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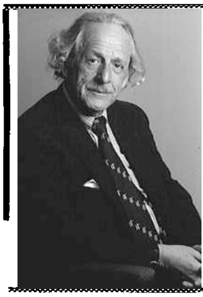

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Science/Technology Policy. Part 2. International Perspectives

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The second part of a discussion of science/technology policy emphasizes its international dimension. The impact of US science-policy initiatives is considered in relation to international cooperation and Third World science. Five experts' views on science-policy issues of today and tomorrow in our global village illustrate the diversity of perspectives. Differences in centralized and pluralistic structures also affect science-policy implementation, as, for example, in the US and the USSR.

Recently, we began this two-part essay with a definition and an exploration of the different meanings of science policy.[1] We provided a short synopsis of the history of US science policy. As detailed in Part 1, much of US science policy has been "formulated" as a direct reaction to the public's perception of international events. It is not usually the result of carefully planned, long-range programming. Harvey Brooks, J.F. Kennedy School of Government, Harvard University, calls it "science for policy," rather than "policy for science."[2] Brooks is one of five scholars with expertise in science policy with whom we discussed the topic of international perspectives. The other four are John Gibbons, congressional Office of Technology Assessment, Washington, DC; Maurice Goldsmith, International Science Policy Foundation, London, UK; Craig Sinclair, Advanced Studies Institute, North Atlantic Treaty Organization, Brussels, Belgium; and Jurgen Schmandt, LBJ School of Public Affairs, University of Texas, Austin.

This second part focuses on the international aspects of science/technology policy. As our world in reality becomes a global village,[3] the decisions of one nation concerning science will inevitably influence science decisions of other countries. The short-range science programs of the US do have an international effect. But both *national* and *international* science policy must have long-range goals, and nations should have the commitment to follow through with them.

US Science Policy and Its Impact on the World

Almost half of the Western world's research and development is carried out in the US. With an estimated R&D budget of $87.2 billion in 1983 and $124.25 billion in 1987,[4] we spend more money on science and technology than the industrialized nations of Europe and Japan. (Table 1 shows the percent of national monies the US and other nations spend on R&D.[5]) The US's continued superiority in many fields of science allows it to define the terms on which other countries will be given access to its technological fruits. In 1984 David Dickson, European correspondent for *Science*, claimed:

> Scientific collaboration is offered to some (such as China, Japan, or India) in return for political and economic favors and denied to others (such as the Soviet Union) as punishment for unacceptable behavior. Both developed and developing countries alike are promised access to the science that they lack facilities or resources to produce themselves on condition that they open up their internal markets to American capital and refrain from anti-American policies. Science, in this sense, has become a currency for diplomatic barter—with the US holding the bank.[6]

Four years later, the perception of the value of technological know-how and free access to it has changed considerably. There has been a movement by the federal government limiting foreign access to US scientific and technological advances. Perhaps this is due in part to fears that some US military-oriented (termed "strategic") technologies will be transferred to the USSR. But this view is not limited to these technologies. Increasingly, there have been attempts (some successful, some not) to limit the transport of information on *any* newly developed science or technology to other countries. This seems to me to be a step in the wrong direction. Gibbons has described the situation well.

Gibbons: ...Following World War II, the US dominated world science and had such a comfortable lead in the world economy that it could afford to be very charitable. We freely gave not only our science, but even our technology to all comers; but that situation has now substantially changed.... The rest of the world is catching up with us in both science and technology. In some cases, others lead, and certainly it's now a very hot horse race in terms of world trade and economics. We've been sort of retreating on the extent to which we should be so open with science. That attitude surfaced in the Reagan administration, which tried to quell the amount of the interaction between US scientists and the rest of the world. There are many who feel that this form of, as it were, secrecy, could really come back to haunt us because it may be based on a false paradigm...that *we* have the science and that *they* are just trying to take it away from us.... The more realistic paradigm is that their science is good and getting better. If ever we should be in dialogue with other scientists around the world, now is the time because we have more to learn from them than ever before.[7]

Goldsmith has also commented on the influence of the Reagan administration on other countries.

Goldsmith: The emphasis on the Strategic Defense Initiative [SDI] has meant that certain scientific programs in the UK have been given financial support when they would have found it extremely difficult otherwise to obtain such financial support from their own government—but there is also another aspect which, again, is linked with the political world in which we live. It is reflected in the behavior of the Co-ordinating Committee for Multilateral Export Controls [COCOM] and the export of high technology to [Eastern bloc] countries. COCOM is the [US-sponsored] group in Paris which determines what aspects of high technology may not be exported to the Soviet Union and her allies.... That aspect of science policy also has an effect upon UK economic and political behavior—the UK has to agree that anything purchased or imported from the US which is on a "no export" list cannot be sent over to any of the Socialist countries. This list limits the trading effectiveness of the UK and other European countries which subscribe to this policy.... There [are] also limitations on open publication of research done by any group which is receiving an American funding [related to] SDI.[8]

The US effort to restrict the flow to nations of the Soviet bloc of new developments in science and technology, particularly any that touch upon "strategic" issues, clearly limits the transfer of science and technology to US allies as well. It remains to be seen whether recent changes in Soviet policies will improve the environment for scientific cooperation and technology transfer. The preoccupation of US science and technology policy with the USSR and the Eastern bloc prompts a brief comparison of science-policy systems of the two superpowers.

The US and the USSR: A Comparison of Science-Policy Systems

Science policy in each country is significantly shaped by its national economic context. While US science and technology (engineering) reflect a competitive market economy and pluralistic politics, Soviet R&D takes place against the background of a centrally planned economy and society.[9] (p. 1)

While *perestroika* points to significant changes taking place right now, science policy is still basically centralized. The organization and conduct of R&D in the Soviet Union is both highly structured and hierarchical. The overall institutional framework resembles the organization of a large business enterprise and operates on three levels of a pyramid. At the top is the organization that develops the broad strategy and sets policy and procedure; the second layer deals with specialized and relatively autonomous agencies that are responsible for directing all activities of a group of R&D facilities; at the base of the structure are the individual laboratories and institutes.[9] (p. 20)

In juxtaposition, the administration of scientific matters in the US conforms with the highly decentralized organization of the federal government. In the executive branch alone there are over 40 agencies and departments directly concerned with science policy. The legislative branch (the US Congress) has over 20 committees and other bodies directly or indirectly involved in science activities. Unfortunately, this plurality of groups militates against any overall plan for managing science policy and usually results "not in a grand design deliberately established but [in] the meeting point of a complex of different wills, both within the executive branch and in the Congress."[10] (Figures 1 and 2 describe the science-policy-making structure for both the US and the USSR.)

Although the Soviet Union was the first nation to recognize science as a national resource, to commit systematically large shares of its budget to the promotion of research, and to try to plan the development of science and technology (in the 1920s), serious attention to planning and management of R&D only began during the late 1950s.[9] (p. 6) Science policy in the US was initiated in the late 1940s. As mentioned in Part 1 of this essay, Goldsmith points out that science/technology policy should also include industry policy.[1] However, in the USSR, science and industry have always been largely separate worlds, coexisting rather than cooperating and pulling in the same direction.[9] (p. 9) Industrial policy in the US is mostly left up to the private sector, which is affected by the vagaries of the economic health of the nation.

In contrast to most Western countries, the USSR has concentrated its basic theoretical research not mainly at the universities, but at the institutes of the Academy of Sciences of the USSR, Moscow; the academies of sciences of the Union republics; and the sectoral research institutes. Institutions of higher learning play a more modest role than they do in the Western industrialized nations as well as Japan,[11] but this role has been increasing recently.[12]

Table 1: **An international comparative analysis of government R&D funding** by objective for the 1983-1986 time period. Data are from the National Science Foundation, the European Economic Community, and the Organization for Economic Cooperation and Development.

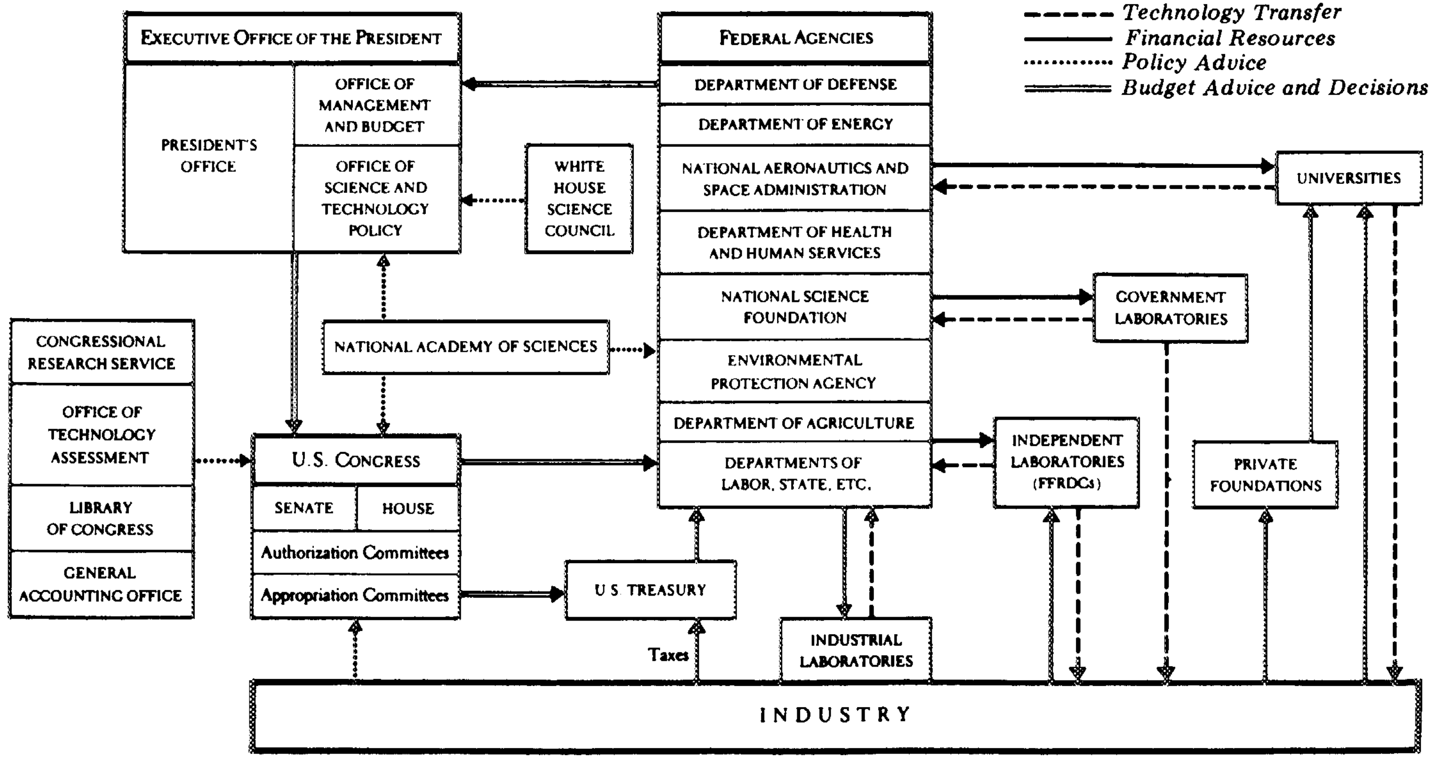
Objective	US	Japan	FRG	UK	France
Defense	69%	3%	12%	52%	31%
Space	5%	5%	5%	2%	6%
Energy	4%	14%	11%	5%	7%
Health	10%	3%	3%	4%	4%
Agriculture	2%	11%	2%	5%	4%
Other (industrial growth and basic research)	10%	64%	67%	32%	48%
Total	100%	100%	100%	100%	100%

Brooks has made some perceptive observations on the state of Soviet-style R&D and its effect on those who work within its rules.

> The entire Soviet R&D system is based on what can be described as a "level of effort" approach, with the total funding being adjusted to keep the scientific work force fully occupied, something which is possible in the Soviet system because the entire enterprise, including salary scales, is closely controlled centrally by the government. Planning of the agricultural research system in the United States follows a somewhat similar pattern. The problem with such a system is that it tends to lead to rather low mobility and flexibility.[13]

Has this low mobility and flexibility negatively affected the progress of Soviet science and technology? Can one science-policy system be better than another? Our five scholars indicate that the answer is yes to both questions. (Brooks comments that the lack of a source of reliable scientific instrumentation and even simple research materials is a serious problem for Soviet scientists, who often have to spend a great deal of time designing and building their own research equipment.[12]) An illustrative example is the successful November 12, 1988, launching of the Soviet space shuttle. It looks quite similar to those spacecraft in the US shuttle fleet, yet its maiden voyage took place seven years after its American counterpart. There is no doubt that both nations

Figure 1: Outline of structure and management of R&D in the US.



have similar emphases in many areas when it comes to funding R&D. Like the US, the Soviets have spent enormous sums on defense, aerospace, and nuclear R&D while underinvesting in industrial R&D.[9] (p. 12)

Sinclair: The main leader in the Soviet Union, as in the US, seems to be military science and space science. [By comparison, R&D] in Soviet universities [is very small]. They [conduct] primary research in theoretical science, [especially] in mathematics.... They've got a good educational base of theory to start with. When you get into practice, then they're held up by the defects of the system—the lack of computers, the compartmentalization of science there, what appears to be subordination to military needs.... Certainly, Soviet scientists are better on the [theoretical level] than in technology or industry.[14]

There are indications that the intense competition between the US and the Soviet Union may lessen. Cultural and scientific exchanges are on the increase; a nuclear arms reduction treaty (albeit only intermediate-range weapons) has been signed, and initial verification procedures for this treaty have been completed; and there are signs of a push towards democratization in the USSR.

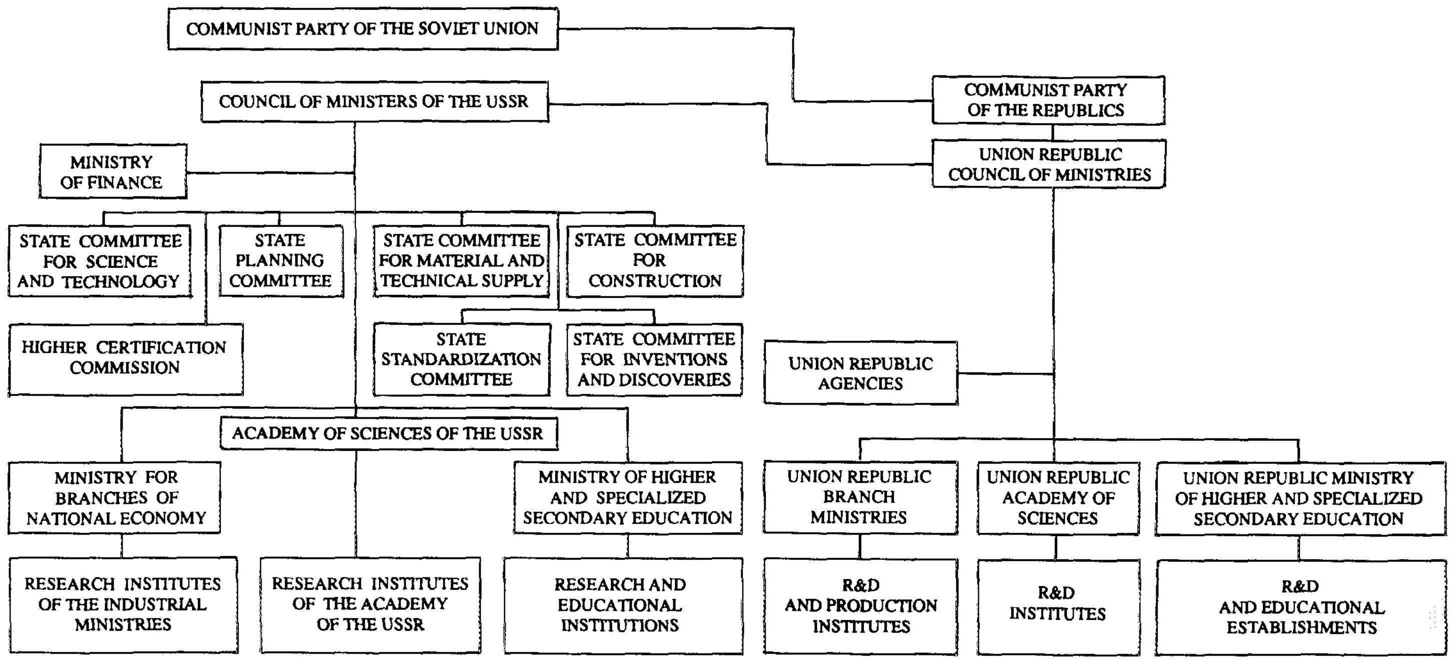
Perhaps now, more than ever before, more cooperation and less competition between the US and the USSR and other nations are possible. The competition between countries, particularly those with discordant ideologies, has always made direct cooperation politically risky. That's why world leaders have tried to work out ways of cooperating on common goals through multinational or universal associations. There have been conspicuous successes: the International Geophysical Year of 1957-1958, the successful campaign to eradicate smallpox from the human population (no naturally acquired cases since 1977),[15] and the more recent efforts dealing with stratospheric ozone depletion over Antarctica.[16] But short-term politics affects long-term policy. So, with a few exceptions (the World Health Organization's smallpox-eradication program began in the 1960s[15]), most wide-scale, cooperative efforts have lasted only a few years. One good example of the on-again, off-again cooperation is the deep-sea drilling cooperative project known as Joides that involved a consortium of oceanographic institutions. The Soviets were active participants in this project to gather ocean bottom core samples but were subsequently excluded from the project during the late 1970s and early 1980s, when relations between the US and the USSR soured.[12]

International Cooperation and the Third World: A Difficult Road

The implementation of a long-term international science policy—one that actually does more than read well on paper—is perhaps one of the most challenging issues facing today's science policymakers. There are relevant institutions—the World Bank,[3] the Canadian-based International Development Research Center (IDRC), the United Nations Educational, Scientific and Cultural Organization (UNESCO),[17] the International Council of Scientific Unions,[17] and other UN agencies (such as the Advisory Committee on the Application of Science and Technology to Development[18]), for example. The oldest of these organizations dates back more than four decades, while the most recent (IDRC) was instituted in 1970. Most have a very broad-based agenda: technology assessment and transfer, science education, health, food production, and so on. Taken as a whole, the results of these efforts have been uneven at best. One of the factors, according to Michael J. Moravcsik, Institute for Theoretical Science, University of Oregon, Eugene, is that

> ...through international assistance, an advanced country might very well turn to doing whatever research and development is needed in its own laboratories, then utilize the results by sending some of its own nationals to the country to be helped to adapt, apply, and implement the results in order to remedy a particular problem. In the process, usually a transfer of hardware occurs from the advanced country to the one to be helped.... Unfortunately, this procedure is at best neutral, and most often point blank counterproductive with regard to the reaching of the...goal, namely, that of creating a scientific and technological infrastructure in the country to be helped.

Figure 2: Outline of structure and management of R&D in the USSR.



> The transfer of results of research and development, generated abroad, and administered by people from abroad, in no way helps the local infrastructure to evolve, and in fact may retard its development by diverting attention from that task.... The complaint is widespread in developing countries by the scientific and technological community that local companies are uninterested in utilizing any home-grown technology and instead spend large sums obtaining technology, or even worse, technological products from abroad.... The conflict is created by several factors, perhaps the most important...being the time element.[19]

It is understandable that developing nations want rapid remedies to their long-standing problems. On reflection, one can think that perhaps the only way to have an indigenous scientific and technological base in a developing country is to have the industrialized nations set up shop *in the country* and to attempt to more fully utilize the level of preparedness of the citizenry. In my opinion, one of the other factors hindering progress in this area is impatience. My colleague Andrew Aines (who is also quite knowledgeable on international affairs), formerly of the Office of the Under Secretary of Defense, Research, and Advanced Technology, Washington, DC, comments that both industrialized and developing nations, when working in partnership for technology transfer, should be prepared for false starts and disappointments as part of the learning process.[20] Whatever the reasons, the lack of actually having "First World" technological transfer being assimilated by the developing nation may contribute to the perception in many Western industrialized countries that Third World science is mostly a one-way exchange, an expensive effort with little in return.

The problems of how to transfer technology to developing nations also show up in the effort to help the nations institute science and technology development as part of their national policy. Aaron Segal, Department of Political Science, University of Texas, El Paso, comments:

> The mixed record of the World Bank and other donors in tranferring agricultural research capabilities compares favorably with the attempts of international organizations to transfer science and technology policy planning capabilities. While China, India, Brazil, Argentina, Mexico and a few other developing countries initiated their science and technology planning efforts in the 1960s and earlier, UNESCO and the United Nations Conference for Science, Technology, and Development (UNCSTD) gathered momentum in the 1970s. The apogee of this effort was the 1979 UNCSTD Conference in Vienna at which all the attending developing governments were to submit a statement of national and technology policies.... The fallout from this international consciousness arousing exercise was limited. The inventories of national capabilities that resulted in response to international pressure were for many countries a useful exercise even if much of the data obtained is questionable. However, the conference quickly turned to regulating technology transfer where views were polarized and skipped over national capabilities except to seek more external aid. Only those governments which had committed themselves to planning S&T [science and technology] prior to the 1979 conference continued to do so afterwards. The highly centralized kind of planning with emphasis on technology transfer regulation which was advocated by UNESCO and UNCSTD is impractical for most countries, and had few takers. Science and technology policy is an excellent example of the problems of institutional technology transfer.[21]

Commenting on the above, Brooks says,

> The Vienna conference of 1979 set up an office of the UN known as the UN Center for Science and Technology for Development, known as UNCSTD.... There seems to be a confusion between the Vienna conference and the center. The center serves as staff for the Advisory Committee on Science and Technology for Development (ACSTD), which is now chaired by Francisco Sagasti of Peru (currently head of strategic planning for the World Bank), and the director...is Sergio Trindade of Brazil, an MIT-trained chemical engineer.[12]

Technology transfer is a slow process, with a low likelihood of short-term success, so many industrialized nations—most prominently the US—have opted to make political influence a key factor in dealing with interfined to physics and astronomy. But now it is spreading to biology with things like the human genome program and some of the ambitious environmental-science programs. So there is a real problem of how to properly allocate resources between these large programs and the general realm of science. Another very important issue is how to improve the role of science in various kinds of environmental, safety, and health regulations.... Those are the two most serious issues facing science policy today and for the future.[26]

Sinclair: There have been all sorts of ways of deciding how much basic science should be funded and how you arrive at that figure. I think also a major science-policy question now is the public perception of science. This is not particularly new but, from my reading, it seems to me there is a big, big gulf [between] what scientists think they are projecting and what the public perceives.... I think there is a big need...to get public perception of science rather more balanced than it is.... Another interesting science-policy question at the moment is what you might call the internationalization of science and scientific division of labor. Science is in a transitional period where funds are leveling off; where the disciplines are breaking up; where the goals are...being questioned.... The institutionalization of science is...under pressure.[14]

Goldsmith: I'm concerned with the effectiveness of science policy. The development of the sociology of science is important, but there are lots of groups, especially universities, taking this into account. Economic research is quite important—I'm...trying to ensure that scientists begin to understand how they can, or must, operate in a [market-based] economic system. This...has been quite alien to the thinking of the [UK] scientific community.... Ethical as well as economic questions are involved in science policy. A good example is the growing understanding of our one-world environment.[27]

Gibbons: If I can lump science and technology together for a moment, the world is afloat in problems of how we can continue to provide a higher standard of living to more and more people—and at the same time not wipe out the quality of our lives or threaten future generations with all of our so-called residuals—that is, pollution. How we can devise ways of making goods and services with [fewer] undesired side effects...using human ingenuity to supply goods and services with less and less external costs is a great challenge to science and technology. A second major challenge is to take the fullest advantage of the extraordinarily rapidly moving fields of molecular biology and neurobiology. We now have opportunities to understand and treat a lot of human ills, including mental illness, dementia, and infectious diseases, with new methods of biotechnology. We may also have another shot at the green revolution—if we are able to accelerate what we used to do with traditional selective breeding....

A third area that I might call verification technology comes out of basic advances in science and its application in things such as seismology and spacecraft. These advances, properly nourished, could enable us to move ahead on effective treaties for arms control and for arms reduction. This is where technology makes it possible for you to get into international agreements when otherwise you simply couldn't trust each other enough to move ahead, given the present level of human experience.[28]

These are very complex issues, but undoubtedly there is an important policy issue dealing with worldwide scientific communication. ISI® processes over one million articles per year from over 10,000 journals and books published in nearly 170 countries. And that is only part of the total output. But I am certain we are not delivering that information to everyone in the most cost-effective manner. We certainly have the means to communicate across borders. However, once information is delivered at a local level, there may not be adequate means to capitalize on that information. The idea of cooperation, of sharing know-how and resources—the goal of the World Brain[29] (which I have discussed in previous essays[30,31])—is so appealing. But its practical implementation depends upon integrating many diverse systems. Given the pluralistic basis of the information industry, it is national science policy and Third World science. When political viewpoints are not to the US's liking, world science suffers. This has been amply demonstrated in the recent dispute over the direction of UNESCO, with the US withdrawing from participation in the UN agency. The US withdrawal of support in 1984 did affect UNESCO-sponsored science projects.[22,23] I have written before about the necessity for sound scientific direction of UNESCO[22] and about the potential for such leadership from the new director-general, Federico Mayor Zaragoza.[23] But the reform-minded director-general has a difficult road ahead—he has excellent ideas, but the timetable for action is still not definite.[24] The US currently remains outside membership of the organization and will no doubt be so until the new administration considers the issue—it is hoped, early in its term. Aines warns that, when the US refuses to participate in organizations that have direct impact on Third World science and technology transfer, the influence of the US diminishes significantly.[20] UNESCO will be the subject of an essay in the future.

Surely the scientific community recognizes UNESCO's key role in several international programs, but its future effectiveness and support depend on its ability to remain aloof from political agendas of individual nations and regions.

Science-Policy Issues—Focusing on the Global Village

The most obvious issues of international science policy concern multinational and global issues not only of immediate importance (such as AIDS), but also those with long-term consequences. For our global village to survive and prosper, myriad viewpoints should be considered until the "big picture" is clear to all. We asked our five experts about the important issues.

Q: What are the most interesting science-policy questions and problems of today and for the future?

Schmandt: I mentioned already one of my favorite topics—that is, the attempt to see how...states or groups of states become players both in preparing talent for science and technology...and also in making use of scientific knowledge in their regional economic development. These initiatives should be broadly based and take into account the negative effects—environmental or health risks of technological change, for example. I think that's a significant trend. Not all of the answers should be looked for from the national capital.... As more and more policy areas are recognized as being science/technology related, the states and eventually the large communities become contributors to decisions in those fields. A second major concern of mine: as the increased level of human activities, due to more people and rising affluence, changes the physical conditions of life...our institutions and concepts for dealing with those changes to the global environment must work more effectively. I don't think we have even started doing so, except...that we know better than we did 10-20 years ago what the increased intensity of human activity does to the globe. I see a low probability of really effective international arrangements to deal with tough issues like...global warming and reducing reliance on fossil fuels on a worldwide scale. Therefore, we have to get much better at figuring out how particular regions of the world are going to be affected by global changes of this nature and how they can contribute to finding solutions. This may include preparing to live in the changed environment, adjusting to the changes that are going to become more noticeable during the next decades.[25]

Brooks: I think that one of the most interesting and challenging questions today, particularly in the US but also worldwide, is the competition for resources—for large and ambitious projects, on the one hand, and the general run of small, investigator-oriented, investigator-initiated science on the other—sometimes characterized as "big science" and "little science": such things as the space station, the Superconducting Supercollider, and so on, versus the general run of work in condensed-matter physics, chemistry, biology, and so on. You see this competition between large, coordinated projects and more dispersed, individual science spreading to an increasing number of fields in science. It used to be largely consound policy for internationally minded agencies, including the large private foundations, to support the needs of less-developed countries.

This survey has only scratched the surface of major problems that could be enumerated under the heading of international science policy. From the brain drain to intellectual property issues, the range of topics is endless. Considering the forthcoming shortages of scientists in the US and elsewhere, the scope of the National Science Foundation, the National Institutes of Health, and other government funding agencies must inevitably include Third World countries in their grant programs.

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