The need for basic research in industry

Industries will have to spend more to make up for the 36% decrease in federal support over the last decade—to maintain their expertise, and to survive the transition to post-industrial society.

J. E. Goldman

Why should there be any basic research in industry? How have recent shifts in our priorities—from defense and space towards energy, health and the environment—changed the outlook for industrial research? How badly has industry been hit by cutbacks in research support and how can it overcome them?

It has been eleven years since I have spoken or written on the subject of basic research in industry. In writing[1] on this in 1964, I had some comments in answer to first of these questions. I repeat them here because they are as applicable today as then, but changes in the environment and in my experience prompt me to add below some comments on the other two questions. Here is what I said then:

"At least four significant reasons can be given for carrying on research in industry. One is purely defensive: If you want to stay in business at a time when technology is marching rapidly, you cannot risk the chance that somebody else will beat you to the new technology. If somebody, somewhere is about to make a major contribution—a contribution that could obsolete your product—you must have people who will know about this, who will know what is happening. If your people are truly productive scientists, original scientists, creative scientists, then they will be sought out. They will be invited to give seminars. They will invite their friends to give seminars. They will attend meetings and conferences and be in touch with the scientific community. They will know what is going on. It is not very likely that an important development will take place somewhere in the world without their knowing about it.

"If you are to tap the world's science and technology, you have to create some science. Your admission ticket to the club is to have something of your own to talk about.

"The second reason for doing research comes right out of the first: If you have those good people—if you are at the frontier—you maximize the probability of doing some of the innovating yourself. This clearly is a competitive advantage.

"Third: research is increasingly an important source of management personnel. Many of today's best college people are youngsters who want to go into research. This is true in science, in engineering, in economics and so on—and this is an excellent way to get people into a company. Start them off on the research road. Top management today needs technically oriented people and one of the best means of finding them and keeping them is through the research lab.

"The fourth reason is that research provides you with possibilities for diversification. A high-quality research program will invariably lead into new fields. It can create those new fields. Moreover, the company that is amenable to diversification can the better justify intensive research areas and programs which may be too costly to justify on the basis of relevance to existing business alone."

As we look now—eleven years later—at the responsibilities of industry to research, and of research to industry, we might well ask, has there been any change in our environment and surroundings to warrant a rethinking of the question? The answer has to be, yes!

For one thing there has been significant change in the patterns of support of basic research both quantitatively and qualitatively. Whereas a decade ago the diversity and multiplicity of support for basic research assured nearly adequate support for all good science—and this includes the healthy infusion of basic research dollars from the research-conscious military and space agencies—today such support tends to be more monolithic and constricted. The rationale for research support by government has shifted in emphasis. The Mansfield amendment[2] has narrowed considerably the degrees of freedom available to the once munificent military agencies; the space program has been winding down and, as is inevitable in a budgetary downturn, basic research support is the first to go. Meanwhile the remaining supporters of basic research, such as the National Science Foundation and the National Institutes of Health have been gravitating to an increasing extent towards the doctrine of so-called "relevance."

Some numbers will underscore this hypothesis, particularly as it relates to physics. Between 1965 and 1975, the total amount of federally-funded basic research has shrunk from $1.78 billion to an estimated $1.68 billion (constant dollars). [See PHYSICS TODAY, November, page 102.] Allowing for additional costs of doing research in today's environment not attributable to inflation, this shrinkage is even greater. On the other hand, the Departments of Health, Education and Welfare and Agriculture, which in 1965 represented 22% of federal basic research support, will account for 43% of the federally supported basic research budget in 1975.

Identity problem

This doctrine of relevance points up what I think is another issue with overtones affecting the support of basic research. In the 1950's and 60's the major national goals around which were marshalled all the available forces of the Nation's economic and industrial power and know-how, including R&D, were defense and space. It is probably superfluous for me to elaborate in this article on the impact these two major

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"The oil prospects for the world are so very dim that the auto industry must have an important, inspired breakthrough within the next 25 years . . ."—from a 1956 speech.

goals had on the research community. There are probably few physicists who do not owe their start in research to the Office of Naval Research, the Office of Scientific Research in the Air Force, the Army Research Office, the National Aeronautics and Space Administration or, if he or she is younger, the National Science Foundation. In an earlier article,[3] I referred to OXR (where X = N, S or A) as the "the greatest philanthropist of all." The goals of defense and space were well defined and their pursuit clear-cut. We knew precisely how to approach them, define their specifications, put in place the systems for their implementation and manage them. Thanks to wise and foresighted leadership, we were able to put the precise roles of R&D, including basic research, into proper perspective. Moreover, responsibility for the implementation of these goals was assigned without ambiguity—notwithstanding the brief polemic between the Army and the Air Force as to who had the responsibility for missiles.

In the 1970's, however, the doctrine of relevance is preached in an entirely different context.

The preoccupation of our society is with crisis problems: the economy, energy, the physical environment, urban blight, health care and transportation. This creates an identity problem for both the scientist and the supporter of science. The role of technology in the solution of military and space problems was clear and defined. The thread that links basic research to the technological goals was not a difficult one to comprehend—either for the scientist who sought to identify it or for the manager or bureaucrat who faced the need to rationalize and understand it. The strategies for new military systems have not been qualitatively different from those in communications that led Bell Labs to support solid-state physics in the 1930's. But how do you turn loose a scientific community that is inherently discipline-oriented to worry about the infusion of science into a technology for transportation, for urban waste disposal, for energy conservation and so on, but for the application of which the sponsor agency has no responsibility?

To illustrate this dilemma, let us take the case of energy research. At first blush one might assume that the creation of the Energy Research and Development Agency would play the role in the energy R&D area that, say, NASA fulfilled in the space mission. But there is a difference between those two that I believe is very significant. NASA (like ONR and the former Atomic Energy Commission) was the ultimate customer, as well as the provider, of resources. NASA (again like ONR and AEC) had the infrastructure and the apparatus, including in-house laboratories, to carry forward programs from the spark of generation to the ultimate utilization of the product. It thus becomes the coupling agency to tie science and technology to ultimate needs.

This is true of ERDA only insofar as nuclear energy is concerned. With respect to the rest of the energy spectrum, it is just an institution for the support and stimulation of R&D; the utilization of results falls within the province of other agencies and institutions. For example, the Department of Transportation has responsibility for transportation, which constitutes 25% of the energy utilization. The bond that connects ERDA with the Electric Power Research Institute, General Electric or Con Ed is thus too loose for the proper stimulation of basic research focussed on the parameters appropriate to specific needs of an industry.

Kiss your car goodbye?

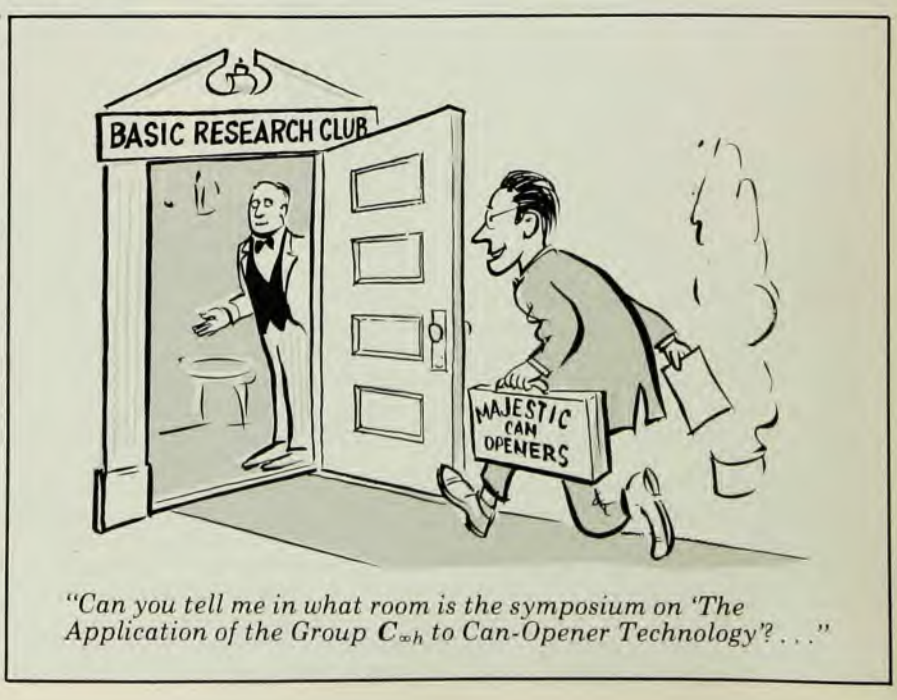
It is here that industry must play a role because industry is basically mission-oriented and links within its purview the entire spectrum of application from research to product. And ultimately it will be industry that will plan, design and build a product.

Let us make the example even more specific by citing the transportation sector, particularly the automobile industry. Forgive me if I once again quote from my writings[3] on the subject—this time from a banquet speech that I gave at an American Physical Society meeting in Chicago in 1956:

> ". . . this I must say à propos of fundamental research in our industry: If there is any industrial area in the United States where an important new idea is absolutely necessary for survival, it is in the automobile industry. The oil prospects for the world are so very dim that this largest of all American industries must have an important, original, inspired breakthrough sometime within the next 25 years, for by then, we shall have to kiss goodbye to any means of [economic] locomotion which requires for its use the internal combustion of fossil fuels. What we must have is something that is so new, so radical and so unanticipated that it would be folly to compartmentalize our thinking into how to go about pursuing this."

I repeat these comments not to demonstrate my clairvoyance, but rather to emphasize all the more that the industry that hopes to stay in business and keep relevant technologies up to date has the ultimate responsibility to do basic research. I do not think it is at all fortuitous that the communications industry and the information and computer industries are the most advanced: They do their own research while the transportation industry, which does not, has got itself into a mess.

"Your admission ticket to the club is to have something of your own to talk about."



"Can you tell me in what room is the symposium on 'The Application of the Group $C_{\infty h}$ to Can-Opener Technology'? . . ."

"I suggest that basic research in the industrial scheme of things has a specific mission to perform: that of keeping the company honest—in the poker sense."

This is the qualitative problem; the quantitative problem is illustrated by reference to another set of figures that relate to basic research spending. Between 1964 and 1974, the total expenditure in the US on basic research is estimated by the NSF to have grown from $2.6 billion to $4.6 billion—an increase of 77% in the decade. *But in constant dollars this increase shrinks to 10%.* The part of this basic research that is done by industry has gone from $549 million to $770 million, an increase of 40%. But in constant dollars this actually represents a shrinkage of 14%, which means that industry is actually doing less basic research today than ten years ago. But here is the real kicker: Federally supported basic research in industry has decreased by 36% in constant dollars.

Other things being equal, it seems clear from the foregoing that any relationship between industrial basic research and innovativeness and economic growth says that we are under-researched. More particularly, industry must make up the shortfall in federal support if it is to survive and grow. I think it is fair for me to assume that, for the readers of PHYSICS TODAY, one need not go through the litany that traces the thread of industrial innovation back to basic research; you are all familiar with many examples.

Now let us consider briefly the national interest. In the two decades following World War II, the US was clearly preeminent in the pursuit of research. This meant, in fact, that during those two decades we were exporting technology and, more importantly, the fruits of technology: products.

Today the situation is quite different. Coupled with the intensification of research activity abroad has been the rise of industrial multinationalism, which infused the concept of industrial research into geographical areas and entities where it had only limited practice before. But the most powerful international language (other than broken English) has been and remains the language of science. Therefore, for an industrial enterprise to participate in the new worldwide dynamism and productivity of R&D in timely fashion, it must learn to talk this international language—and this can be done most efficaciously through direct participation in science.

Research unlocks the storehouse

Finally I find, not only as a scientist but as an industrial manager as well, one subtle but nonetheless real dividend to be derived by the industrial practitioner of basic research. One of the most critical problems within industry is the acute need for self-analysis. The time it takes for information on the intellectual health of a company to feed back through its market performance is much too long, and the process is too complex and cumbersome to be useful. It is a fact of industrial life that those who live it are inward-looking—I would use the word "parochial" but that word has too many pejorative connotations. I do not intend to cast such negative implications on its practitioners, but rather I wish to suggest that this is necessarily a way of life for the industrialist. He or she is much too preoccupied with corporate goals and his or her output is much too sensitive in terms of company security to permit scrutiny by the outside world.

As a result, industrial institutions tend to get inbred, and the management has no ready, continuing means for self-analysis to determine how good they really are. The output of the applied scientist, the engineer, the manufacturing specialist, the economist, the financier, and so on, is confined within the system. As a result, every organization tends to think of itself as being good, a sort of defensiveness born of necessity. I suggest that basic research in the industrial scheme of things has a specific mission to perform: that of keeping the company honest—in the poker sense. It is a sort of calibration point of the company's expertise. After all, the basic researcher receives prompt and thorough evaluation from his peer group, which by definition exists outside the confines of his organization. You learn pretty quickly who is good and who is not; who is creative and who is not, and you also learn who is pedestrian and who is not. The scientific in-house establishment then becomes a standard with which much of the rest of the organization can be calibrated. This constitutes a useful resource to management, if it wishes to use it.

Daniel Bell has stated[4] that the knowledge resource is the key to the post-industrial society. To carry that thought further, I submit that basic research is the key that unlocks the storehouse of knowledge to those industries that hope to survive the transition into that society.

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This article is an adaptation of an address given at the annual meeting of the Corporate Associates of the American Institute of Physics, which was held 2–3 October 1975 in Washington, D.C. The theme of the meeting was "The adequacy of today's physics for tomorrow's technology."

"Federally supported basic research in industry has decreased by 36% in constant dollars."

"Since your last visit, Professor Clumpp, our basic-research department has been moved into less spacious quarters . . ."

References

1. J. E. Goldman, International Science and Technology, Dec. 1964, page 38.
2. PHYSICS TODAY, Feb. 1970, page 63; May 1970, page 61; Sept. 1971, page 61.
3. J. E. Goldman, PHYSICS TODAY, July 1957, page 25.
4. D. Bell, PHYSICS TODAY, to be published; see also page 70 of this issue. □