Research Plea to Industry, Academia

A call for greater cooperation between the two institutions; fundamental research should be goal

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We are entering a new era in the way scientific research is managed and supported in the United States. And the most outstanding feature of this era will be the growth of industry-supported research in our universities. I have for some years advocated a closer connection of this kind, though I did not foresee the spectacular chain of events in molecular biology that have added such impetus to it. These have livened the debate about age-old ethical issues and the role of universities in commercial activities. Yet on balance most of us would agree that our molecular biologists have presented our society with problems of the kind we like to have.

As a corporate spokesman, let me begin with some observations about the economic engine which will actually deliver the benefits of recombinant DNA technology to people. It is an oft-repeated view these days that the United States is the undisputed world leader in the *generation* of knowledge through research, but that in recent years we have fallen down on the even more important job of *using* that knowledge effectively in support of economic growth. As some of you may know, I have from time to time said that one of the reasons for this failure is that the United States graduates *less than half* as many engineers as the Japanese per capita and *twenty* times as many lawyers. For the duration of the morning, at least, I would like to downplay that view.

Recognizing this technology delivery problem, the universities accept their social obligation to facilitate commercial applications of their discoveries. This point was featured prominently in the summary of discussion that came out of the Pajaro Dunes Meeting, a meeting called by university presidents of five leading research universities to disucss issues raised by research connections between industry and academia. Clearly, the universities also want to share the spoils of their research. Balancing obligations and rewards with all the obvious ethical issues is an exacting task. Now let me set the theme for my remarks.

An increase in industry-supported academic research is economically and socially desirable. As a matter of fact I have advocated *tripling* industry's support over this decade from about $200 million to about $600 million a year. This would mean an increase from just about 4% to about 15% of what the United States Federal Government provides, assuming government support remains constant in real dollars. I should emphasize that I am not talking about industrial philanthropy, but about research consistent with a commercial "mission." I advocate this increased coupling because there is fine science and technique created in academia which is not effectively coupled to the nation's commercial innovation system. There is much to be gained for both academia and industry by increasing the coupling. Company and campus can strike bargains that offer strong mutual benefit—not *win-lose*, but *win-win* deals.

What stands in the way of win-win deals? The most important obstacles are cultural differences and the different objectives of the two. Industry is output-oriented; industrial managers aspire to efficient production of goods and services. To the industrialist, paying for research implies ownership of the results, which are used to establish proprietary competitive advantage if at all possible. Industry wants to limit risks, financial and social; risks must be assessed, numerically if possible, and then balanced with the rewards for commercial success.

On the other hand, university faculty and administrators consider themselves as communities of scholars. The primary research aim is the creation of knowledge. Educational values are important. There is a tendency to be adverse to commercialization, seen by some academicians and public interest groups as exploitation of the public. Still, academic institutions usually want to participate in the payoff from their research, though they often express the desire to serve the "public good" not "special interests." This means that they favor actions that presumably would spur competition and not confer proprietary advantage on any one player.

It is significant that there are wide differences in academia in regard to these matters. An indicator can be drawn from a study by Martin Lipset of Harvard. That study showed that the disciplines most aligned with conservative political ideas and favorable to the private sector are engineering, medicine, and chemistry. The opposite pole is occupied by social sciences, physics, and mathematics. Significantly, the most intensive industry-university relationships have been in engineering, chemistry, and medicine, and the least intensive relationships in physics, social sciences, and mathematics. On the university side, larger firms with long-range outlooks, fairly secure in their commercial positions, have been the dominant players.

But even in engineering and chemistry, establishing links between industry and academia is often fraught

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with suspicion and ignorance of the other's ways. Into this situation steps the lawyer. He or she can play a key role in constructing realistic agreements by helping the client recognize that all the traditional values of either party cannot be protected absolutely; some risks are inevitable. The lawyer can help both parties recognize that ownership of a single patent is not likely to be critical.

There are some exceptions. One example on the industry side was Carlson's original patent on xerography. On the university side, I might cite the University of Wisconsin's 1927 patent on a process for manufacturing Vitamin D, which brought the university some $14 million from 400 licenses. Or I can cite Indiana University's patent on stannous fluoride which brought the world Crest toothpaste and the university $2 million from the licensee, Proctor and Gamble. Such exceptions are a risk. Nevertheless, a portfolio of patents plus the know-how acquired in R&D usually provides the commanding position. So exclusivity is not usually critical, particularly on patents originating from basic research.

The lawyer can help universities recognize that reasonable publication delays for protection of patent rights are very seldom critical to achieving precedence for discovery in the scientific community. And such delays are critical for patenting. As you may know, if information about an invention is disclosed publicly in any way, the chances of obtaining a patent afterwards in most countries of the world are seriously compromised. The lawyer can also point out that if the partners' interests are reasonably well matched, such research agreements are not likely to change the direction of academic research substantially, except as dictated by bonafide research results achieved by industry and made available under the agreement.

Finally, the lawyer can help industry recognize that the most productive research requires some freedom of action by researchers themselves. When research is programmed too tightly, micro-managed we might say, poor research is often the result. The desire for creativity is why industry goes to academia.

Thus, the lawyer can and should play a key role in balancing conflicting interests by detailing risks, assessing their importance against the possible benefits, and by helping clients recognize that different solutions are appropriate to different institutions, different stages of research, and different businesses. In other words, the lawyer should be an important member of the negotiating team. The principals should not adopt the strategy of first working out the deal between themselves and leaving their lawyers to clean up the mess. However, as you will realize, there are increased risks for lawyers and the legal profession in taking an active negotiating role. I would be interested in your opinion of how far lawyers can and should go—"can" because it takes keen judgment based on knowledge of commercial innovation to advise clients; "should" because of professional ethics.

Now for the details. First, more about industrial objectives in these agreements; next, a comparison of some specific agreements, and finally some comments on desirable directions for industry support of university research.

THE ROOTS OF INDUSTRY'S OBJECTIVES

We cannot consider industry objectives in funding university research in isolation from industry objectives toward higher education in general. In order of importance, industry looks to higher education for: A steady supply of *well-educated* graduates; relevant basic science, and scientists able to offer fresh insights; and, sometimes, technological ideas and leads. Graduates are by far the most important. Of the professionals that Exxon hires in a typical year, more than 70% are likely to hold degrees in engineering or science. Many hold advanced degrees. It is our acute awareness of the importance of these educated people to Exxon's future that most animates our desire to be certain that higher education remains healthy. In 1982 Exxon will contribute nearly $30 million to higher education. In addition we will spend over $4 million supporting research in universities. Even in supporting this research our motives are strongly influenced by our interest in education, both on the undergraduate and graduate levels. Indeed, Exxon is probably not unlike the rest of industry in being at least as interested in promoting academic research *as part of the educational process* as in the results of that research.

Beyond excellent people, industry is interested in innovation rather than in research as a stand-alone activity. Industry's interest in research is as an element of an innovation system. "Innovation" is of course the term for the entire process of taking an invention from the glimmer of an idea to a widely adopted, commercially useful process or product. Contrary to popular belief the invention and deployment of new technology does not usually begin with basic research. Can you name a Japanese Nobel Prize winner? The Japanese have in the past carried out virtually *no* basic research. Yet, as we have learned, the Japanese are a highly innovative people, and tough competitors. More basic research—nay, more R&D—does not automatically produce more innovation. The new socialist government in France has just announced plans to boost national R&D, as a percent of GNP, by about one percentage point—from 1.6 to 2.4 percent. The Canadian Government is using R&D as a nationalistic rallying point. They will learn, as others have, that simplistic notions of this sort are usually ineffective in stimulating innovation.

Advances

Carrying this point a bit further, let me point out that advances in basic science depend on advances in technology. Galileo and Newton could not have redefined the universe without the telescope. The dramatic advances in molecular biology in our own time would have been impossible without the electron microscope, x-ray crystallography, radioactive tagging, and chromatography. And solid state physics didn't become a major branch of science until *after* the transistor was invented.

The truth is that progress in science and technology hinges upon *connections* between activities from the purest science to the most mundane commercial operations. It is easier to *foster* those connections in-house and that explains why most companies do their research in-house, rather than going to research institutes or colleges and universities.

Connections focused on academic science do offer industry valuable opportunities. However, with its concentration on basic science, most university research is not geared to invention and innovation. That is why colleges and universities have never earned large sums from patents and licensing. Their ideas usually require too much development work and entail too much risk to be commercially attractive. Biotechnology may be an exception, yet no one can doubt that expensive development efforts lie ahead in this field as well. We're already beginning to see a shakeout among fledgling genetic engineering companies built more on hope than on technical substance and managerial expertise.

In short, the overriding goal for industry is the delivery of goods and services to the public, governments, and other consuming institutions. Most academic people recognize this as the primary industry function, and it is that recognition which can serve as the base for agreements between industrial and academic partners.

COSTS/BENEFITS OF SAMPLE FORMS OF RESEARCH AGREEMENT

Now, granted that a company intends to sponsor university research, what form of agreement should be sought? There are many possible modes. For Exxon's part, we have become involved in more than 20 over the years, including such familiar ones as summer jobs for students and faculty, direct grant programs, industrial affiliate programs, consultancies, contract research, and faculty advisory groups. Let me consider the advantages and disadvantages of two kinds of arrangements.

The first is the research consortium. Some consortia have been in existence for several years—for example, the Carnegie-Mellon Processing Research Institute, the University of Delaware Catalysis Center, and the MIT Polymer Processing Program. More recently, in the glamor field of integrated circuit research, Stanford has excelled, snaring a reported $10 million in funding from some 14 corporate sponsors for its Center for Integrated Systems. Cal Tech, MIT, the University of California at Berkeley, and Cornell have undertaken similar programs. A comparable industry initiative is the $20 million program just announced by the Semiconductor Research Cooperative, headed by Eric Block of I.B.M. The cooperative will pool monies collected from some 50 companies to support long-term university research related to semiconductors. Another important objective of course is to increase the supply of faculty and graduates.

The research consortium is clearly popular with industry. It represents a low-cost, low-risk option for ensuring that basic research of importance to industry continues or expands. It also represents a low-cost, low-risk option for the universities, because it scarcely threatens their traditional concerns, values, and interests. With many companies involved, none is in a position to exert a strong influence on research directions. For similar reasons there are few problems with publishing results, though there can be delays to allow for patent filings. Industry participants are almost always willing to allow universities to hold the patents. Enough companies are usually involved that company demands for exclusive licensing would not have much point. Only a few faculty or public interest groups seem to object to the usual royalty arrangement: either the contributing companies acquire the licenses royalty-free, or their contributions are considered prepayment of royalties.

Stanford has also helped pioneer a somewhat riskier approach that may enable universities to profit more from their research. Six companies have been induced to put up an initial $7.5 million to form Engenics, a new genetic engineering company, headed by the former board chairman of ITEK, Frank Lindsay. This company in turn has granted 30% equity interest to a nonprofit center for biotechnology research. The mandate of the center is to fund basic research related to biotechnology, mainly at Stanford and the University of California at Berkeley. In return Engenics obtains limited exclusive licenses on patents obtained as a result of that research. Such an arrangement provides some insulation for the university against conflict of interest. But here, as elsewhere, society must depend on the ethical traditions and the personal standards of the people involved. Making agreements public will exert a useful control.

Benefit Question

But on the subject of risk, let me pose this question: if the research consortium is a low-risk, low-cost option for supporting university research, is it also a *low-benefit* option? Consortia seem to be giving the universities what they need most these days—the assurance of long-term support necessary to pay adequate faculty salaries, to keep laboratories up to date, and to support graduate students. But will they promote connections that will significantly spur *both* scientific progress and technological innovation? In particular is industry getting enough out of such deals, including the Engenics arrangement, that we can anticipate many more? I will not venture a direct judgment, except to mention another option that may be the "comer" in industry-supported research on campus.

I am speaking of long-term sponsored research programs like those announced between Monsanto and Harvard, Hoechst and Mass General Hospital, and Exxon and MIT. Such agreements substantially increase opportunities for one-on-one exchange. In fact on the industry side, the motivation seems to be as much to develop the expertise and know-how of their own researchers, as to support the discovery of new knowledge. Furthermore, because there is more interchange, there is more chance that the science developed will have a bearing on company problems.

At the same time the risks are higher. A company must "bet" more money on a particular program if that program is to have enough scope to make a difference. Consequently, as part of its fiduciary responsibility to the stockholders, company management must have a voice in deciding who performs the research, and what the research addresses in order to ensure that it has a bearing on company interests. Likewise, if there are patentable discoveries, management must ensure that they will benefit the company in some proportion to the money at risk.

Given the higher degree of company interest—in all senses of that word—the academic researchers in turn risk greater pressures to divert their research in uncongenial directions, delay publication, and grant more generous patent and licensing conditions. In my view, many of these problems can be minimized in the negotiating stages, with the imaginative counsel of the law.

Exxon's own research agreement with MIT continues a long tradition of cooperation between our two institutions, going back to the 20s and 30s and the days of Professor Warren K. Lewis. Professor Lewis and his students played major roles in several of our classic innovations in petroleum technology, including fluid catalytic cracking and synthetic rubber. Under the new agreement we think we have struck a fair balance among the competing interests. Exxon will provide MIT with between $7 million and $8 million for research on combustion science over 10 years. Exxon representatives will designate the research projects from among those that MIT proposes. But the two MIT professors who will direct the research, Jack Longwell and Adel Sarofim, will also have money to pursue combustion research projects of their own choosing. The amount will be equal to 20% of the money spent on the designated projects.

Research results will be published promptly and openly, although where patent applications are possible, the agreement permits a 90-day delay. MIT will have the first right to file patents on any technology that may be developed, but Exxon will have the right to use them without royalty and share the royalties from licensing to third parties. The agreement will nominally extend for 10 years, though either side can withdraw after two years' advance notice. All these details have been widely publicized.

We at Exxon think that the agreement is working well for MIT and for us. But we would not champion the terms of the agreement as standards. The watchword should be *pluralism* — a diversity of arrangements reflecting the diverse interests and requirements of those involved. We are far from exhausting our fund of ignorance about the most effective ways for fostering the industry-academic connection.

I would offer these somewhat personal observations on the issues usually debated in connection with such agreements. In the matter of *control*, it is well for the company not to forget why it has come to the university. A wise industrial research manager is after unique individuals, different from, though complementary to his own people. The manager wants the researcher to run to daylight where he sees it. You can destroy creativity in straining to control it.

Publication ought not to be an issue, except occasionally, if the focus is on basic research. It is surely reasonable to delay publication to allow for the filing of patent applications. Not only will this give an academic institution a chance for some return on its research, it does no permanent harm to open communications in science. As you know, the purpose of the patent system is to *encourage* the communication of knowledge and technique. I suspect that some of the secretive behavior reported from microbiology meetings stems from a similarity with microelectronics. Microelectronics companies file relatively few patents. The field moves too rapidly, and it is too easy to "invent around" patents. The information in your patent may only make it easier for the competition. If that is the case, the problem may ease as biotechnology matures and as the perception grows that new technology is no longer "easy" to come by.

Patent ownership is less of an issue than the rights and conditions for licensing the patent. Unless I am mistaken, most companies are willing to let universities own the patents resulting from industry-supported research. The rub comes with the question of *exclusivity*. Sometimes overlooked is that exclusivity has advantages and drawbacks for both parties. While a company with an exclusive license is protected to some degree from competition for a time, the exclusive right usually confers an obligation to develop. While a university may prefer the more "democratic" strategy of nonexclusive licensing, the risks of development may be so great that what is nobody's exclusive license may turn out to be nobody's development.

I note that Monsanto will receive exclusive license to any patents resulting from the company's recently announced, $4-million, five-year grant to Rockefeller University. In our combustion research agreement with MIT, we elected *not* to press for exclusivity. However, we did want to ensure that we could practice the patents royalty-free as a price for funding the research and MIT accepted that argument. Probably, this issue must be nogotiated case by case.

PLEA FOR INDUSTRY-SUPPORTED BASIC RESEARCH

To sum up my argument, powerful influences are combining to bring industrial and academic researchers together. To get the most advantage from the trend both will have to find ways to accommodate their cultural differences. Members of the bar who are wise in the ways of science and technology can serve both parties by acting as mediators dedicated to win-win agreements. Agreements will and should take a variety of forms, reflecting the extraordinary diversity of the nation's industrial and academic institutions.

It is all too easy for the funders and the performers of research to become polarized. Preoccupation with commercial dogmas on the one hand, preoccupation with the doctrines of academic science on the other, can block progress. Accommodation has almost always been between those extremes, even where government is the funder.

Because so much of the controversy does swirl about commercial questions, let me close by entering a plea for more focus on agreements supporting *fundamental* research. Times are changing but both academia and industry seems to require more selling on this point. The country will spend some $80 billion in R&D this year, and of that well over two-thirds will go toward development work. And, typically, some 20 years pass from the inception to the deployment of a major new technology, although in some fields such as electronics, half that figure may be more realistic.

The process is so expensive and so slow because we are receiving inadequate help from predictive science. In the petroleum and chemical industries, we typically must build pilot plants costing hundreds of millions of dollars to determine whether and how we can practice a technology on an industrial scale. The reason is that we still know too little about the structure and chemistry of hydrocarbons and this applies particularly to synthetic fuel resources like coal and oil shale. There are similar problems in other industries. Designers of aircraft and steam turbines spend heavily on wind tunnel tests because they lack a good theory of turbulence and of materials failures. In electronics, development costs for high-capacity memory chips have skyrocketed because the developers lack understanding of the combinatorial mathematics that would reduce the time expended in designing and testing high-density circuits.

As a nation, we are entering a period of intense economic and military competition. Research in our academic institutions has long been an American strength. Academia, industry, and the nation have much to gain if academic research can reinforce our industrial innovation system. The members of this audience are uniquely suited to play honest broker to this coalition and I urge you to do so.