PROFESSIONAL RELATIONS BULLETIN

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FROM THE EDITOR . . .

Official DPR Election Returns

Chairman-elect:	
Alan C. Nixon	156*
Secretary:	
David Garin	74
Paul A. Rebers	87*
Alternate Councilor	
John S. Connolly	130*
Member-at-large:	
Grace Borowitz	130*
Jo-Anne Jackson	35
Mordecai Treblow	121*

* = Elected

The last DPR election experienced a few hitches, as I'm afraid you may remember. Those who worked on it offer their apologies. I was *not* involved, so I can try to explain what happeed. By tradition (but not by formal requirement), the immediate past chairman of the Division supervised the full process, from obtaining candidates through counting the ballots. Unfortunately, last year's past chairman refused to accept this obligation, and fairly late in the year chairman Dennis Runser jumped in to accept the added burden and carried through with the election. Unfortunately, even with Dennis's heroic efforts, other problems developed with mailing labels and the mailing itself (not our fault), and ballots did not go out until late December, well after the mailing date we were led to expect.

Ballots received through January 14th (well after the published deadline) were counted, as we knew that most members received their materials quite late. Even so, the total received—161—were substantially fewer than normal (ca. 250). I don't believe any of the results would have changed if more ballots were sent, but all concerned deeply regret what happened.

Chairman-elect

Our current chairman-elect, Alan Nixon, attended the Divisional Officers Meeting earlier this year. It brought together chairmen-elect from various ACS divisions. To quote Dr. Nixon, "This was a very fruitful meeting, well organized and well run, which dealt with the business of organizing sessions for national meetings. It was an intensive working session. The only time I got out on Bourbon Street was after 10:00 p.m."

His other comments included the following, which I will share with you: "One of the important duties of the Division of Professional Relations is to be a watch dog over ethical matters in the Society. It is my contention that it is the professionalism of the members of the profession which assures that the members of the profession will act as professionals and to do that they must act ethically. I also contend that a person who acts ethically should not be placed in a position of having to put his future in jeopardy in so doing. The person who attempts to serve the public interest by revealing unethical actions of his employer or government must be protected by law.

"I believe one of the goals of our Division is to encourage the passage of such laws. Some protections are coming slowly through case law but an act of Congress is much more powerful and more easily applicable. Some countries in Europe, as well as Canada, and a few states in this country have such laws. Future DPR programs will examine how these laws have come about and how they work.

"Members who have ideas about what actions the Division should take or programs it should sponsor should let me know."

Bylaws

The last issue of the *Bulletin* discussed a major problem with interpretation of the ACS bylaws related to Divisional representation on the Council, and how the current interpretation (with which we disagree) resulted in the DPR being unable to regain a lost Councilor. Well, we have submitted a formal bylaw amendment to correct this problem. We are working with the ACS Committee on Constitution and Bylaws to arrive at workable language, and the amendment should be up for a vote at the Fall meeting. You might want to alert your local section Councilors to look for it later in the year, and give us their support. The bylaw should have no effect on local section Councilors, but deals only with the distribution of the allotted number of divisional councilors among the divisions.

Contents

This issue contains two of the papers presented at the DPR symposium, "Leaping the Technology Transfer Barriers," held at the Philadelphia national meeting last year.

Commercial

This is a personal appeal. The DPR has only one Councilor, yours truly. Much to my surprise, I have found it impossible to be everywhere at once. It would be most helpful to have another Councilor or two to help represent your Division. Only *you* can make that happen. Please sign up some colleagues. Thanks.

—Dennis Chamot

LEAPING THE BARRIERS: THE ROLE OF THE INVENTION ADMINISTRATION ORGANIZATION

H. Gordon Howe
Director—Invention Administration Program
Research Corporation

Research laboratories of academic and scientific research institutions are fertile sources of scientific discoveries and breakthroughs which can lead to new technology and indeed to entire new industries. As some examples, witness the maser from Columbia University which led to the laser; the ferrite core computer memory system from MIT; the irradiation of milk to produce vitamin D from the University of Wisconsin; the use of stannous fluoride as an anticaries agent from Indiana University; and the transformation of microorganisms by genetic engineering from Stanford University and the University of California.

All of these developments were giant steps forward, and it might be argued that they would have been brought into use in spite of all the barriers that exist to the transfer of technology simply by the sheer weight of their significance. What, however, of the lesser developments that arise in the research programs of these institutions, those that are monumental but represent a small step forward in the art, a small advance in the technology? Will these be recognized and adopted by the industry to which they relate, or will they wither and lie fallow because of various barriers?

What are these barriers? What are the obstacles to the transfer of technology from the university laboratory or the medical research laboratory to the marketplace? There are many, some primarily of historical interest and some current and formidable, some perceived and some real. Let me ennumerate a few.

First there is, or was, the traditional feeling among academic people that patents are "dirty," that it is not seemly for a research scientist to patent his discoveries and profit from them financially, that to do so is somewhat unethical and demeaning. Because of this feeling, some institutions, 25 or 30 years ago, would not permit the patenting of research results or would require that the resulting patents be dedicated to the public. Happily, this philosophy no longer exists to any significant extent.

Second, there is a significant ignorance on the part of academic scientists of the workings and benefits of the patent system. It is frequently not recognized that utilization of the patent system can be of immense benefit to the inventor, his institution and the general public. It is not understood that in many instances the incentive for developing an invention and bringing it to the market can be provided only through the protection that patent coverage offers to the developing firm. Many inventions which might have benefitted the public were never developed because they were in the public domain; to repeat an old phrase, "everyone's business is no one's business."

Third, there is the misconception, which still exists in many circles, that publishing and patenting are incompatible. Publications are the life blood of the academic scientist, both to pass on the knowledge he has gained to his peers and to the public, and to advance his professional career. The immediate benefits of a publication outweigh, in his eyes, the long term benefits to be realized from patenting. What is often not recognized, however, is that these two objectives are not at all inconsistent, particularly so in the United States. Even if a publication has appeared, a U.S. patent application can still be filed if this is done within one year of the public availability of the publication. Furthermore, if a U.S. application is filed before the appearance of the publication, patent protection can then be obtained in most foreign countries of the world if applications are filed within a year of the U.S. filing date, even if an intervening publication has appeared. And finally, even if a paper has been submitted for publication, there is frequently adequate time to prepare and file a patent application before the publication appears.

Fourth, a barrier which was significant in the past but which has been alleviated considerably by the passage of Public Law 96-517 is the matter of governmental involvement. Prior to PL 96-517 there was a myriad of patent policies promulgated by the various departments and agencies of the Federal Government, some more and some less restrictive. A company seeking a license under a government-supported university invention frequently did not know the extent of the rights that might be available to it, and this often had to be determined through a lengthy and uncertain petitioning process. Many companies were unwilling to take the risk involved when other equally attractive opportunities were available without these uncertainties. In addition, there was, and still is in many instances, an imposed limitation on the period of exclusivity that could be provided in a license under a government-supported invention, further reducing the attractiveness to a commercial licensee.

These problems have to a large extent been eliminated by Public Law 96-517. A university can now be assured that it will be able to retain title to a government-supported invention and to license the patent rights. Furthermore, if the licensee is a small business, as defined in the Code of Federal Regulation, Title 13, Part 121 as amended, an exclusive license for the life of the patent rights can be granted. In the case of larger companies, however, exclusivity can be granted for only a limited period of time, and in all cases the United States Government is entitled to a nonexclusive, royalty-free license for governmental purposes. This latter provision can, of course, be very inhibiting in the case of inventions whose primary use would be by or for the Government.

Fifth, most inventions emanating from universities and research institutions suffer from the fact that they are in an embryonic or early developmental stage. It is the function of most such institutions to do basic research rather than to develop inventions. Such inventions, therefore, have rarely advanced beyond the laboratory or prototype stage, and the institution rarely has the facilities or capability to complete the development.

It is therefore incumbent upon the industrial licensee to recognize the merits of the invention at this early stage, to assume the risks inherent in developing it, and to take all of the steps necessary to perfect it and bring it to the market. The time required to carry out such a program can vary from 2 or 3 to as long as 8 or 10 years, thus consuming a considerable portion of the 17 year patent life, and the cost involved can range from a few hundred thousand dollars to as much as five or ten million dollars or even more. Various studies have shown that the investment required to develop a new pharmaceutical or agricultural chemical product and to obtain FDA clearance for marketing can be as high as 20 to 30 million dollars. It is obvious that such a risk would not be taken in the absence of an exclusive license under sound patent protection and that only well-financed firms can afford to undertake such gambles.

Sixth, there is the difficulty of communicating the availability of university technology to industry and of communicating industry's needs and desires to the academic and scientific community. Although considerable advances have been made in this area, it is still a highly imperfect process. Research scientists and their institutions frequently lack an intimate knowledge of the firms that might be interested in their developments, except perhaps at a local geographical level, and companies interested in acquiring new technology are often baffled by the problem of where to look for pertinent developments among the hundreds of institutions conducting significant research. Bridging this communications gap is a serious and continuing problem.

Seventh, there is the problem of having the invention picked up and adequately developed even after it is identified by a qualified firm. There is, of course, the well-known NIH (Not Invented Here) syndrome which has been widely recognized as a technology transfer barrier. Scientists, engineers and technicians in industrial laboratories are certainly more inclined to favor and promote their own concepts and developments as opposed to those coming into the company from the outside, for both personal and professional reasons. When a new product or process concept is brought into the company for evaluation, therefore, it must run the gauntlet of scepticism, resistance and competition from internally generated ideas. Only the most deserving will pass this test.

When the invention is accepted as worthwhile by the company management, there is still the difficult task of negotiating an appropriate license agreement or other commercial arrangement. Here, the frequent lack of mutual understanding and possible conflict between the needs and desires of the parties can present serious difficulties. The desire of the institution is to advance its educational and research objectives, to assure free dissemination of information and knowledge, to provide benefit to the public, from which it may derive some or all of its support, and to generate funds for the furtherance of these objectives. The desire of the licensee is to produce a product or offer a service, to improve its competitive position and to enhance its profitability for the benefit of its shareholders. The inventors and the university may wish to publish their research results; the licensee may want to restrict publication. The institution may wish to make the invention widely available to the public; the company may wish total exclusivity. The inventor may feel that his development is pioneering and invaluable; the licensee may feel that it represents a modest advance. The licensee may wish the university to agree to enforce the patent rights; the university may not wish to be drawn into litigation for both financial and public relations reasons.

All of these, and other, differences, must be resolved so that an agreement acceptable to both parties can be achieved. The negotiation of such arrangements requires knowledge, experience and patience but the final agreement can be the foundation upon which the ultimate success of the invention may stand or fall.

Finally, there is the matter of the product "champion." Although it may not be absolutely necessary, it can be extremely helpful to have someone within, or closely connected with, the licensee who firmly supports and promotes the invention, someone who believes in it. Development programs rarely run smoothly; unexpected obstacles, set-backs and delays almost always occur. It can, at these times, be very tempting for the company to give up on the invention. If there is a product champion, however, the chances that the program will be carried through to a successful conclusion are greatly improved. Unfortunately, however, internally-generated developments are more likely to have their champion than those externally acquired. The "licensed-in" inventions will therefore have a more difficult time proceeding through the various stages to ultimate development and marketing.

What is an invention administration organization and what role can it play in "leaping" the technology transfer barriers just mentioned? For the purpose of this presentation, an invention administration organization will be defined as an off-campus organization which the institution utilizes for the administration of its inventions rather than performing this function through its own staff or personnel. There are a number of such organizations presently in existence, including Research Corporation, University Patents, Inc., Battelle Development Corporation and Arthur D. Little, Inc. All of these offer a service to institutions, and occasionally to independent inventors, comprising the evaluation of potential inventions, the patenting of those meeting their acceptance criteria and the commercialization of these accepted inventions through licensing or otherwise. To illustrate how these organizations operate, I will give a brief description of Research Corporation, the organization with which I am affiliated.

Research Corporation was founded as a not-for-profit foundation in 1912 by Dr. Frederick Gardner Cottrell, Professor of Physical Chemistry at the University of California, Berkeley, and inventor of the electrostatic precipitator for removing fly ash and other particulate material from smoke stacks and industrial exhaust gases. The original assets of the foundation were Cottrell's patent rights on the electrostatic precipitator. Its chartered purposes were to assist other inventors in the commercialization of their inventions and to distribute its net earnings in the form of grants to support basic research in the natural sciences in academic and scientific institutions. Today we distribute about three million dollars annually through our Grants Program to colleges and universities.

Our charter also provides that we may acquire gifts, and other assets including inventions, and administer them through licensing or otherwise. In the late 1920's and early 1930's we undertook the administration of a number of important inventions including the synthesis of vitamin B_1 and pantothenic acid, both highly successful developments.

In the middle 1930's we initiated our Invention Administration Program which is today one of the major activities of the foundation. Under this program we offer a service to academic and scientific nonprofit institutions comprising the evaluation of invention disclosures which the institution elects to submit to us for feasibility, patentability, licensability and commercial potential; the acceptance of those inventions which meet our criteria; the securing of patent coverage on these accepted inventions in the United States and in foreign countries; and the introduction of these inventions into commercial use through licensing of the patent rights or through the establishment of start-up companies or joint ventures. At the present time we have Invention Administration Agreements in effect with approximately 300 institutions and our gross annual licensing income is in the neighborhood of nine million dollars.

How do organizations such as ours assist academic and scientific research organizations in overcoming the technology transfer barriers? We do so by providing a complete invention administration service focusing on all phases of the technology transfer process.

The first phase is education. Faculty and staff scientists and engineers must be made aware of how the U.S. patent system operates and how its foreign counterparts operate. They must know that U.S. patent rights will be lost if a patent application is not filed within a year of first publication of an invention; that most foreign rights will be lost unless an application is filed *before* any publication; that a thesis becomes a publication when it is made available in a university library; that an abstract circulated at or before a scientific meeting is a publication if it discloses the invention; that in many foreign countries an oral presentation, even though not otherwise in writing, may constitute a publication.

Inventors and potential inventors must be taught what an invention is. They must be told how to keep adequate laboratory notebooks and records so that their rights will be preserved in the event that someone else makes the same invention independently and at about the same time. And most importantly, they must be made to appreciate the patent system and its advantages to the inventor, to his institution and to the general public.

This educational process is carried out through our "patent awareness program"—a program of visits by experienced staff members to the institutions we serve, on a frequent and recurring basis. During these visits we meet with administrators, staff and faculty, individually, in small groups or in general seminars to transmit this necessary information. This is an imposing task given the heterogeneous nature of a university or research institution, the constant shifting of personnel and the fact that it is impossible to know who will make the next invention. Nevertheless, we have found from experience that such a program can significantly raise the level of patent awareness at a given institution and increase the number of invention disclosures that are submitted for processing.

The second phase involves protecting the invention once it has been identified. Skillful patent drafting and prosecution by experienced patent attorneys knowledgeable in the field of technology to which the invention relates are prerequisites to good patent coverage. Since in most instances successful licensing depends on sound patent protection, it is essential that this step be performed professionally and expertly. A valuable invention can be lost or seriously limited through poor patenting.

Many institutions use a local patent attorney to obtain protection on their inventions, perhaps one who is an alumnus or friend of the institution. Such an arrangement may be satisfactory if the invention falls within the area of the attorney's technical expertise but may fail completely in other areas. University inventions tend to fall in every conceivable area of science and technology and no single attorney can be competent in all such areas. The patent administration organization, with a large volume of patent prosecution activity, can utilize the larger patent firms with attorneys versed in all fields of technology, or can select specific attorneys from different firms depending on the nature of the invention.

Supervision of the patenting process with ultimate licensing or commercialization in mind is another important function of the invention administration organization. Since most university inventions are in an early state of development and evolution, they frequently tend to evolve and change as the process proceeds. Continual review of both the status of the invention and the progress of the patent prosecution is necessary to insure that maximum patent protection will be obtained and that the issued patents will support a successful licensing program.

Another important function of the invention administration organization is the securing of foreign patent protection. With many kinds of inventions, agricultural chemicals, for example, broad international patent coverage is helpful, if not essential, in attracting licensing interest on the part of the large multinational firms that are the potential licensees for such developments. Without foreign protection, such inventions may not be licensed and developed.

Foreign patenting, however, is expensive. Obtaining patent coverage in the major developed and industrialized countries—the Common Market and Japan, for example—can cost in the neighborhood of $20,000 to $30,000, and the cost of maintaining such patents is substantial and increases year to year. Few academic and scientific institutions have the available funds to undertake expenses of this nature, particularly so when the foreign filing decision must be made at an early time in the development of the invention when the uncertainties and risks are great. The invention administration oranization routinely undertakes this risk, thereby enhancing the prospects for transfer of the technology into broad public use.

The third phase in the process is the transfer itself, the licensing of the technology or the use of it to establish a new start-up company or a joint venture. To carry out this process effectively, knowledge and experience are essential. The university or research institution is not normally in a good position to perform this function. It is often done by a part-time person with inadequate facilities and budget. The invention administration organization, on the other hand, is staffed with full-time professionals, knowledgeable in the legal aspects of patent licensing and experienced in the practicalities of license negotiation and supervision. The organization develops and maintains contacts with industry, is familiar with the product interests and needs of companies in many fields, and is able to attract the attention of the appropriate individuals within such companies when it approaches industry with a licensing proposition. It is familiar with and utilizes all of the tools that are available in the licensing profession—the directories, the computer data banks, the consultants, the venture capitalists and the organizations devoted to technology transfer. In other words, it is in a position to conduct a full-scale, international licensing effort.

The existence of such organizations is of benefit to industry also. The problem faced by many companies is how to interface with the multitude of institutions that may be developing technology of interest to the company, how to optimize the technology search effort. This can often be facilitated by contacting an organization such as ours that administers inventions for many institutions.

Another important factor in the technology transfer process is experience in the development, negotiation and drafting of licensing arrangements. This is a specialized field that requires an intimate knowledge of patents, licensing law, antitrust law, government policies and regulations, technology, economics, business and many other factors including the art of negotiation. It requires a team effort employing the talents of many different individuals. Most institutions do not have the staff to bring all these talents to bear on the problem. Because of this, we have seen many instances where agreements decidedly unfavorable to the institution have been entered into, whereas the use of an invention administration organization might have produced a more satisfactory result.

In the administration and licensing of inventions the possibility of unlicensed infringement always exists. If the invention is licensed, the licensee usually wants action to be taken against the infringer. If the invention is not licensed, such action might be necessary in order to secure an income from the invention and the patent rights.

Infringement litigation is expensive, particularly in the United States. To carry such an action through to a decision in the courts can cost anywhere from $500,000 to over $1,000,000. Few institutions are in a position to undertake such an expense. Furthermore, most institutions wish to avoid litigation because of the unfavorable publicity involved and the negative effect it can have on public relations. On the other hand, a successful licensing program is difficult to maintain unless industry recognizes that the patent rights will be enforced.

The invention administration organization can play a useful role here by relieving the institution of infringement and litigation problems. The organization has both the experience to deal with infringement problems and the financial capability to take legal action should this become necessary. Although we prefer to avoid such litigation if possible, we have in several instances over the years gone to court to enforce the patent rights that we administer under our university agreements.

Finally, the invention administration organization plays an important role in transferring technology from the laboratory into public use by undertaking the financial risk, thus relieving the institution of this burden. All of Research Corporation's services of invention evaluation, patenting and licensing are provided entirely at our expense and at no cost to the institution. We hope to recover our expenses out of our share of future income. The institution therefore has available to it the opportunity to have any or all potential inventions evaluated and administered without any concern for budgets and without the need for diverting funds from other worthwhile pursuits.

In closing, the invention administration organization plays a useful role in leaping technology transfer barriers by educating institutions about inventions and patenting, by providing a complete patenting and licensing service to academic and scientific research institutions at no cost to these institutions, by providing expertise in the bringing of such inventions to the market, and by offering to industry a source of new product and business opportunities and an experienced and knowledgeable organization to deal with in the acquisition of such technology.

DPR Membership Application

I am a member of the American Chemical Society.
Enclosed is $4 to cover dues through December 31, 1985.

Signature: ______________________________

Printed Name ______________________________
Last *First*

Address ______________________________

____

Mail to: **Paul A. Rebers, Secretary**
Division of Professional Relations
P.O. Box 70
Ames, Iowa 50010

ORGANIZATIONAL INNOVATIONS TO PROMOTE SCIENTIFIC AND TECHNOLOGICAL VITALITY

Don I. Phillips[1], Executive Director
Government-University-Industry Research Roundtable

In 1970, Professor Don Price of Harvard reflected on the emergence of our nation's scientific and technological enterprise during World War II by observing:

> The most significant discovery or development for science and technology to come from the war effort was not the technical secrets that were involved in radar or the atomic bomb. It was the administrative system and set of operating policies that produced such technical feats.[2]

From these organizational innovations, a national system for scientific research and technological development evolved that has been the envy of the world.

Today, however, there are indications that our extraordinary system for conducting and utilizing scientific research has grown old. There are signs that it lacks the flexibility and vitality needed to meet new challenges and sustain the nation's economic strength and competitiveness. American leadership has eroded in various technologies including electronics, automobiles, and steel. There is concern about sustaining our leadership in biotechnology. University science and engineering departments, which are charged with conducting much basic research, are beset with problems. Reports document deficiencies in equipment, facilities, numbers and quality of graduate students and faculty, and research support procedures. There is widespread concern in government, industry, and universities that our country has not maintained the innovative characteristics that fueled our earlier scientific and economic success.[3]

Ironically, these and other issues are arising even as Americans are looking as never before to science, engineering, and education to help solve their problems. The strength of this interest, and its distribution across all sectors of society—federal, state, and local governments, industry, universities, and the general public—is a rare phenomenon, one that did not exist during the post-war, high-growth period of science, based largely on federal interests and initiatives. Each sector expects that a strong scientific and technological enterprise is critical for the achievement of its goals. The three principal expectations are:

1. Advancement of knowledge
2. Education and training of the next generation of scientists and engineers
3. Achievement of specific national and local goals and development of new and improved products and processes

These expectations place a challenge before those concerned with the health of American science and technology, comparable to that faced during and following World War II: now we must devise the organizational arrangements appropriate to *today's* needs and opportunities for the conduct of high quality science and for its effective utilization.

Many such steps are underway. I will examine two with which I am or have been involved: one at the national level, the Government-University-Industry Research Roundtable, and one at the state level, the North Carolina Biotechnology Center.

The Research Roundtable has been established only recently. The discussion, therefore, focuses on 1) the changing nature of the relationships between the sponsors and performers of research that prompted its creation; 2) the philosophy guiding its operation; and 3) the initial operational plan.

One of the topics that the Roundtable will take up is the newly-developing relationships between state governments and the scientific and technological enterprise. These relationships are especially relevant to this volume, given the emphasis of the states on promoting technological development in state and local economies.

Government-University-Industry Research Roundtable

The Government-University-Industry Research Roundtable is an experiment with a new type of institution to provide a forum where scientists, engineers and administrators from government, universities and industry can come together on an ongoing basis to explore ways to improve the productivity of the nation's research enterprise through improved working relationships among the sectors. The object is to try to understand issues, to inject imaginative thought into the system, and to provide a setting for discussion and the seeking of common ground. The Roundtable will not make recommendations, nor offer specific advice. It will bring all interested parties together. The Roundtable was established under the aegis of the Council of the National Academy of Sciences.

The partnerships in research and education that have developed over the past four decades between the federal government and universities are a central feature of the growth of our scientific enterprise. Prior to World War II, research at universities was supported largely by universities themselves, industry, and private foundations, with only modest amounts provided by the federal government, except in agricultural research. Events surrounding the War, and subsequently the Cold War and Sputnik, and national concerns for health and international prestige and competitiveness, were to change all this in ways that only now are becoming fully appreciated. The federal government-university partnership grew rapidly in the 1950's and early 1960's. Federal funding of academic research increased an average of 15 percent annually, in real terms, from 1954 to 1964.[4] The federal government also contributed substantially to building the infrastructure that was so essential to the conduct of this research. Federal programs provided direct support for graduate and postdoctoral fellowships, scientific equipment and facilities, and university institutional development in science.

The universities responded vigorously to this infusion of public funds for academic science, growing sharply in their capacity for research and graduate training in the sciences and engineering. Leading research universities expanded their facilities, faculty, and enrollments, while other institutions established new doctoral programs and began competing for research funds.

Rapid growth ended in the mid-1960's, and many structural problems in the system emerged. Federal agencies were forced to reassess priorities, cut entire programs, award fewer and smaller research grants, and limit funding for training, equipment, and facilities. Research support began to be provided increasingly on a cost-reimbursement basis within a procurement philosophy. Executive Branch agencies responded to congressional calls for increased accountability for expenditures of public funds by tightening cost accounting and reporting requirements and increasingly questioning research costs, especially indirect costs. Procedures within government and universities became increasingly bureaucratic.

Many universities found themselves overextended, with a high percentage of tenured faculty, relatively top-heavy administrative structures, and major investments in facilities and equipment with inadequate means of maintaining them properly. All this when research costs were escalating rapidly, student enrollments were declining steadily, and alternative sources of support were not well developed.

By the late 1970's, these structural and institutional problems in the federal government-university partnership were sufficiently exposed and sensitive to raise a long list of issues on which there were tension and disagreement regarding the support and conduct of academic science.

The growth in federal funds for science attracted most of the attention of the academic scientific community; relationships with state governments and industry diminished. Industry, in turn, enjoying the post-war economic expansion and international technological dominance, had little incentive to nurture relationships with universities. Today, in spite of the continued dominant federal role in academic science, new alliances are emerging. Why?

Since 1960 the state and federal shares of support for higher education have been generally comparable, and in recent years, state spending has outpaced that of the federal government. The federal role is much more prominent than that of the states at major research universities and private institutions, however. Except for agriculture and other selected topics in a few states, most organized research and other "sponsored" or "directed" activities have been conducted in response to federal objectives and guidelines, not those of states. Support by the states for faculty salaries, buildings, and other elements of the infrastructure, of course, has been critical to building capacity in the universities to conduct this research. State government policies regarding consulting, indirect costs, financial management, and capital acquisition and construction also influence in meaningful ways the capabilities of universities to carry out research and educate graduate students.

In recent years, state governments have been seeking to go beyond these relatively benign relationships with universities to find ways to mobilize the academic resources in pursuit of state and local goals, needs, and opportunities. The principal driving force behind these initiatives is economic development—to increase the efficiency and productivity of the current economic and industrial base, including the creation of new firms as well as innovative improvements in the operation of existing firms, and to acquire a solid base of emerging technology companies.

In large part, the renewed interactions between industry and universities have resulted from deficiencies in our economic and technological infrastructure that became most apparent in the late 1970's. Rates of productivity increases declined, and in some years reached zero; by various measures of technological innovation, the U.S. was falling behind its major international competitors; and inflation, unemployment, and plant closings signalled a general economic malaise throughout the country. Decreased national investments—private and governmental—in R&D and the failure to utilize effectively existing knowledge were viewed as two major causes of the decline in the nation's technological vitality.

In reestablishing ties with universities, industry wants to ensure a continuing strong research and education enterprise in the country and seeks additional access to new knowledge and expertise in the universities. Although industry continues to support only a small fraction of university research, its support increased by fifteen percent between 1982 and 1983, without correcting for inflation. Total industrial support for all R&D also is growing, with an expected increase of seven percent, in real terms, from 1983 to 1984.[5]

Universities themselves also are seeking to enhance the quality of these new alliances. It would be naive not to include the search for additional sources of financial support as one of the motivating factors, but I would like to think that other factors are of at least equal importance. Universities see the alliances as increasing their abilities to contribute to national, regional, and local needs. In addition, they expect that these new connections will provide new and valuable perspectives to undergraduate and graduate education as well as to the conduct of fundamental research.

The concept of a forum was first proposed by the National Commission on Research in 1980 as an innovative way of responding to controversial issues at the government-university interface in a non-adversarial setting. This idea was endorsed by the National Academy of Sciences Ad Hoc Committee on Government-University Relations in Support of Science, which issued a 1983 report calling for the establishment of such a forum and detailing a suggested mode of operation. The Committee cited "an overwhelming need for better mutual understanding among the partners" in the research enterprise and conceived of the forum as a device for improving communication on important policy issues. As the concept of the forum was implemented under NAS auspices, the roles of state governments and industry were added to the charter to more accurately reflect the full range of relationships important in sustaining a strong scientific enterprise, and the proposed forum was named the Government-University-Industry Research Roundtable.

Funds for initiation of the Roundtable were provided by the Academy. Support for long-term operation is being sought from private foundations. The Sloan and Mellon Foundations and the National Research Council Fund each have made substantial contributions.

The Roundtable's 18-member Council was assembled early in 1984. The Council functions as a steering group, establishing the overall framework for the operation of the Roundtable. Convening for the first time in May, 1984, the Council identified issues for Roundtable examination, and formed an Executive Committee charged with the task of establishing working groups to address these topics.

Four working groups are being constituted. Each has a chairman and vice-chairman from the Council. Other working group members will be recruited wherever the most appropriate people for the topics at hand can be found. The four groups each have a general area of jurisdiction within which, with oversight by the Council, they will select particular topics for examination.

Group One, "Capacity of Academic Science: The Identification, Recruitment and Retention of Talent" ("Talent"), is concerned with the identification, recruitment and retention of high quality personnel into scientific and engineering careers. The purpose is to investigate the conditions and strategies that will attract excellence from all segments of the population into science and engineering on an ongoing basis, and that will encourage experienced faculty members and senior investigators to continue their careers. The group will not become involved in forecasting manpower needs.

Group Two, "Capacity of Academic Science: Institutional Renewal" ("Institutional Renewal"), is concerned with all the organizational arrangements bearing on the research enterprise as well as with physical facilities and support mechanisms. This scope encompasses: relationships between sponsors and performers; facilities, equipment and data bases; multidisciplinary research and education; and the capabilities of universities to contribute to national needs.

Group Three, "New Alliances and Partnerships: Enhancing the Utilization of Scientific Advances" ("New Alliances"), will focus on the ability of government, arrangements for promoting the cross-fertilization of ideas and increased utilization of basic knowledge and technology. "New alliances" refers to the joint ventures and emerging relationships among universities and between universities, industry, state governments, and federal labs.

Group Four, "Major Institutional Issues Involving the Relationship Between Science, Technology, and the Performers and Sponsors of Research" ("Larger Issues"), is concerned with broad and longer range matters underlying the whole research system. The specifics of what this group will address are still under discussion. Nonetheless, the types of questions it is thought Group Four may focus on range from how the federal government sets priorities and allocates resources for science (pork barrel vs. peer review; executive roles vs. legislative roles; strategic planning vs. decentralised pluralism) to matters surrounding societal expectations of academic science.

Let me emphasize again that the role of the Working Groups and the Roundtable as a whole is to define options and to suggest possible ways to proceed, not to recommend any particular policies or programs. The success of the Roundtable depends on its ability to ask the right questions and to explore the important topics. We welcome input from the scientific and engineering community.

The North Carolina Biotechnology Center

The North Carolina Biotechnology Center is an example of one of the "new alliances" to be examined by Working Group Three. This alliance, initiated by the North Carolina State Government, involves state and local governments, the federal government, public and private universities, industry, and the financial community.

The North Carolina Biotechnology Center (NCBC) is established as an office within the North Carolina Board of Science and Technology in the Office of the Governor. The Center consists of a small staff with the charge to stimulate the development and application of biotechnology within the state. The Center's budget includes about $1.5 million in state funds and about an equal amount from industry and the federal government.

The Center pursues its objectives through a variety of programs:

Research and Education. The Center, in cooperation with universities and industry, is conducting three major programs aimed at strengthening biotechnology research and education in the state: University/Industry Cooperative Research Center in Monoclonal Lymphocyte Technology; Triangle Universities Consortium for Research and Teaching in Plant Molecular Biology; and the Biomolecular Engineering and Materials Applications Center.

The research and education takes place at participating universities, primarily Duke University, North Carolina State University, and the University of North Carolina at Chapel Hill; activities also take place at participating companies. The programs are administered through the Center, but guided by groups of university and industry scientists and engineers. The Center stimulates and facilitates university-university and university-industry collaboration, both at the institutional and working scientific levels.

Industrial Liaison and Business Development. Programs in this area focus on three objectives: 1) recruiting new industry to the state; 2) nurturing the development of new and existing businesses within the state; and 3) enhancing the interactions between universities and industry. The programs are carried out in cooperation with the universities, the N.C. Department of Commerce, the N.C. Technological Development Authority, local chambers of commerce, and others concerned with economic development. In pursuing these objectives, the Center seeks to create networks of and stimulate interactions among scientists, entrepreneurs, and sources of financial, managerial, and technical assistance.

Promising New Initiatives. In a field with the great potential of biotechnology, it is critical that scientists and engineers have the opportunity to pursue untried ideas that hold promise for scientific advance, technological development, and effective education. Therefore, the Center conducts a grants program to provide "seed money" to university and industrial scientists and engineers to allow them to conduct preliminary investigations and educational programs based on their new ideas. It is expected that funds from sources in addition to the Center will be obtained to carry out these projects. If the results of these early research and training programs show promise, it is assumed that additional resources to carry the work further will be obtained from other public and private sources. The grants are intended for new faculty members in universities, established faculty members who are initiating new research programs, and individuals who are starting or expanding small businesses related to biotechnology.

Communications. The Center publishes a newsletter and an inventory of all scientists and engineers in the state working in fields relating to biotechnology, organizes conferences and workshops, and seeks to work with schools, museums, and community groups to improve the public's understanding of biotechnology.

Roles of States

The North Carolina Biotechnology Center is only one of the new technology programs initiated by North Carolina in the past eight years. And, North Carolina is by no means alone among the states in assuming new roles in science and technology. Reports by the National Governor's Association and the Office of Technology Assessment indicate that all states are now involved, one way or another, in seeking to achieve their goals (primarily economic development) through more effective investments in and utilization of their scientific and technological resources.[6]

The state strategies center around collaboration among government, academia, industry, the financial community, and the general public. The strategies assume that the federal government must continue to be primarily responsible for support of basic research and for guiding national economic policy. The states, however, acting as a catalyst, a stimulator, and a convenor, see their roles as fostering and supporting the partnerships between higher education, business, and other sectors that can accelerate the rate at which scientific advances are translated into new or improved products, processes, and techniques.

State strategies for "leaping the technology transfer barriers" can be grouped into four categories. States with the most vigorous programs are undertaking a comprehensive approach that includes activities in all categories. Other states are beginning with less intensive efforts.[7]

Policy Development. A state level task force, board, or commission is frequently created by the Governor to foster development and implementation of policies and programs. The organization works with businesses, local governments, educational institutions, and the public in identifying needs and opportunities and outlining strategies for pursuing them.

Elementary and Secondary Education. Effective utilization of scientific advances depends on an ample supply of scientists and engineers and a population with a general understanding of science and technology. States are implementing a wide range of programs and policies aimed at improving elementary and secondary education, in general, and science and mathematics education in particular.[8] The recent national reports have drawn increased attention to the problems here, but many states had begun to address the deficiencies before these reports were issued.

Research, Higher Education, and Training. Advanced education and research programs in universities are strengthened in related areas. Working relationships between universities and industries are being enhanced by the establishment of advanced technology centers, research institutes, research affiliates programs and other industry-university linkages. New and/or advanced technology is pursued, rather than simply high technology research and development. This ensures that traditional industries such as textiles and automobiles are encompassed, as well as new firms concerned with computers, robots and other sophisticated technologies. Training and retraining of workers are given priority, and special arrangements between community colleges and industrial firms are devised to match qualifications with requirements.

Private Sector Development. Innovative development organizations, incubator facilities and venture capital firms are being established in several states to assist new small business ventures get off the ground. Through technical, managerial, and financial assistance, states are helping firms spawned by new technologies to gain a foothold.

Some states are developing special programs that link universities and R&D institutes with traditional industries such as automobiles, textiles and steel. The intent is to enable such firms to develop innovative means of improving products and lowering costs.

I conclude the paper with an examination of the implications of these state initiatives for the evolution of a national policy framework that will promote scientific and technological vitality. The approach here is to raise issues, rather than to provide answers. At this stage, answers are probably premature. The state initiatives are still too new to allow thorough assessment, and the scholarly community is only beginning to address the topic after a long period of neglect.

The term, "technology transfer," should be defined broadly to include all the processes by which fundamental knowledge or scientific advances are utilized by some component of society to meet its goals and objectives—for example, producing a new product or process; writing regulations to govern the handling of hazardous wastes; developing a new chemistry curriculum. A great deal of research by persons from a broad range of disciplines has shown that this knowledge utilization process is very complex; it includes many interactions between the people and organizations involved; and it involves complex patterns of information flow and decision-making. The translation of knowledge into applications is not the linear process from basic research through applied research, development, demonstration to product that is often characterized in the diagrams. I fear that the term "technology transfer" too often brings to mind this linear model and, as a result, leads to simplistic strategies for promoting enhanced knowledge utilization.

Many of the state strategies appear to recognize this complexity. And, they are based on the premise that the joint efforts and complex interaction that must be a part of promoting knowledge utilization do not often just happen.

One needs to balance the potential advantages of this decentralized and perhaps more flexible approach provided by state leadership with the potential disadvantages of duplication of effort, economic inefficiency, and interstate competition with no net national gain.[9] While these tradeoffs need much further examination, Governor Richard Thornburg of Pennsylvania has argued in favor of the advantages of state leadership, if it goes beyond "smokestack chasing" to include a comprehensive strategy like that outlined above. Such an approach, he feels, can make all states "winners". All the elements of the strategy are good investments for the state (and the nation) regardless of whether the state is successful in encouraging a specific firm to start up or expand.[10] In addition, state efforts directed toward facilitating the incorporation of new technology into industry can result in net productivity increases of benefit to the nation as a whole; it is not simply a situation of "winners" and "losers" resulting from a company changing the location of a facility.

The findings of a recent comparative study of the relationships between federal R&D policy and technological change in seven major American industries—semiconductors, computers, aircraft, pharmaceuticals, agriculture, residential construction, and automobiles—also are pertinent to an examination of the potential role of the states in technological de-

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velopment.[11] The authors found three types of policy that have been successful in the past: 1) government R&D support for technologies in which the government has a strong and direct procurement interest; 2) decentralized systems of government-supported research in the "generic" area between the basic and the applied; and 3) a decentralized system of clientele-oriented support for applied R&D.

Features that were found to be keys to success in areas 2) and 3), those areas of primary concern in this discussion, are:

- Involvement of *both* the scientific community and those interested in applications in the allocation of R&D resources.
- Evolution of the research system on the basis of the needs and desires of the scientific community and those concerned with applications; the initiative and the design of the programs were not centrally orchestrated.

The authors did not extend their analyses to the potential contributions of the states to industrial innovation, except in agriculture where states have had a longstanding dominant role. Their findings, however, are consistent with the approaches being used by the states. States are directing their efforts toward "generic" technology and applied R&D through collaborative arrangements among the producers and users of knowledge. Their style is one of facilitating joint efforts, not of centrally controlling the action through administrative or bureaucratic structures.

There is general agreement on the policy that the federal government is the primary sponsor of basic research and of all R&D for defense, space, and other well-defined public purposes. The private sector is responsible for product development in the civilian sector. There still is no general agreement, however, on the roles and responsibilities for general applied research and technology development in the civilian sector—processes essential to translating basic knowledge into applications. The study cited above notes how any such policies must take account of the unique characteristics of each industry sector. The general conclusions of the study, however, taken together with the state approaches to technological innovation imply that new federal-state cooperative arrangements that involve industry and universities may be what is needed to fill the void in national policy for science and technology that now exists between the areas of basic research and commercialization. A policy statement on "Technological Innovation" adopted by the National Governors' Association at its recent summer meeting includes proposals for such federal-state cooperation.[12]

Central to any discussion of the nation's scientific and technological vitality is an assessment of the capability of institutions of higher education to continue to carry out high quality research and education. The Government-University-Industry Research Roundtable was created in response to the perception that this capability is now threatened. The states are crucial parameters in the equation for determining how to overcome the deficiencies and to respond to new challenges. States provide significant general support to public colleges and universities. More recently, as part of their new technology initiatives, they are providing additional support in selected areas for faculty, students, and specialized equipment and facilities, often with innovative arrangements for management and sharing. One of the tasks facing the Roundtable, along with other groups concerned with the nation's scientific and technological vitality, is to delineate the appropriate state roles and to figure out how they are best combined with those of the federal government and industry to ensure the continued capacity of academic science.

Summary

The Government-University-Industry Research Roundtable and the North Carolina Biotechnology Center are two organizational innovations that have been created to enhance the nation's scientific and technological vitality. The Research Roundtable, in turn, will examine other innovations that might help to achieve this goal. Both organizations operate on the basis that this vitality will be achieved only through collaboration among all sectors of society. And, as a part of their missions, they seek to promote such collaboration both at the institutional and at the individual levels. The Biotechnology Center is an example of the new roles in science and technology being assumed by state governments. These roles demonstrate that states should be granted a more prominent place in national science and technology policy.

Footnotes

1 The views expressed here are those of the author and do not reflect the views of the Council of the Government-University-Industry Research Roundtable or of the Roundtable working groups.

2 See report entitled *Toward a Science Policy of the United States*, U.S. Congress, House Committee on Science and Astronautics, Subcommittee on Science, Research, and Development, Washington, D.C.: U.S. Government Printing Office, 1970, p. 81.

3 See press editorial, "Revitalizing the Scientific Enterprise" by Dale R. Corson, released July 1, 1984 by the National Academy Service of the National Academy of Sciences, Washington, D.C.

4 See "Federal Support of Academic Research," a working paper prepared for the Sloan Commission on Government and Higher Education, April 7, 1978, by Geoffrey White, cited in *Strengthening the Government-University Partnership in Science*, report of the Ad Hoc Committee on Government-University Relationships in Support of Science (GURSS), of the National Academy of Sciences, Washington, D.C.: National Academy Press, 1983, p. 41.

5 "Facts and Figures of Chemical R&D" a special report in the July 23, 1984 issue of *Chemical and Engineering News* 62(30):36-68.

6 "Technological Innovation: State Initiatives and Federal Policy," discussion paper, Task Force on Technological Innovation, National Governors' Association, February 26, 1984; *Technology and Growth: State Initiatives in Technological Innovation*, reports of the Task Force on Technological Innovation, National Governors' Association, October, 1983; *Technology, Innovation, and Regional Economic Development*, Office of Technology Assessment, July 1984.

7 Ibid.

8 *A 50-State survey of Initiatives in Science, Mathematics and Computer Education* (#SM-83-1), Denver, CO: Education Commission of the States, September, 1983, 96 pp.; *Working Paper No. 1: State Programs of School Improvement, 1983: A 50-State Survey* (#1-83-1) by Van Dougherty, Denver, CO: Education Commission of the States, October, 1983.

9 Congressional Budget Office, *The Federal Role in State Industrial Development Programs*, Washington, D.C.: Congress of the United States, July 1984, 79 pp.

10 Governor Richard Thornburgh, "State Strategies and Incentives for Economic Development," Pittsburgh, PA: The University of Pittsburgh, reprinted from *The Journal of Law and Commerce* 4(1):1-17, 1984.

11 Richard R. Nelson and Richard N. Langlois, "Industrial Innovation Policy: Lessons from American History" *Science* 219:814-818, (FEB 83).

12 "Technological Innovation," Policy Statement, National Governors' Association, Summer Meeting, 1984.