usually be cured through judicious use of antibiotics, and the mixing of cell lines can sometimes be resolved by immunochemical testing or the acquisition of new cultures. Once these hazards are appreciated, the biochemist and others interested in mammalian cell culture have a new tool at hand for the exploitation of new areas of research.

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A British Perspective on American Science Policy

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Science, in its issue of 12 January, devoted a News and Comment item to what it calls "the most comprehensive look at American Science Policy ever taken by outside observers"—a report which was recently issued by OECD (the Organisation for Economic Cooperation and Development, the successor to the Marshall Plan in Europe). The heart of this report, *Science* says, is the analyses by four "examiners," and these, it is claimed, are "filled with impressions of weakness in the American system." I was one of the examiners, and was assigned the task of commenting on American science policy in relation to academic science and the universities. I certainly did not intend my analysis to be an attack on American practice. It was in fact aimed far more toward the European members of OECD than toward the Americans (or even the Japanese). The questions and suggestions which seemed to me to arise did not actually get published by OECD and do not emerge clearly in the reports published by *Science*, the New York *Times*, and *Nature*. I should like to give them here, with the following preliminary comments.

I understand *science policy* to mean the complex issues involved in spending some 18 to 20 billion dollars a year of federal money, together with large amounts of state, foundation, and other public funds: How much to health, space, physics, oceanography, and so on?

I certainly did not understand my job to be that of telling Americans how to run their own science. I was reporting to OECD, a body with 21 members, of whom the 20 non-American ones have more to learn from the U.S. in this respect than the U.S. has to learn from them. At the same time, I saw no reason to pretend that the U.S. science policy is perfect, and did not hesitate to ask the Americans questions challenging enough to be interesting. But by picking out only these items from my report, *Science* failed to give a true picture of the balance of the whole.

True, as *Science* says, we were officially in the States for only 14 days. But I started being personally involved in American science policy (as a recipient of a U.S.-financed fellowship) a third of a century ago. I suppose I have visited the States about 30 times, for various periods; in the laboratory of which I am chairman there are at least a dozen people who have postdoctoral experience in U.S. laboratories. The OECD official 2 weeks is not the whole story.

Summary and Questions

(*Questions are addressed to the Americans, suggestions to the Europeans.*)

1) The United States has a well-developed system of organizations concerned with formulating science policy.

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The subject is approached from three complementary angles: that of the Executive (through the President's Special Adviser on Science and Technology and the three major committees of which he is chairman—the President's Science Advisory Committee, the Office of Science and Technology, and the Federal Council of Science and Technology); that of the Legislature (through a number of special committees); and that of bodies independent of government, particularly the National Academy of Sciences but also certain nonprofit organizations such as the RAND Corporation and the Brookings Institution.

2) It is important to note that each of the three has available not only the advice of senior "experts" but also considerable resources of skilled manpower for analytical and similar work.

Question. It might be argued that there is considerable duplication of analysis and appraisal by the Executive Branch and the National Academy, and increasing duplication with work sponsored by the Legislature. Is this considered desirable in the interests of getting an all-round view, or should the trend be restrained through further cooperation between the different interests at the level of fact-finding?

3) The U.S. policy-making bodies have been outstandingly successful in appraising the situation in various large fields of science, such as chemistry, oceanography, plant sciences, and environmental sciences. This success has depended on a combination of a large number of vigorous scientific leaders, from bodies such as the National Academy or the President's Science Advisory Committee, with a strong supporting staff, who carry out the detailed work. *It is suggested* that studies of comparable value will not emerge from Europe unless there is cooperation between National Academies or similar bodies in a form which brings together the most active and forward-looking scientists from different countries (instead of only the most eminent), with adequate supporting staff.

4) The American machinery for putting science policy into operation is highly diversified, but, as far as pure science is concerned, it has, broadly speaking, two major characteristics: federal support of science is provided predominantly by means of grants awarded for the support of rather precisely defined projects; and grants in a particular field are, in the main, made by the department or agency which is responsible for carrying out official executive action in that field.

Question. Does the administrative linking of research to practice lead (i) to undue diversion of research to areas where the problems are practical, immediate, and acute? (ii) to any embarrassment if the research side of a department shows that the executive side has been pursuing a wrong policy? (iii) to duplication or inadequate coordination of basic work in which several departments are interested? or, more positively, (iv) to a greater readiness of Executive divisions to be aware of and responsive to scientific advances?

5) The American machinery of "reviewing committees" for assessing applications for grants is very much more extensive, and demands from its members much harder work, than is usual in Europe. *It is suggested* that European practice might be improved, and that a useful step would be some degree of international cooperation, in which a national grant-giving body would invite a few foreign scientists to serve on some of its reviewing committees.

Question. To what extent has the United States found it necessary or desirable to pay fees (and at what level) to those serving on such committees? What is the desirable ratio between older, more experienced but perhaps less open-minded scientists and younger scientists, who are more likely to be professional rivals of the applicants?

6) The project-grant system has great advantages in that it facilitates the rapid development of new areas of science and gives opportunities to young scientists in their most active and creative years. It can be criticized as tending to encourage the fragmentation of science into "grant-sized" packets and to overstimulate competition. Its effects on university structure, although in the main beneficial, have some less valuable aspects; these are mentioned below.

7) America has, up to the present, been little more successful than any other country in developing a rational and socially responsible approach to the problem of maintaining a balance between subjects within the field of science as a whole. Whereas in most European countries the existing balance has resulted from a combination of accidents of personality and the ease of advance in various directions, in America, where an independent science is a fairly recent growth, the existing strategic disposition of forces is largely a result of reactions to external demands, such as those of the undeveloped frontier beyond the settled areas, followed by reactions to the military, and later the space, phases of the Cold War. At the present time, the basic needs of American society, expressed in the phrase The Great Society, are becoming important influences on the directions in which American science evolves. The United States is actively searching for organizational forms through which these influences can be expressed and made effective.

Question. If one assumes that, in spite of a temporary setback, there will be an important reorientation of American science toward Great Society projects, how far is it anticipated that this will demand large-scale changes in university organization and structure? Can the American, and could the British or European, university systems adapt themselves without governmental assistance?

8) The machinery for the involvement of democratically elected representatives in science policy decision-making is evolving rapidly in the United States. It is still rudimentary in Europe, but there are no obvious constitutional or other reasons, except sheer inertia, why Europe should not leap well ahead in this respect, since America tends to be hamstrung by internecine rivalries between existing committees, whereas Europe starts almost from scratch.

9) The social sciences are not represented in the main American science-policy-making bodies. Current discussions envisage bringing in people from the "hard" social sciences, such as economics, political science, law, and sociology. There are, however, already many people trained in these subjects within the civil service, both in the United States and in Europe. Moreover, the main deficiencies, particularly in relation to Great Society programs, seem to be in the "softer" subjects, such as social psychology, social anthropology, race relations, and the like. But these are politically so "hot" that it is difficult for governments to become official sponsors of research which retains its essential intellectual freedom, however much the government may recognize the desirability of further financial support in these areas.

Question. What is American thinking about ways to give greater support to these social sciences which have major impact on crucial social issues?

10) As for the educational field, the federal government has in recent years had an important effect on science education at primary and secondary levels, but mainly through rather indirect channels, and largely in the area of curriculum improvement.

11) A feature of American undergraduate teaching is the widespread adoption of an "elective system," which allows a student to make his own choice from a very diversified à la carte menu. This gives some license for frivolity and superficiality, but—probably more important—has many advantages in a time of rapidly expanding and differentiating sciences. *It is suggested* that most European universities have not gone far enough along this path.

12) In the United States there is a great development of graduate schools, in which formal teaching is continued longer than it generally is in Europe, extending into the period in which the student begins supervised research for his Ph.D. degree. *It is suggested* that Europe needs to develop many more graduate schools involving advanced instruction; some of these might well be international in organization.

13) In America there is much closer contact between industry and the universities than is common in Europe. The contact is primarily with the graduate and postgraduate schools, but its influence permeates downward to the undergraduate level.

14) An important and often dominating influence on the character of American universities is reliance for support of research on federal project-grants, or on research contracts similar to those awarded industry. This leads to great flexibility and adaptability, and encourages academic-industrial connections. It carries the danger of inducing too much fragmentation, at the expense of a broader, more synthesized education. The problem for America is that of minimizing the dangers; the problem for Europe, that of gaining the advantages.

Questions. How far is America likely to go along the line of increased federal support of institutions, in comparison with the European Napoleonic tradition in which universities are organs of the State, or the British system of semi-independence under the University Grants Committee? What advice can America offer about the possibility of using state support of institutions to encourage in Europe the development of more flexible, cross-disciplinary university-like institutions, linked with industry and other social needs (similar to the complexes around Massachusetts Institute of Technology, Stanford, and the University of Michigan)?

15) America has gone somewhat farther than Europe along the historical path away from a situation in which higher education is restricted to an elite, and toward one in which it must fill a mass demand. This has led to a great diversity in quality between the best and the worst institutions, which tends to exaggerate the "internal brain drain." It looks as though the situation may soon be made still more difficult by competition between undergraduate and postgraduate activities for the available funds. American attention at present seems to be concentrating on raising a number of second-rank universities into the first rank. Another process which has taken place is the effective grouping of numbers of different campuses, possibly differing in quality, into university systems (examples are the campuses of the University of California and those being set up by the State University of New York; the University of London is a European parallel).

Questions. At what stage (in terms, for instance, of numbers of students) is it desirable to transform a single university into a university system? Is the "multiversity" really a valuable concept? Can existing universities be advantageously grouped into a system? European universities tend to set a high value on individual character, either of the institution as such (for example, Oxford) or of particular departments (such as the Cavendish, or the Heidelberg department of physics). How important is such differentiation, and to what extent is it compatible with (i) multiversities and (ii) university systems?

16) It is argued that the "technological gap" is mainly toward the "D" end of the long spectrum of activities covered by the phrase "R & D." The universities are, thus, not the main agents by which the European situation can be improved. Nevertheless, there arises the *question*: How far should universities be encouraged—or indeed allowed—to move from R toward D? Is it harmful, or beneficial, to industry if activities almost at the pilot-plant level are carried out within universities?

17) The attitude of European universities toward "the brain drain" is necessarily ambivalent, since it is usually advantageous for an academic to have worked for a time abroad (and, in many fields, preferably in the United States). The important problem is that of increasing the attractions which bring emigrants back to Europe after a few years. *It is suggested* that Europe does not sufficiently exploit the pull which could be exerted by its cultural life if this experience were made more readily available to young scientists. This is quite largely a question of salary levels, and of ease of moving upward to positions of independence; further international cooperation within Europe to raise the general level of sophistication of its science policy would make it easier to win the respect and allegiance of young scientists with experience of conditions in the United States. Organization of graduate schools located in Europe but having some American faculty members is another attractive suggestion.

18) Ultimately, the attraction of America for scientists who emigrate permanently and are lost to their home countries is quantitative, a matter of salary and opportunities; this probably implies a qualitative difference but does not originate from it. The only way to slow down the brain drain from Europe in any important way is to spend more money on science within Europe.