data transmission, is to inaugurate a policy of varying prices with the time of day. During "off-peak" periods, communication-satellite systems will have large "excess capacity." Once the system is in operation, the cost of using the excess capacity will be slight. Thus, it may be possible—say, during the night—to use the satellites for transmitting facsimile mail and taped television or data at very low prices. Unless some such arrangement is made, the potential demand for such uses is likely to be small.

If a low-cost method is found for bringing closed-circuit television into homes and offices, this could generate an important demand for international communication capacity, probably a much more important demand than that of commercial television. Though much more expensive than telephone, it would provide a close substitute for travel for many business and official purposes.

Thus new forms of international communications—probably some kinds that are not recognized today—will add something to the demand for capacity. Whether they will dramatically increase total demand or will have only a modest effect is hard to say.

Communication satellites promise substantial reductions in cost, as compared to the new submarine cables, if high rates of utilization can be achieved. The real question, therefore, is demand: Just how soon will demand be sufficient to support such systems? If we judge on the basis of past growth of international telephone traffic, plus possible channeling of telegraph traffic and potential new uses, that day may not be too far in the future. That does not mean it will be next year, however, or even 1965, but some time thereafter (*2*).

References and Notes

1. F. R. Kappel, "Communications in the space age," lecture delivered at the University of California, Los Angeles, 29 June 1960.
2. The research that serves as a basis for this article was performed for the Long-Range Studies Committee of the National Aeronautics and Space Administration, Washington 25, D.C.

Dilemma of Academic Biology in Europe

University customs steeped in the past make difficult the development and retention of creative scientists.

William V. Consolazio

The observations reported in this article are the result of approximately a year's stay in Europe, recently made possible by the National Science Foundation in its newly inaugurated advanced study program set up for the purpose of augmenting the skills and understanding of its career scientific staff.

The deeper I probed into this survey of the organization and the needs of European academic biology, the more I became convinced that whatever I reported would be a first approximation to a most complex and singularly important subject. In spite of extensive effort, the time I spent abroad proved much too short for the needs of the task. Several specialized biologists could have been profitably occupied at this chore, each spending as much time in each of the countries I visited as I did on my entire trip.

I would like to begin by defining a few terms. Although I have used the term *science* throughout this article, I refer specifically to the biological sciences in the broadest sense. I have written about European science. Actually, I refer to science in Europe west of the Iron Curtain. I visited all but two countries in Western Europe. I include Israel, not only because I visited there but also because, intellectually, Israel is part of the West.

I visited as many centers of research as time and my professional interests permitted; however, I visited people rather than institutions. Before I left the United States I prepared an itinerary based on the recommendations of many American experimental biologists who know Europe and whom I hold in great respect.

It is a truism that science is international; it knows no national boundaries. It is also axiomatic that whether or not there is science in a country, or whether there is a good or a bad science, depends on the number, quality, and training of the nation's scientists, the availability of research funds, the extent of the nation's educational facilities, and the state of its research equipment and laboratories. But more than this, the nature of a nation's science depends on the intellectual and scientific traditions and attitudes of that country—I would say on the intellectual and scientific receptivity of a nation. One thing is clear: no nation has a monopoly on intelligence and on scientific potential. Bright young men and women are just as common in the more unfortunate and poverty-stricken countries as they are in the wealthier and intellectually more highly developed nations. The only difference between the haves and the have-nots with respect to scientific potential lies in the fact that in the more fortunate countries young people are better trained and utilized, and that the potential is thus more fully exploited. Despite our self-castigation, we in the United States don't waste nearly as many young people as are wasted in Central and Southern Europe.

It is well known that, of the countries I visited, science is most highly developed in the British Isles, in Israel, and in Sweden. There are pockets of scientific activity of very high quality in most of the other countries of Western Europe, but on the whole one can say that as one proceeds south, both the quality and the quantity of scientific activity decline. But let me add

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quickly that the best southern European scientists are as good as the best Swedish and British; they are fewer, and they work under considerably more stressful and less rewarding conditions. Southern European scientists are considerably more isolated; they have heavier teaching loads; their facilities are more primitive; their pay scales are very low; and the student body is unselected and is rarely trained to follow a career in science.

The most productive European scientists I met all had a common training. In general, they had all been trained in the same scientific centers, both in Europe and in the United States. All came from a common mold and had become siblings through education. It also is a fact that all productive scientists in Europe read and speak English, most of them fluently. English and American journals and monographs predominate in their libraries—an indication of the dependence of European science on English and U.S. publications and of the universality of English in the scientific world.

Of great interest in this connection is the significant number of productive European scientists who have at some time in their careers received support from the Rockefeller Foundation, either in the form of a fellowship or indirectly through grant funds. This record of the Rockefeller Foundation is one of which Americans should be exceedingly proud. It also demonstrates the value of the grant-in-aid system of supporting science. Rockefeller Foundation funds have always been in very short supply. They have always been employed as catalysts, and the high points of European science attest to the past effectiveness of this system.

World Wars I and II played a significant role in the decline of science in Central and Southern Europe. The disruptive effects of the two wars, of course compounded by Fascism and Nazism, drove some of the best experimental biologists out of Germany and Italy. A few of these experimental biologists went to the British Isles and Scandinavia; the majority came to the United States. Europe still has to recover from this catastrophe. But it seems to me that Europe has lost its dominance in science for reasons other than the wars. Independent developments in the new world; nationalistic, linguistic, and cultural barriers; and economics—all have taken their toll. It is to some of these issues that I address myself.

Why Biologists Leave Europe

Scientifically, Europe is being outstripped at a relatively fast rate by the United States. Although Great Britain, Sweden, and Israel are increasing their research activities, by comparison with the increase in the United States, the increment is small. This results in the emigration of far too many able young people from Europe to the United States. Very few Americans seek permanent scientific employment in foreign countries, with the exception of those who seek it in Israel, so that the movement of scientists is practically all in the direction of the New World and, primarily, of the United States. Emigration begins when young people seek further training abroad. Exposure to the great scientific centers of the United States and a taste of our high standard of living exert an irresistible pull on them. By contrast, a return home often means a lack of opportunity to grow intellectually and difficulty in supporting oneself and one's family. It is logical, then, for these young people to seek permanent residence in the United States.

Europe has neither enough trained people nor the facilities to exploit the many scientific breakthroughs that still occur there. This discouraging state of affairs is very frustrating to an individual who makes a fundamental discovery and then has to stand by and watch it being exploited in a prosperous country like the United States. Those who have had this experience once or twice soon break out and leave.

With respect to the criticism leveled at the New World for proselytizing these young people, my answer is that society is the beneficiary when there are nations that, from whatever motivation, give assistance to deserving young people.

However, we in the United States should make every effort to encourage the young people who come here for training to return home when they have completed their training. I believe we should do it by persuasion and by helping to modify conditions at home and not by legislation. Nevertheless, it is good for Europe to find the United States competing for its young people. This competition forces political and educational authorities to focus attention on the problem of emigration. When attention is drawn to the problem, reforms are inevitable. We ourselves can help these returning young people by giving them financial aid until they become established in their home environment. It does no good to train them in the techniques of modern experimental biology and then banish them to a desert to count sand particles.

The late Enzo Boeri, who had to live with the problem, described it more dramatically than I can. "History teaches us that when freedom of thinking, speaking, and writing was acquired, a second step appeared necessary: freedom from want. What is the use of my freedom of thinking, speaking, and writing—claimed the poor—if I starve? What is the use of my freedom of thinking, speaking, and writing if I am a teacher of experimental science and I have no money to plan and make experiments? We must extend the old concept of academic freedom and take it also to mean freedom to act, freedom to perform one's academic function without being compelled by poverty to inactivity" (*1*).

Unfortunately, any system of foreign aid that absolves the home country from financial responsibility for establishing its young people encourages further irresponsibility. It may well be that foreign aid should be tied to a matching-fund system irrespective of whether the aid or the matching-fund comes from private or public sources.

Science in Israel

The size, population, and economic status of a nation bear little relationship to the quality of that nation's science. In my opinion science in Israel—a relatively new state not much bigger than New Jersey, with a population of some 2 million and with phenomenal social and economic problems still to be solved—is of higher quality and better developed than that in any country in Western Europe, with the possible exception of Great Britain and Sweden. The Israelis have harnessed their energies collectively to raise the intellectual standards of their country. Their political and scientific leaders are responsive and responsible. This is a country where intellectual ability is held in very high regard, and where the people are willing to impose on themselves a tax structure which is practically confiscatory to raise the standards of living, higher education, and science. These people make the most of every foreign opportunity available to them. They spare no effort or expense to send

their best young people abroad for training, and then they make it advantageous for them to return. As I said earlier, Israel is the only country that has been able to attract U.S. scientists as permanent residents. Part of this, of course, is due to the fact that some American Jews have identified themselves with Zionism, but a good deal is also due to good working conditions in Israel. Scientific tradition in Israel is but one generation old. But Israel has imported and adopted the best of the Western scientific tradition—scientific honesty, respect for merit, self-criticism, and rewards based on competence.

Traditions and Nationalism

Italy and Southern Europe, on the other hand, where the scientific tradition is old, have retained many of the symbols but few of the ideals of science. I am convinced that the "institute"—the administrative unit for academic science and education—is partly responsible. It is headed by a director who is also, except in rare instances, the only full professor. An institute may contain any number of staff members, varying from one or two (usually the rule) to numbers that approach those of our more highly developed university departments, but staff members are usually junior and subservient. The few able and productive directors make a substantial effort to develop an attractive environment for a creative staff, but attractive environments are the exception rather than the rule. The director of an institute holds power of livelihood and promotion over his assistant. As someone put it, the institute directorship, at least in Southern Europe, constitutes the last stronghold of feudalism. The director is a potent force because in Europe the university is usually a federation of colleges or institutes, or both. He holds membership in the academic senate, which is in most cases the administrative and executive arm of the university. Rectors and deans are rarely selected for executive ability; positions are usually honorary—a relic of the pomp and pageantry of the past. It is this academic senate that stands in the way of many of the reforms that are so badly needed in the European university.

Junior faculty members seeking permanent university appointments tend to cultivate the good will of the institute director and of members of the academic senate rather than to concentrate on scholarly accomplishments. It is the tragedy of many European universities that their young people must cater to the powers that be if they are to receive rewards. In a system where youth is subordinate to age and the elder scholar happens to be a brilliant individual, the young man may suffer but society and science nevertheless gain. If, on the other hand, the same youth is exploited by mediocrity, everyone loses. Unfortunately, in any society mediocrity is more apt to be prevalent than genius.

In many of the old and great medical schools of Europe there are still no institutes or departments of biochemistry and microbiology. Every European university has an institute of zoology and one of botany, but none of biology. Under the present system, if one wanted to introduce genetics, embryology, microbiology, or biochemistry into a university curriculum, it would be necessary either to create new "chairs" (new institutes) or to see to it that an individual who received his earlier training in an older discipline seeks further training in the newer one. Institute directors will be likely to resist appointing, for example, a biochemist or microbiologist to an existing "chair," such as human physiology or comparative anatomy, unless the candidate began his career as a human physiologist or an anatomist. Efforts to introduce the newer disciplines through this system have not been very successful.

Even more resistance greets proposals to create new institutes. Creation of new institutes would encroach upon the prerogatives of existing institutes and directors and threaten the present power structure. The professor's salary still depends to a large degree on the number of students registered in his course. In many European medical schools the funds resulting from clinical analyses (blood and urine analyses) revert to an older department within the medical school. It would be natural for the professor of an older department to resist the creation of new institutes with which such funds might have to be shared. There is also severe competition in the graduate faculty for the few graduate students. No one wishes to diminish the number of students in his own course by sharing them with a new colleague.

Does the size of a nation bear any relationship to the breadth and depth of its science? The fact that a nation is small does affect the type and the variety of its science, the example of Israel notwithstanding. It is economically impossible for a small nation to support research of the breadth and depth of that going on in the United States today. One finds very highly advanced physical and chemical biology in Sweden, for example, but one doesn't find the same depth in the other branches of biology. One finds some of the world's best intermediary metabolism and protein chemistry in Great Britain, but not an equally potent genetics. It is economics, to a large extent, that stands in the way of developing breadth. But economics is by no means the only or even the primary factor. Nationalism and the limitations imposed by the manpower pool play an even more significant role. The manpower limitation, however, could be overcome were it not for nationalistic barriers. The European environment is not conducive to the importation of scholars from foreign countries. In the United States, academic and scientific personnel at least cross state boundaries. Such exchange, of course, is the source of our national strength economically and of our scientific strength, too. But in Europe scientists do not often settle in countries other than their own. The many national and intellectual barriers get higher and more difficult to surmount, with the result that European science becomes more isolated and provincial.

European universities are old. Some go back to the 10th and 11th centuries. They began as institutions for the training of the clergy and were used later for training in professions associated with the humanities—law, linguistics, literature, and so on. It seemed to me that too many European universities are much as they were when they were established; they have changed very little. They are still dominated by classicists. Descriptive biologists still speak for biology, and they cling to what they have. Just as long as these groups are dominant, they are a power to be reckoned with. Classicists and descriptive biologists tend to delay modernization of the university to accommodate modern science and seem fixed in their belief that one professor suffices for a department. In many respects the professors in old-line disciplines fulfill their responsibility to the university by their teaching. They need nothing for their research but their collections, the library, paper, and pencils. Consequently they seem to have little appreciation of the nature and needs of modern experimental science. Modern laboratories and the establishment of a departmental

structure are matters foreign to their understanding.

The academic atmosphere in Europe is somewhat more relaxed than its counterpart in the United States. In spite of this, in the past Europe has produced much of the great science of the world. There is no paradox here—all agree that great thoughts are nourished in a leisurely atmosphere. The combination in the past of a relaxed atmosphere at the summit and an ever-replenished pool of youth dedicated to furthering the aspirations of the leader proved most profitable. Unfortunately for this system, young people the world over are in rebellion against exploitation and especially against traditional ways that perpetuate the status quo. But although there is a stirring and an unhappiness, little change will occur till the youth are encouraged to develop independently, till those who have emigrated are encouraged to return home, and till scientists and teachers are encouraged to cross national and disciplinary barriers.

For comparison, one can point to the fact that no small part of Israel's scientific success can be traced to its spirit of internationalism. Its scientists and its science are truly international. Our strength here in America stems from a highly competitive system and from the same international outlook. As long as universities in the United States continue the practice of competing vigorously with each other and with international universities for the best minds, just so long will our science remain strong.

Economics of Academic Biology

The creative life of the university in Europe is still best suited to the upper-upper classes, those of noble birth and wealth. Not too long ago those seeking careers in the university were expected to be individuals of private means. The university was not an employer of educators and scientists, as it has come to be in the United States. Many universities still fail to realize that teaching and research are professions associated with a livelihood. Consequently, academicians without private means of support must look to extracurricular sources for their living, for the university is often incapable of meeting its financial obligations to its employees. There is no longer a place for the dilettante in science; science has become much too complicated, too expensive and competitive, and government, the major source of support of European universities, has not yet assumed its full responsibility.

In 1953 Italy spent $23 million on its universities and high schools (*1*). This amount was to meet the educational needs of a population of approximately 40 million people. These figures include all expenditures—for buildings, salaries, libraries, research, and so on. If I can trust my memory, figures for the United States for higher education alone and for the comparable period were of the order of $3.5 billion. The U.S. expenditure was for a population approximately 4 times the population of Italy but, as I said, for higher education only. What can one do but keep salaries low if the funds available for education are so pitifully small? And how can we expect more than one professor per institute? Under these circumstances, the talented youth without hope of tenure or the security of a sponsor would be foolish to elect academic science as a career, for he could never give his full energy to research and teaching. To expect to do so would be unrealistic.

Except in rare instances, all support for higher education in Europe comes from taxes. Consequently, salaries are generally standard and comparable throughout universities and throughout the civil service structure. Therefore, there is little incentive to move from university to university and from civil service to university, and vice versa. There is still too little competition from industry, since there is little intellectual and social reward associated with an industrial career. The academician is held in great respect in Europe, but prestige in itself is insufficient to make the academic career attractive. I do not want to create the impression that salary is the only motivating factor in a scientist's life, but where the standard of living is low, money takes on great importance. Under low-income conditions creative people who are wholly dependent on salary will and do seek other professions or leave for greener pastures.

A Need for Change

Governments in Europe, it seems to me, have leaned over backward in their effort not to interfere and have deferred too much to university committees, sometimes piling one committee on top of another and thus further weakening university administration. The academic world in Europe is thus without "executive" officers who could become responsible for modernizing and upgrading the university.

I am convinced that the individualistic, "efficiently" administered American university, both public and private, with all its disadvantages, is to be preferred above any of the types of institutions of higher learning I have seen in Europe. If nothing else, American universities at least offer variety and competition.

Ways must be found to upgrade science and the teaching of science in Europe. Modification of the existing university structure offers hope. But this avenue of approach from within is slow and painful. The most logical and most effective device lies in the development of international institutes of science and technology. Those Europeans who think about such problems strongly advocate such a development. Institutes of this kind are the Technion in Haifa and the Institute of Science and Technology at Imperial College, London. A study group of the North Atlantic Treaty Organization has recently advocated similar developments (*2*). In contrast to the over-all institute, covering science and technology, establishment of specialized institutes has been suggested, such as institutes of cell biology. The advantages and disadvantages of these approaches have been discussed by many, and I do not consider them here. Suffice it to say, I feel quite strongly that international institutes, to serve as model sysems, offer the only real hope of change, and that the more specialized institutes hold the greater promise.

These model institutes should be under international management and, preferably, funded from private sources. At the beginning they ought to be staffed by nonnationals. Only an international institution can be free from local economic pressures and from efforts of competing institutions to attract teachers and scientists of high caliber. Foreign professional staff is as essential as foreign management if tradition and local political considerations are not to have the upper hand. At present, local customs are steeped in the past, pay scales are too low to make academic science an attractive area of employment, and local talent tends to be too provincial. In my judgment only the establishment of an international institute can shake European scientific education to its roots, and only an international institute can show Europe the modern way.

One frequently hears it stated that the way to uplift European biology is to put more money into the system. Heaven forbid! It does no good to develop programs of general support to science in "depressed areas," including some areas of Europe, without first introducing and fixing within the populace those scientific ideals that reward honesty in science, that recognize the value of self-evaluation and self-criticism, and that place scientific accomplishment above all other gains. These ideals are the core of the successful scientific environment. Scientifically "depressed areas" need assistance of a bread-and-butter nature. They don't need caviar. They need teachers, textbooks, journals, audio-visual aids, and the like. They need scientific instruction and examples of the "scientific method" at the most primary level. Giving research funds of a general support nature to existing institutions would only continue the present intellectual stagnation and perhaps even deepen it.

International institutes of cell biology can bring some of the ideals of science to these "depressed areas" and can serve as models, setting standards of research and education now lacking in all but a few nations of Europe. Through them young people would be exposed to the highest ideals of science, trained in the most recent techniques, and thus enabled to take over the training of subsequent generations. To my way of thinking, one model institute strategically placed would be of far greater value than all the foreign grant-in-aid, training, and fellowship assistance now made available to each of the countries I visited.

U.S. Aid for Research and Training

Of the many problems facing European science, a few can be solved with money. The amount isn't very large by U.S. standards, even though it is for too large to be attainable from present European sources. It is not our responsibility to underwrite European academic science, but it certainly is in our national interest to render some financial aid. We need a strong European science not only because Europe still is a producer of many original ideas but because we need competition to keep our own science healthy and dynamic. We also need training centers for seasoning our young people—training centers, different from our own, where, for example, the mind gets greater play than the machine. The Europeans have had to make do. Lack of funds to some extent has been a blessing in disguise—it has forced Europe to stress conceptualization rather than experimentation.

The kind of aid European science needs from us is of two types—support for its best young people and support for a few of its more creative scientists. Some of this we are already giving. Support for the young people should be in the form of postdoctoral fellowships for training in the United States and of support for a few years of subsequent research to help establish them at home. A fellowship program without some support at home is of little value. The Rockefeller Foundation was very successful with this type of program a generation ago, and it should not be too difficult for us to emulate its success. The other type of program can be in the nature of grants to help the more creative people establish and maintain training programs. There are very few postdoctoral students in Europe—first, because few training centers exist, but even more because there are few sources of funds to support these young people during an additional few years of training.

Of course we can make available textbooks, journals, audio-visual aids, and other teaching essentials. These items are desperately needed, but federal and private U.S. overseas agencies exist that can handle these needs. We can, however, make available our surplus, unused scientific equipment and periodicals now gathering dust and deteriorating in a large number of laboratory storerooms throughout the nation. A small investment to recondition and redistribute this equipment will gain us many friends and at the same time help familiarize many young people with laboratory techniques with which they are now unfamiliar. A simple expansion of existing book exchanges can accomplish the rest. Europeans are too desperately in need of scientific equipment and periodicals of any kind to let pride stand in the way of acceptance.

Whatever financial support is made available to Europe from U.S. sources should be direct—from the primary agency to the scientist. It should come from many of the same agencies, both private and public, that are now functioning in the United States, and certainly not from any specially created agency of the federal government. For whatever reason, we now tolerate a multiplicity of agencies for the support of science in the United States; that same reasoning obtains for Europe. But I repeat—aid should come directly and not through any middle-man international organization.

Europe Can Help Itself

Europe can begin to help itself too, for the manpower it is wasting constitutes a valuable and irreplaceable natural resource. European economic recovery has been dramatic. European citizens of wealth, industrial corporations, and governments have a responsibility to finance the education of their youth and the research of their scholars. Public organizations do now exist, but they are much too inadequately financed and managed for the task at hand. Tax incentives will, to some degree, further the development and growth of philanthropic organizations. It will take Europe a long time, even with the best of intentions, to approach anything like the present American response to the needs of its science.

Before I close I should like to leave one more thought. Anyone who has traveled about Europe or in other parts of the world in the last few years is aware that the world is in a deep ferment, politically, socially, and economically. Fundamentally, as in all such awakenings, it is the young people who are stirring. They are aware of the strangle hold of tradition and the dead hand of the past, and they are losing patience with delays and, yes, even obstruction. We, one of the youngest nations of the world, one born of rebellion, the most powerful economically and intellectually, can easily afford to share a bit of our good fortune and wealth with them. Any assistance we can give them will eventually be of benefit to us as well as to them. Such aid may spell the difference between survival of life on this planet as we now know it or total destruction. Will it be possible for responsible people and nations to move before the help provided is, once again, too little and too late?

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