic and scientific skills while in America. They have been exposed to what, for many, is a radically different and liberating atmosphere in medical research and education, and this has often been the most important and persisting part of their experience. It is often called the "American approach," and it is characterized by small-group teaching, early independence of the young investigator, student-professor informality, full-time clinical faculties, team-research among scientists of equal rank, absence of academic hierarchism, free movement of scientists among institutions, and interdepartmental collaboration in research and education.

With the passage of time, more and more Europeans who have had the American experience are moving into positions of prominence in their own countries. It is probable that about 80 percent of European academic leaders have visited the United States, and fully 60 percent of the present scientific leaders have had definitive training experience in U.S. laboratories.

The new generation is attempting to reform European medical, scientific, and educational patterns, stimulated by what they saw in America. Everywhere in Europe one sees evidence of the struggle and early signs of change. Multiple professorships in a single department have at last appeared in Germany, striking at the heart of hierarchic departmental structure. In the past decade all but one of London's 12 medical schools have been converted to a system of full-time clinical faculties; about half the huge medical faculty of the University of Paris is now on a full-time basis, and the system of full-time faculties has made its first appearance in Italy at the University of Pisa. "Clinical clerkships" and other forms of small-group teaching are replacing the large formal lectures of the past, and the "Clinical Pathology Conference," first introduced in Boston, is spreading throughout Europe. A system of entrance examinations, together with limitation on the size of entering classes, has been finally accepted in Germany, France, and certain schools in Italy, and capitation fees, (an arrangement whereby the student pays the professor for each lecture attended) are becoming a thing of the past.

Today there are many European laboratories which are technologically and scientifically equal to American laboratories, and perhaps sometimes superior to them. But the American experience is still considered indispensable for the aspiring European scientist. It is an old joke in Great Britain that, for the young man to move ahead academically, he must, after his M.D., get his B.T.A. (Been to America).

The Different Paths of Biomedical Science

What happened in Europe in recent generations to so retard its evolution in medical research and education? Prior to World War II, Sweden was virtually the only European country where science and education had been able to change substantially with shifting social and scientific requirements. This no doubt is part of the explanation for Sweden's emergence during the past generation into biomedical leadership, despite its having a scientific community less than one-fourth that of Germany, France, or the United Kingdom and one-twentieth that of the United States.

Elsewhere in Europe, since the turn of the century, medical science and education had been increasingly succumbing to the oppressive, stagnating influence of hierarchic structures. The power of professors had so increased that the educational purposes of the universities were being subordinated, and the nature of the professors' power frustrated efforts toward modernization and reform. For the first 40 years of this century there was virtually no expansion or evolution of medical education in Europe. During this period only a single new medical school was established in the United Kingdom, and only two were established in France. In 1957 the Debré plan brought the first curricular changes in French medical education to be introduced for over 50 years. Botany, Greek, Latin, and classic Materia Medica still encumber the curricula of many Swiss, Austrian, Italian, and German medical schools. The idea of having a full-time clinical faculty did not appear in Europe until after World War II. Clinical departments were, and often still are, built around the private practice of the professor. The grooming of sons and nephews for dynastic succession to professorships has persisted even into the present decade in France and Italy.

In the United States, on the other hand, reforms introduced early in the 20th century prevented the development of the inertial traditions that encumber European medical schools. Organizationally, many of the powers of the European professor were transferred to a career-appointed dean, a professional category unknown in European medical schools until very recently. Without power enclaves, it was possible for American institutions to experiment with patterns of education and science organization and to adapt to changing social and scientific circumstances. Certainly this flexibility accounts in large measure for America's emergence into leadership in biomedicine within barely two generations.

There is perhaps another, subtler factor which contributes to the difference in evolution between American and European science. In mid-century, the United States is, in a philosophic sense, committed to the scientific method as a major line of attack for bettering the circumstances of human life. In Europe, on the other hand, science is greatly admired for its intrinsic scholarship (more perhaps than in the United States), but its pertinence to important aspects of human life and death is less widely and less intuitively accepted. Existentialism expresses some of this difference. While the popular faddism of "existentalism" has passed in Europe, as it has in America, nevertheless existentialism has had a profound influence on European thought, even in scientific circles. In the view of the existentialists, science deals with the commonality of the external aspects of life. It has nothing to say about the internal uniqueness of existence, which, to the existentialist, is where the crucial problems of the human condition are found. Europeans do not doubt the usefulness of science, but many are uncertain about its primal importance.

There are several subtle manifestations of this difference in point of view. Perhaps it is most vividly illustrated by the fact that the main support of biomedical research in the United States comes from a group of institutes (NIH), most of which carry "disease" labels: cancer, heart, arthritis, neurologic diseases, and so on. In no European country is this pattern seen. Indeed, in many continental countries, medicine, especially clinical medicine, has not even been considered to be among the "sciences" until recent years. In two countries governmental councils for medicine have been added only in the past 2 years, corresponding to the councils of biology, mathematics, and so on, which have existed for many years.

Another manifestation of the difference in point of view is the continuing popularity of the cure resorts and health spas of Europe, each accredited for the treatment of specific ailments by virtue of subtle characteristics of its water or its climate. This centuries-old practice still has a strong, mystic hold in lay and even professional circles. The 70-odd spas in France, the 200 or so in Germany, and the scores in virtually all other European countries are "licensed" by the governments, and, in many instances, government-financed, despite the evidence and conviction among academic medical people that there is little or no scientific basis for their allegedly specific curative properties.

The difference in philosophy between the United States and Europe with respect to the aims of medical science was succinctly expressed at a recent conference in Paris. An American scientist was describing a large-scale, controlled study of the factors influencing the incidence of myocardial infarction in man, when a French cardiologist whispered: "You Americans amaze me! There you are, busily trying to prolong life, when we French haven't even decided what it is!"

But within the difference in philosophy toward science is also to be found the richness Europe and America have to offer each other. While large numbers of Europeans come to the United States for the "American experience," increasing numbers of American scientists are coming to Europe to study in European laboratories. There are 18 different institutions in Europe which regularly have three or more visiting American scientists in residence. More than 30 American scientists were studying at the Pasteur Institute last year. The Weizmann Institute in Israel, the Medical Research Institute at Mill Hill, in England, and the Karolinska Institute in Stockholm attract equally large numbers. In 1962 NIH provided 208 postdoctoral and sabbatical fellowships (the "sabbatical year" is unknown in Europe) to American biomedical scientists for study in Europe. Guggenheim, Rockefeller, Commonwealth, and other foundations also provide fellowships, and under the Fulbright Act travel expenses are paid for large numbers of Americans who study in Europe.

It is not only a technologic experience which the American scientist seeks in Europe. Science has a dimension in Europe which is hard to find in the United States. Partly this is historical. To walk along the turbulent Rue Claude Bernard in the Latin Quarter of Paris near the ancient medical school where Laënnec, Paré, and Charcot once taught; to see the Leeuwenhoek microscopes and Einthoven's bow and arrow for pulling quartz-strings for his galvanometers in dike-girdled Leiden; to visit the Teatro Anatomico in Bologna and the Billroth surgical amphitheatre in Vienna—this is only part of it. Beyond this are the cultural depth and philosophic self-criticism of the modern European scientist. His training and demeanor as a scientist derive from the European strife and cultural vicissitudes which created science. If there is an "American experience" which is transforming European biomedicine, there is also a "European experience" which is enriching and strengthening American science.

Persisting Problems

No longer is lack of funds for research the most pressing problem in the biomedical sciences for the more advanced countries of Europe. Governmental support of research is increasing everywhere. While nowhere in Western Europe does the percentage of gross national product devoted to biomedical research equal that of the United States, in Sweden it nearly does, and in most of the other countries the percentage is rapidly rising.

The big remaining problems relate to manpower and the circumstances of the scientist. The salary of scientists and academicians is seriously inadequate in many parts of Europe. This is partly because scientists and academicians are paid by the government. Holding down government wage and salary levels has been a prominent part of Europe's constant, but not very successful, battle against inflation. In Italy the academic salary is so low that it is treated as half-time payment, and many Italian scientists have two jobs—an arrangement made convenient by the 4-hour midday siesta in Italy. There is only one clinical department with a full-time staff in all 22 of Italy's medical schools. And at Sacred Heart, the 3-year-old medical school in Rome, so far all professors are "half-time," holding simultaneously another professorship at another medical school. In northern European countries the salary situation has been much improved in recent years. Scandinavian countries have long had full-time clinical faculty, and, in more recent years, France, Holland, and Great Britain have adopted the practice.

A serious personnel problem in European biomedical science is the problem of attracting young people to scientific and academic careers. Salaries at intermediate academic levels are exceedingly low in most countries, and succession is slow and uncertain. The ratio of the number of positions at the assistant and associate professor levels to the number of professors is, on the average, about a third that for most American medical schools. Research fellowships are exceedingly scarce throughout Europe. There is no exact word for "fellowship" in the French language—nor does it exist in CNRS or INH budgets. Sweden and Denmark appear to be the only countries with research training programs in biomedical sciences as comprehensive as those in the United States. In these two countries there is specific planning, with salary increases for each advancing stage. The young man interested in research can see before him a progressive career in science which, while competitive at all levels, offers the possibility of a reasonable income, position security, and progressive independence until he is ready to compete for a professorship.

With national economies booming and financial support of research rising rapidly in Europe, why has there been so little provision for research training and the support of promising young scientists? Undoubtedly it is because these are needs which nonscientist government officials and legislators are slow to appreciate. It is well to realize that, in the United States, too, it was not until nearly 8 years after NIH support for costs of research projects was reasonably adequate that the training programs of the various NIH institutes received full congressional support. Perhaps Europe will show a similar lag before its scientists and educators are able to persuade their legislators that a scientific community is no stronger than its scientific training program.

Summary

European biomedical research is now in full resurgence, 19 years after the devastation of the World War II. The more advanced countries of Western Europe are gradually approaching a position of economic self-sufficiency with respect to research. However, certain problems persist. Lingering nationalism and language differences continue to inhibit Europe from finding its full strength as a scientific community. Educational reforms, manpower planning, and scientific support still lag far behind the technologic recovery of science. International pooling of scientific interests and activities, so necessary for the smaller countries, has been slow to develop.

The bonds between American and European biomedical science are extraordinarily strong and healthy, the result of the huge flow of young Europeans to America and of American scientists to Europe for training. These training exchanges have done much more than extend technologic competence. The two communities, one European, the other American, have different attitudes and atmospheres for research, which complement and strengthen each other. The benefits which lie in collaborative research and training among laboratories of the two communities are becoming more and more apparent and no doubt will lead to new levels of creativity and productivity in biomedical research.

Notes

1. The 12 countries are Austria, Belgium, Denmark, France, Finland, West Germany, Holland, Italy, Norway, Sweden, Switzerland, and the United Kingdom.
2. The six regions are Africa, the Americas, Europe, the Eastern Mediterranean, Southeast Asia, and the Western Pacific.
3. Many "unadvanced" countries do also. There are, for example, at least 30 countries in the world with "atomic energy commissions"; some of these countries do not yet even have a university.
4. The OECD is successor to the economic council which guided the Marshall Plan; it is now an intergovernmental economic agency for Western European countries, the United States, Canada, and Japan.
5. In this method, awards are made only for the immediate costs of a specified research project. Applications are judged competitively on the basis of the scientific merit of the proposed project, by nongovernmental experts in the applicant's field of research, and without consideration of the departmental status or academic rank of the applicant. The scientific stature of the applicant may influence the making of the award but is not the primary consideration.
6. In accordance with the laws governing NIH, research grants are awarded on a competitive basis, applicants from the United States and from overseas competing for the same funds. Awards are made solely on the basis of the scientific excellence of the project, regardless of the nationality of the applicant. However, certain fiscal and program restrictions have always governed overseas awards.
7. The comments and opinions expressed are those of the authors and do not necessarily represent views of NIH.