University-Industry Teamwork

With growing importance of university R&D in U.S., new ways are sought to make practical use of findings

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I shall discuss some of the questions that arise in the relations between universities and industry in the area of basic research and technology transfer, and as a physicist and as president of a major research university I can claim some authority to address that subject. I'm also currently serving as chairman of the Committee on Science and Research of the American Association of Universities, and I'm participating in a new Business-Higher Education Forum established to promote better understanding between these two sectors. So I've been much involved in questions and problems that bear on your professional activities.

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I scarcely need remind LES members of the crucial role that basic research — the discovery of fundamental new scientific knowledge — has come to play in modern industry. Much of the so-called high-technology sector has been brought into being, and almost all of industry has been revolutionized, by science-based developments of recent years — computers, electronics, lasers, chemicals and pharmaceuticals, and a whole array of other scientific breakthroughs.

Basic research has generally been a pluralistic undertaking in this country, performed by industry, universities, government laboratories, and private institutes and laboratories. But there has been in recent decades an increasing concentration of basic research in the nation's universities. Today, nearly three-fourths of all basic research in the United States is done in our universities.

Basic Research

There is no question that industry has reduced its share of basic research, for various reasons, but I suspect and certainly I hope that more basic research is actually going on in indutry than the figures suggest. Much depends on how the figure-compilers define basic research as contrasted with applied research. Ed David, president of Exxon Research and Engineering, recently pointed out that the National Science Foundation and most academic researchers define basic science in terms of its motivation — research undertaken for the extension of knowledge rather than for its utility — while industry defines any work which produces new understanding, regardless of why it is undertaken, as basic research. However defined, basic research of outstanding quality has been turned out in the nation's leading industrial labs, and they have the

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Nobel Prizes to prove it. Industrial researchers have some important advantages, including great familiarity with existing technology and the real-world problems to be solved in a given field, and the background to recognize and seize upon potential leads in the areas of their more concentrated interest, and we need their continuing contributions.

In the broader research realm, we have other important needs — for the long view, for the cross-fertilization of widely separated academic disciplines, for the pursuit of knowledge utterly divorced from any intentional considerations of practicality. These are the kinds of research needs that the university in our society is particularly well suited to meet. The university is first and foremost an educational institution, concerned not with specific research missions but with learning in all its aspects. It has a unique mix of people — independent-minded faculty, eager undergraduates, highly-motivated advanced students. The faculty are chosen for their originality, productivity and independence, and they're not so much employees as partners in the enterprise. The university has a unique mix of facilities — not only classrooms and labs, libraries and field stations, but important intangibles such as tradition of academic freedom.

All of these characteristics work together to make universities the most logical source of original and startling new ideas, the place for scientific breakthroughs and their rapid exploration. It's not surprising, then, that basic research comes to be concentrated heavily in universities.

New Urgency

Given that fact, we need to examine more closely how best to make the fruits of university research widely available for the benefit of society. This isn't a new question, of course, but it's been given new urgency by the present high concentration of basic research in the universities, by the soaring cost of today's research, and in particular by the current national concern about the apparent fall-off in American innovation and our lagging productivity.

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I suspect no one knows for sure what the connection is between our productivity problems and our declining levels of innovation relative to those of such countries as Japan and West Germany, nor do we understand the prime causes of these problems. There are undoubtedly a number of factors at work, some of them interrelated and reinforcing one another. One which is clearly significant and which we here can address is the need for closer university-industry relations and improved technology transfer from university research. In singling out this factor I don't mean to give it undue weight or to suggest that we needn't work also on other causes. But it's easy to feel defeated in the face of complex problems that are treated globally. It's often more productive to zero in on those specific areas where we can have an impact.

One essential step in bringing about closer relations between our campuses and the industrial sector is to arrive at a clearer understanding of each other's purposes, needs, policies, and the realities which shape each other's functions. So I shall sketch briefly the process of university research, how it operates, what policies guide it, how technology transfer occurs.

First, let's look at the broad purposes of university research. An individual faculty member may be driven simply by the irresistible urge to know more about some special corner of the universe. But society supports universities because it is recognized that increased knowledge and understanding eventually benefits the whole society. So university research is intended to serve the needs of the whole society, the common good. It isn't intended to meet the exclusive needs of any one segment — not industry, not agriculture, not labor, not the faculty members themselves. As it happens, university research does often meet the direct needs of one or another segment as it seeks to serve the broader society — research may benefit certain industrial firms, for example, as it explores the economic wellbeing of the society, or it may benefit some agricultural interests as it investigates plant diseases or improved crop yields for a hungry world. But the fundamental criterion of university research is always the common good.

In the course of performing research, the university also accomplishes another basic purpose, the education of graduate students. These are the apprentice scholars who will in time take over continuing search for new knowledge and its application in the nation's private and public laboratories.

Research Subjects

What kind of research projects does a university undertake? It explores those areas which hold promise of leading to new knowledge or understanding, or of new applications which can't be undertaken as effectively by other sectors of society. Faculty members choose their own subjects for investigation, within the important limits of available funding, to which I'll return in a moment. Research project selection can't be ordered or directed from outside the institution, although faculty members are always open to persuasion about the importance or inherent interest of a topic. But faculty choices are subject to peer review or review by department chairmen or deans to assure their academic soundness and significance.

Who pays for the research the university performs? In research universities today, whether private or public, financing comes from a number of sources — the university's own funds from gifts and endowments or tuition, the state in the case of public universities, the federal government, foundations, and also from industrial and agricultural firms or organizations. The federal government currently provides a substantial portion of the research funding of the outstanding public and private universities, through the National Science Foundation, the National Institutes of Health, the Departments of Defense, Energy, and Health, Education and Welfare, and other agencies.

What kinds of impacts does external funding have on university research programs? The most obvious impact, of course, is to make possible the performance of much more research than the university could ever finance through its own intramural funds. In most cases the research that isn't externally financed simply won't get done, no matter how dedicated or hard-working the faculty member who wants to do that research may be. With a few exceptions, inexpensive research is behind us. Experimental science is now highly sophisticated. Basic data is increasingly hard to come by and to grapple with, and instrumentation is more often than not extremely costly. So, both the external sponsor and the university have an important stake in the sponsored project. The broad society stands to be the ultimate beneficiary through the increased flow of new ideas for application and development.

But external funding is not an unmixed blessing, and universities must exercise great care and wisdom in the administration of their research programs if the broad society is to reap the maximum benefit from the results. For example, while research projects are determined by faculty choice and academic significance, the university runs the constant risk of having its research program subtly diverted toward those areas where the financing happens to be available. It would be naive to think that this doesn't happen. The university must therefore make wise use of its own or other unrestricted funds to maintain some balance in its program and to provide occasional support for promising projects so novel in concept or high-risk in likely returns that they fail to attract external funding.

Specific Needs

External sponsors usually have specific needs and are more likely to encourage projects with some relevance to those needs, some promise of eventual or even early utility. This is particularly true of industrial sponsors, and of course it's understandable. But it is absolutely essential to society as a whole that there be freedom to undertake broad, unfettered kinds of investigations and to follow unexpected leads in different directions as the research progresses. The results of more narrowly-targeted research may well bring about improvements two- or threefold or even fivefold in magnitude, but what will be forfeited are the occasional breakthroughs leading to improvements a hundred- or a millionfold in magnitude, such as the transistor or the laser.

The university must constantly seek to weigh the prospective benefits of its research to the common good against the particular benefits or costs to one or another segment of society. I assure you that this is not an easy task. A case in point is the ongoing public controversy about University of California research in agricultural mechanization and the breeding of plant strains better adapted to mechanical harvest. Critics of the research claim it was encouraged by contributions of large-scale agricultural firms to the university's research program, that mechanization has brought large profits to "agribusiness" while hurting the small-scale farmer who can't afford such mechanization and displacing large numbers of farm workers who don't have alternative job opportunities. Supporters, on the other hand, claim that the research was in no way motivated by industry funding, that mechanization was a logical next step in the evolution of California agriculture, that it has cut costs and so saved crops that would have been lost to foreign competition, thereby deepening the nation's balance of trade deficit, and that the retention of those crops has retained jobs for workers in California processing plants. They point to a recent major economic report predicting that any recession will have a significantly lighter impact on California in part because of the strength of the state's agriculture. As you can see, the public interest is not always easy to identify, but decisions can't be avoided just because they're tough to make.

How are the results of all this university research conveyed? How does technology transfer or at least the first step from new knowledge toward its eventual application usually take place? The time-tested university methods are the presentation of papers at scholarly meetings and the publication of articles in scholarly journals. These writings are usually highly technical in nature, not because of any desire to be esoteric but because other researchers must be able to follow in detail, to evaluate and criticize, and to build upon the work. Publication usually takes place as soon as possible so that the faculty member who first makes the finding will receive proper credit and so that others in the field who may need just such a piece of knowledge can move ahead with their work. The right of the faculty member to timely publication is one of the conditions the university must insist upon in agreements with external sponsors of research.

Convey Findings

But technical articles in scholarly journals are not easily available to the broader public, and universities may supplement these publications with efforts through public information offices or extension services or campus meetings of industrial associates to convey findings to those who are in a position to apply or develop new knowledge. And, of course, industry and other potential users should plan an active part in technology transfer by keeping well informed of research progress on the campuses.

I should remark here that the public sometimes seems to think that university professors are completely indifferent to the practical uses of their research. Nothing could be further from the truth. I know of no one who is not truly delighted when a seemingly esoteric discovery turns out to be adaptable for everyday use.

Publication of a finding places it in the public domain, of course, and an industrial firm interested in using the discovery to develop a new product has no guarantee that, if the development goes well after a considerable investment of funds, another firm won't step in to share the market. This leads us to consideration of the particular aspect of technology transfer you are most concerned with—patents and licensing. Although I've already disavowed any great expertise in this area, I can mention a few points as they relate to the framework of university research I've just sketched.

University research isn't intended or designed to invent things, but occasionally — often fortuitously — patentable concepts emerge. Generally, I'm told, patents are issued to the individual faculty member but usually assigned on a voluntary or mandatory basis to the university, or sometimes to the external funder of the research in question. The faculty member receives a share of any royalties resulting from the patent.

The federal government, despite its extensive involvement in university research, has never developed a unified patent policy. Some 20 federal agencies fund university research, and I gather there are some 20 varying policies. The Department of Defense, for example, often waives in advance all rights to patents except for a license to develop any patents for the government's own purposes. Other agencies retain all patent rights. The Dole-Bayh bill now before Congress would unify federal policy and allow the universities to retain patents arising from federally-sponsored research, subject only to government license for government purposes. The University of California among other institutions is supporting this measure.

Neither the government nor the universities, of course, have the interest or the capability to develop patents for use in the private sector. So, patented ideas will not serve the common good unless they are licensed to commercial developers. Universities, therefore, have a responsibility to seek and respond to licensing opportunities.

Nonexclusive License

If the patent is for a product that requires few development costs and can be widely used, it is generally licensed on a nonexclusive basis. I'm told that the University of California, for example, grants nonexclusive licenses for a desalinization membrane which is an important but simple part of a large technology. The same is true for several new strawberry varieties, the fruits of which I hope you will enjoy in the near future.

If, however, the patent development will involve high costs and considerable risks to the commercial outcome, the potential developer will be willing to proceed only if an exclusive license is granted. And since such a situation may involve the prospect of high profits in exchange for the risks, the question of which firm receives the exclusive license is obviously a sticky one. Because the ultimate criterion is the broad public benefit, a university will want to be sure a prospective

licensee is one fully able to bring the development to fruition for public use. An industrial firm which has helped fund the research in question obviously has equities in the matter.

When a corporation which has been issued an exclusive license appears to accrue large profits from its development, the university is sometimes criticized for allowing a private firm to benefit from research which may have been performed through public financing. But the public certainly won't benefit from undeveloped ideas and unlicensed patents. The licensee does assume the high risks often involved. The university can't set limitations on profits by dictating prices or marketing conditions. The university itself shares those profits through royalties on the patents and can use such funds to balance and extend its own research program. The ultimate check on large profits, of course, is the strong incentive they provide to other firms to invent around the original patent and enter the market with even newer technology. This is healthy and certainly does benefit the public.

There are some conditions a university should insist on in its licensing agreements. A primary one is diligent development — a company should not obtain an exclusive license and then shelve it merely to foreclose other firms from using it. Another is an appropriate limitation on the use of the university's name in advertising and publicity. Universities aren't in the business of endorsing products, even when their scientists make the discovery.

Finally, I should note that the pressures for better transfer of technology are leading to new forms and experiments. One that has attracted wide attention is the Harvard University-Monsanto agreement, which is said to involve some $23 million in support of research at the Harvard Medical School over a period of 12 years. In exchange, Harvard has reportedly licensed Monsanto the patent rights to a possible biological substance which may or may not be discovered in the course of the research. This agreement is interesting not only because of its magnitude and duration, but also because it involves an advisory committee of five prominent persons not connected with either Harvard or Monsanto to assure the protection of the broad public interest under terms of the agreement.

Cooperative Projects

Other developments include three-way federal-industry-university cooperative research projects being sponsored by NSF, congressional bills to establish university centers for industrial technology, and more active programs of exchange of scientists between university and industry—all of which involve complex kinds of patent and other intellectual property problems.

Clearly, the nation needs and is moving toward better arrangements for the transfer of technology for the good of society — for our economic wellbeing, our health, our national security, the safety of our environment, the general quality of life in America. It is up to us in the universities and in industry to find new and better ways to bridge the gap between research on campus and application in the private sector. Find them we will — through hard work, trial and error, and the recognition of common goals and relative equities.

Above all, we must support the scientist and the environment in which new ideas will continue to flow. For with the scientist lies the source of the intellectual property that will eventually benefit society. We must design the commercial and legal frameworks that will best bring those ideas to use for the common good. Each of you has an important role to play in this challenging arena. We look forward to working closely with you.