Promoting University Technology

A call for institutionalizing the transfer process on a long-term basis

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The need for the effective promotion and transfer of university technology to industry is more important today than ever before to us as a nation. We are at a critical point. This transfer process must be made more effective. Licensing personnel must take a broader view of the system within which they labor, for the survival of their profession is at stake.

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While licensing personnel may often perceive their contribution in licensing as the key factor in university-to-industry technology transfer, this is truly not the case. Their contribution is only a small part of the transfer process, albeit an important one.

The formal licensing of university technology to industry is often the culmination of a process that has long preceded the involvement of the licensing executive. It is long-term scientific cooperation that is the most effective mechanism for substantive technology transfer from a university to an industrial company. Licensable subject matter springs from that joint scientific endeavor.

To the industrial company, licensing is often a condition precedent to the investment of substantial sums of money in personnel and plant which the company expects to later recover in profits.

One Measure of Success

To the university, licensing of technology is only one measure of success in creating a useful advance in knowledge, based on its prior investment in research as a part of its basic mission. The university has no capability to deliver goods to the general public; it must rely on industry. Once licensing of a particular technology is accomplished, the university must continue to advance knowledge, and again create that which can later be transferred to industry. This research effort must be undertaken in parallel with the education of students who will eventually replace readers of this paper in their licensing functions.

The advancement of knowledge by its nature involves basic research, and this basic research is vitally important to industry. For without the continuing output of basic research, applied research would soon die, and without applied research, there would be no development of new products or new technologies. Without new products and new technologies, there would be no grist for the licensing mill. The need for the licensing executive would be severely diminished, if not eliminated.

It is important for licensing executives, as well as research directors and corporate presidents, to be fully aware of the important changes that have occurred in the mix of performers of basic research in the last two decades.

Because of these changes, universities must continue to improve their efforts to transfer the results of their research to industry and other universities, for unless their research results are used at some time in some way, the funds spent for that research are a complete waste of resources.

It is imperative for industry to reconsider the attention it gives to the conduct and output of university research. The time is upon us where industries critically need the results of basic research conducted in the university. We cannot continue to have universities' basic research efforts isolated in an ivory tower.

Random Process Today

For in spite of the great strides made in the last 10 years to find better ways to facilitate the transfer of technology between parties (whether both are industrial companies, or one is a university and one a company, whether nationally or internationally), the transfer of technology today is often a hit-and-miss, random process. We must continue efforts to institutionalize this transfer process and make it more effective.

In institutionalizing the university-to-industry transfer process, we recognize there will be many difficulties due to the differing nature of the corporate and university institutions involved. (The analogy of the difficulties of the developed and emerging nations as blocs to find ways to cooperate and better use technology for the good of all is relevant.) Misunderstandings and misconceptions exist. Universities must shed their sesquipedalian wordings, and industries not expect dramatic and programmed results two months after the initiation of a university research program.

One means by which LES members can make a

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positive, long-term contribution to the transfer of university technology to industry will be suggested. It is designed to improve upon the hit-and-miss nature of university-to-industry transfer of technology. Other means are also needed, since the problem is not amenable to a simple solution.

To properly understand the nature of the problem, it is necessary to review trends in research over the last 20 years, and analyze the impact of those trends on the activities of the licensing profession. These trends should be of concern to every licensing executive since they will have a great impact on his or her future activities.

Understanding the climate in which basic research is conducted, who performs and who pays for research in this country should not be an idle concern. Such an understanding is of importance to the vitality of our free enterprise system, our national technological leadership, and the licensing profession.

In a survey recently released by the National Science Board, entitled "Science at the Bicentennial: A Report from the Research Community,"[1] the results of an extensive survey of leaders in the university and industrial sectors were released. The survey summarized the most critical issues facing basic research in the near-term future. Many concerns were listed, and, obviously, many of them related to the constraints on the availability of funds for basic research in the university and industrial laboratory.

Among the university respondents to the survey, the greatest concern of all was the tremendous pressure on the university sector for more applied, overly targeted applied research at the expense of basic research.

Greatest Problem

Among industry respondents to the survey, it was predictable that Government regulations and controls on research were perceived as the greatest problem. However, the near-term relevance of research as the only research objective was ranked as the second greatest concern.

Both groups were extremely concerned about the negative attitude of the public and Congress toward basic research. The respondents apparently saw this as a threat to future funding, to the availability of qualified young people who would spend their lives doing basic research, and as a threat to the vitality of our research system. It is well known that the public attitude toward the value of basic research has changed dramatically in the last 20 years, to the point where there is far less support for using tax dollars to support basic research.

Those involved with the outputs of research, however, recognized the need for both basic and applied research as prerequisites for problem solving and the advancement of quality of life. It is perhaps not as well understood by the public that the most cost-effective results occur when industrial and university researchers work in close partnership. Licensing executives as a group have not, in my opinion, given this basic symbiotic relationship the serious consideration it deserves. They feel it is not their responsibility. They are wrong.

George Russell, Vice-Chancellor for Research and Dean of the Graduate College at the University of Illinois, in the referenced report,[1] stated:

> A careful analysis of successful solutions to some of the major problems this nation has faced in the past, whether it be in food production, communication, transportation, medicine, etc., will reveal two essential ingredients for success: a core of basic knowledge, generated in most cases from "non-relevant" research, and a cadre of well-trained individuals who can extend and expand or re-direct their fundamental research to the solution of the pressing problems of the time. In the corn country of Illinois, we do not today reap 150-200 bushels of corn to the acre because we set this as a goal, and did "relevant" research to achieve that goal, but because basic "non-relevant" research in plant genetics helped to obtain the fundamental insights needed to make the slow but steady progress in agricultural technology that was required.

A similar position was also reported by George Pake, Vice-President of Xerox Corporation, who said:[1]

> I believe there is no doubt in anyone's mind that the federal agencies, with congressional and possibly even public support, have been pressuring the universities in more applied directions. Here I feel my experience in both sectors, i.e., universities and industry, is of some value. Basic science is what universities do best. Applied research and development is what industry does best. It is not easy to justify to stockholders large expenditures on basic research that is just as likely to be applied by a competitor as by my own company. Universities on the other hand cannot solve real-world problems because they have no inherent requirement to solve such problems. As an industrial research manager, I depend on universities to build the fundamental science base from which my research scientists can draw in solving applied problems for Xerox.

These stated concerns express the realities of research funding in the United States.

Research and development in the United States is big business. In 1975, $35 billion was expended for this activity.[2] The figure is misleading in one sense, since two-thirds of this amount was for developmental effort, and only one-third, or $12.7 billion, for basic and applied research. However, $12.7 billion is still too large a number for most of us to comprehend with ease.

Of the $12.7 billion spent for basic and applied research, about one-third ($4.4 billion) was for basic research, and about two-thirds ($8.3 billion) for applied research. Thus, in our total national effort, we spend twice as much for development as we do for basic and applied research, and twice as much for applied research as for basic research.

National R & D Growth

In 1965, our national research and development expenditure was only $20 billion. In 10 years, this had grown by 75% in current dollars. However, when the effects of inflation are considered, our total research and development effort did not grow 75%, but only 10% in constant dollars over a 10-year period.

Total basic and applied research grew 80% in the last decade in current dollars, but only 14% in constant dollars. It is important to note that industry's performance of basic and applied research dropped from 46% of the total national effort to only 40% percent in the last 10-year period. Universities, on the other hand, increased their share of the total basic and applied research effort, from 20 to 26%.

Since applied research is preceded by basic research, and without basic research, applied research would soon dry up, we must consider who performs, and who pays for, the basic research effort in this country.

In 1975, $4.44 billion was expended for basic research, up 73% in current dollars from the $2.75 billion level in 1965. This was an increase of only 9.5% in constant dollars over a 10-year period.

The significant change in basic research, however, was that the industry component was *down* 21% in constant dollars over the last decade, while university basic research effort was *up* 33% in constant dollars over the same period.

Reaching further back, to the year of 1955, industry in that year performed 36% of all basic research. By 1965, this had dropped to 23% of the total national effort, and in 1975, to only 16%.

Universities, on the other hand, in 1955, performed only 30% of all basic research. By 1965, this rose to 44%, and by 1975, to 54%. If Federally-funded research and development centers operated by universities with Federal funding are included, the total university-run basic research effort now accounts for 61% of our national effort.

In addition to industry and university components, the Federal Government in 1975 conducted about 17% of the basic research; 6.3% was conducted by nonprofit research organizations other than those in the university sector.

Thus, there has been a dramatic shift of research performers over the last 20 years. Industry performs only one-sixth of all basic research in this country; universities now spend over three times as much for basic research as all industry.

Little Change Seen

These are the facts behind the concerns expressed about the future of basic research in the United States in the National Science Board report.[1] The future augers little change in this mix of performers, except perhaps for universities to do a greater percentage of the basic research.

Elmer B. Staats, Comptroller General of the United States, in a statement entitled "Improving the Climate for Innovation — What Government and Industry Can Do,"[3] stated:

> The private sector generally does not support basic research and education unless it can identify a direct, prompt, and adequate return on its investment. A few exceptions are large corporations and philanthropic foundations. As part of the Federal Government's responsibility, therefore, it must continue to provide major support for basic research and graduate education in both physical and social sciences and the engineering disciplines.

In addition to direct support of basic research at universities by industrial companies, we must also remember that it is the Federal tax on industries' profits, as well as on individual incomes, that is the ultimate source of university research support. In 1975, Federal funds paid for 68% of all basic research conducted, and 70% of that conducted in universities. Direct industry support of university research pales in comparison; only 3% of university basic research, and only 4% of university applied research, was funded directly by industry in 1975.

Thus, the university community and industry are indirect partners in basic research. Industry taxes are funneled through the Federal conduit to provide the funding of university research. Additionally, other tax dollars are funneled, at least to public institutions, through state taxes, and show up as "university-contributed funds" in the list of sources of university research support.

If the premise of basic research being essential as a concomitant ingredient with applied research in the development of new products is correct, then it is now more essential than ever before that universities and industry become more direct partners. This partnership must extend beyond the mere flow of dollars. The continued vitality of our national technological leadership is at stake.

We must adapt our university-industry interface to this new research situation and structure our activities as licensing executives in recognition of realities of where research is being performed.

We believe it is true that basic research leads eventually to major innovations, and that applied research, based on no new advancement of knowledge, generally leads to relatively minor product and process improvements. Obviously, what the licensing executive would like to see are major innovations, since these will have a greater impact on his employer's profits over the long term than do the relatively minor changes. There is a communication problem, however, in getting the performers of basic research together with the performers of the applied research, i.e., companies that have the capability of delivering to the public useful results in the form of tangible products and services.

According to the latest figures available from the National Science Foundation, 11,162 companies in the United States are conducting research and development. Concurrently, 540 universities are conducting research. Dealing with combinations of numbers of this magnitude poses a dilemma beyond comprehension for most of us. If there were only one contact by each university with each company performing research, over 5.5 million contacts would be required. The answer to the dilemma may lie in the concentrations of the performers of research.

Ninety-nine percent of all university research and development is conducted by 540 universities.[4] However, the top 150 universities conduct 92% of all this research; the top 100, 83%; and the top 50, 62%. Annual research budgets in these 150 universities run from $4 million to $95 million. The research efforts at any given university are generally broadly based across many disciplines. If specific academic disciplines are considered, there is also great concentration. The top 100 universities did 85% or more of all research in all disciplines analyzed separately by the National Science Foundation, including engineering, chemistry, physics, medicine, environmental, computer sciences and biological sciences. The top 50 universities did at least two-thirds of all the research in these same disciplines.[4]

Expenditive Correlation

University research is reported by discipline and classified by many under the "Higher Education General Information Survey" (HEGIS) taxonomy, while industrial activity is most generally classified with the Standard Industrial Classification (SIC) business code number. Thus, research statistics reported for industry are difficult to correlate with dollars spent for university research in any discipline. Nevertheless, concentrations do exist in both university and industrial sectors.

In 1974, the latest year for which detailed data is available, \$22.4 billion was spent for all industrial R&D. Only 100 companies accounted for over 75% of this expenditure, and 4 companies alone accounted for 19% of the effort. Taking another cut, 126 companies with over 25,000 employees, were responsible for almost 75% of the total R&D effort.[5]

On an industry basis, 80% of the industrial R&D was conducted by the aircraft and missile, electrical and communication, machinery, motor vehicle, and chemical sectors. Obviously, the tremendous funds required for development in some of these sectors caused the concentration.

Only \$683 million was spent for industrial basic research in 1974; 204 companies with over 500 employees did 88% of this research, and 73, with 25,000 or more employees, did 60%. These same companies apparently had strong applied research efforts also.

There is also a substantial concentration in basic research by industries. The chemical and pharmaceutical industries expended 39% of the basic research funds; the electrical and communications industry, 27%; aircraft industry, 8%; and all others only 26%. Thus, we can see why so many licensing executives are associated with either the chemical/pharmaceutical, or the electronic/communications industries.

Examination of these concentrations would indicate that 100 research universities and 204 companies perform 73% of all the basic research in the United States. If communication between performers of basic research and performers of applied research is essential, and given the mix of research performers today, then it is conceivable that a system could be structured for 100 universities to be in contact with the 204 companies who perform basic research, thus requiring only 20,400 interfaces, rather than 5.5 million.

Focal Point

Would it not be possible, therefore, that the top 100 research universities and the top 200 companies that conduct basic research cooperate to initiate the institutionalization of technology transfer on a continuing basis, by establishing an adequately staffed, long-term basic research communication focal point within each of the respective organizations where this has not already been done. Thus, a means would be provided for improving university-industry relations with respect to the conduct and products of research. It is possible that, through proper structuring, this program could initially involve publishing a listing of individual contact points, by which the industrial companies cooperating in the pilot program could receive from the universities a notice of new technology available that might be of potential interest to them. This initial contact could serve as a base upon which further discussion and exploration of common interests could be developed on a selective basis between individual companies and individual university scientific personnel. It is conceivable that companies could list technology areas of interest to them on a confidential basis. Since the goal would be to establish long-term, person-to-person contacts, no royalty payments to any third party would be involved.

Once the appropriate methodology was worked out and the system smoothly functioning, other research-oriented companies and other universities would be invited to join the effort. A minimal fee would probably have to be established to pay for the common services.

Although the National Research and Development Council in England, and Canadian Patents and Developments, Ltd., in Canada, have served their countries well, this type of structure is not necessarily the best as a solution to our present dilemma. Some have suggested that the Federal Government create a new entity to serve this purpose. I do not agree. We must, in my opinion, have as much direct personal contact as possible between the university and industrial scientific sectors, with no intermediary.

There are some obvious disadvantages to this proposal. For example, it does not initially encompass all universities conducting significant research, and certainly not all of those that will come up with research breakthroughs. Nor does it encompass all companies doing research, at least in the initial stages. From the university's standpoint, this is a real weakness, since it leaves out many smaller companies who are the most innovative and the most receptive to the new ideas that are yet unproven in the market place.

Further, policy differences will have to be negotiated between university and industry participants. This mechanism does not solve, at least initially, the problem of misunderstandings and different missions. Given the present performers of research, the missions of industrial companies and universities in the research area have more in common as time passes, with a greater need for interdependence. Differences must be resolved. Such resolution will require communication.

Commonality of Interest

The mechanism proposed would provide for initiating needed communication not just in relation to patentable technology, but in research areas where there is a scientific commonality of interest. By initially including only those companies doing basic research, the problems of initial communication would be minimized, and those companies seeking to merely skim off the best of university research developments, and with no real long-term interest in basic research, would tend to be excluded from this system.

Universities do not have the capability of delivering the products of basic and applied research to the using public, yet they do most of the basic research. Industry does the great majority of applied research, and this must be coupled with the university research effort. The mechanism proposed would address itself first to the difficulty in communication.

Communication is carried out by individuals, and not by institutions. This is true in research, as it is in licensing. It is individuals who detail the mutual agreements, develop work plans, or create the visions; it is the institution which those individuals represent as employees that assures the viability of the longer term relationship. The establishment of a meaningful communication at various levels is essential.

The advantages of this proposals would appear to outweigh the disadvantages. The cost would be relatively small. An important positive step would be taken to improve the long-term transfer of university technology to industry.

Numerous technical societies have addressed themselves to this same problem, recognizing the absolute need for more interchange between university and industrial scientific personnel.

An excellent example of this was reported recently in an article entitled "Pathways for Interaction Between Academia and Industry in Technical Research" by H. W. Rahn and E. P. Segner, Jr., of the University of Alabama.[5] In discussing the results of two joint meetings of the Industrial Research Institute, Education Committee, and the American Society for Engineering Education, Engineering Research Council, they summarized as follows:

> . . . it is apparent that there is a need for a mutual relaxation of the policies of both industry and universities in order to interact freely with each other. Generally these problems can be solved through early discussion and exchange of information. In nearly every example discussed (in the article), the importance of communication was emphasized. Good communications result only when both parties work at it. Industry cannot get instant knowledge any more than a professor can get instant experience. Industry must give its staff time to find out what is going on in academia and in professional societies, and professors must spend some of their time studying what is happening in industry. Also, the movement of people back and forth through sabbatical leaves and/or consulting agreements was stressed. The key words appear to be communications, mutual trust, interest, effective commitment, lasting relations and person-to-person relationships. Through these activities not only will industry and academia benefit, but the nation as well.

Industrial companies, universities, our nation, and licensing executives will benefit from the proposed interaction. Licensing executives can be of great value in this process to their employer and their profession, whether they are employed in industry or the university community, by encouraging, aiding, and abetting a long-term contact at the research level between scientists of the two types of institutions. In this way, the licensing executive will become an active participant in the creation of licensable technology, not merely a passive provider of services relating to proper legal form after the scientific advances have been made.

I encourage each of you to examine in more detail the shifts in patterns of basic research that have taken place in the last 20 years, evaluate what that shift means to your employer, and, as appropriate, work toward the establishment within your organization of a meaningful function for increasing the contact at the scientific level with those universities which can provide the needed basic research to match your own applied research activity. Those companies and universities which have already taken this step have found it profitable.

We must find the means to more effectively transfer university technology to industry. We must institutionalize the transfer process on a long-term basis and not let it remain a short-term random one. If we are successful, there will be a strong demand for the licensing executive in the long term. The universities will have to educate the young people who may become tomorrow's licensing executives. It will take the brightest and best students to meet the varying demands that could continue to be placed on the licensing executive, but we must solve the present interface problem if they are to be needed.

The future promotion of university technology to industry is in the hands of today's licensing executive, who must become an active participant in changing the nature of the technology transfer process if his profession is to survive.

NOTES

1. *Science at the Bicentennial: A Report from the Research Community.* National Science Board. 1976.

2. *National Patterns of R&D Resources, Funds & Manpower in the United States, 1953-1976.* National Science Foundation — NSF 76-310. April, 1976.

3. *Research Management.* September, 1976, Volume XIX/No. 5. Industrial Research Institute.

4. *Expenditures for Scientific Activities at Universities and Colleges, Fiscal Year 1975, Detailed Statistical Tables.* National Science Foundation — NSF 76-316.

5. *Research and Development in Industry 1974.* National Science Foundation, NSF 76-322. September, 1976.