

LETTERS

The Intrinsic Value of Basic Research

The difficult economic situation in Mexico has put pressure on our politicians to trim and tighten the budget, so scientists and policy makers have been forced to answer the question: What is basic research good for? Some months ago, a new law for science and technology was proposed; it has been discussed in many forums. The final text of that law lists the guidelines for deciding which scientific and technological activities should be supported. Such activities should contribute to solving the country's problems and should demonstrate a strong sense of social responsibility. That is, the country needs the kind of applied research that will have a short-term local impact on education, environment, and the quality of life of the population.

Such a view sounds reasonable, at least in principle. Applied research is indeed needed, but what about basic research? The budget for science and technology is limited, and the new guidelines seem to imply that, if the results of basic research can be shown to be useful in the future for specific applied research, the chances of funding increase.

Talking to colleagues who work in fundamental areas, I often hear: "This is the way things are now. If we must adapt our research program to fulfill the new requirements, we will. Anyway, we can also apply to other, more productive areas the techniques we are developing and using to solve our problems." The list of projects accepted for funding last year by the National Council of Science and Technology Research (CONACYT), the main Mexican research funding agency, includes several in fundamental research as it relates to some specific productive application.

Letters and opinions are encouraged and should be sent to Letters, PHYSICS TODAY, American Center for Physics, One Physics Ellipse, College Park, MD 20740-3842 or by e-mail to ptletter@aip.org (using your surname as "Subject"). Please include your affiliation, mailing address, and daytime phone number. We reserve the right to edit letters.

Basic research has, in many ways, led to important advances in applied research. For example, I wrote this letter using a computer, which in my view wonderfully illustrates what basic research has to say about its own usefulness. Furthermore, many examples exist of successful collaboration between pure and applied scientists, like the application of mathematical theories in economics or the use of techniques from elementary particle physics to develop medical instrumentation. Such collaborative successes are not new; basic research has been incredibly useful in the past and has given us reason to expect that it will continue to be so.

Researchers, then, have a drive to make basic research useful. There is nothing wrong with that. Applied research by any definition has its roots and sustenance in pure research. One form could not exist without the other. So basic science is useful in that it is the origin of applied science, and it has contributed to many technological advances.

In my opinion, though, the question of the usefulness of basic research should not be asked, and certainly not in the context of funding. The examples above notwithstanding, the question makes no sense. Basic research does not have to be useful. Its *raison d'être* is not to serve or be productive. Those are welcome side effects, but even if no examples existed of applications that have had a profound positive impact on society, basic research would still be worthwhile. It simply is. Along with other creative human activities, like the ability to communicate or to write music, basic scientific research forms one of the cornerstones that define our being human. The point is not whether fundamental research is useful, but that it is, like other forms of creative expression, part of the definition of human society.

People who have never had real contact with science are likely to be unaware of its essence, which goes beyond any application. And, when faced with the pressing needs of society and a limited budget, politicians

may fail to give pure science the priority it deserves.

I believe the solution is education—letting people, beginning with ourselves, know what we scientists really do and why we do it, without trying to put makeup on our work to make it more acceptable. If we cannot face and cherish the truth about ourselves and our work, how can we expect other people, including policy makers and funding agencies, to do so?

Some scientists have compared the usefulness of basic research to the usefulness of a child. One interpretation of that analogy is that we hope a child will grow up to be someone great. Another interpretation is that, without children, there would be no adults, the majority of whom are useful to society. These answers parallel those given as examples for the usefulness of basic research. But children and basic research both have value just by what they are, independent of what they will become.

I cannot understand why people, including some scientists, do not realize that the name we have given to these activities is no coincidence. Indeed there is, and should always be, research that is basic, fundamental, and pure.

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Energy Possibilities: Windows, Windmills, and Satellites

The special Energy Challenge issue of PHYSICS TODAY (April 2002) contained a number of articles that focused strongly on energy production, whereas the possibilities of energy savings were given small attention. So it bears repeating, as mentioned in the article by Arthur Rosenfeld, Tina Kaarsberg, and Joseph Romm (PHYSICS TODAY, November 2000, page 29), that energy efficiency is a vital part of meeting the energy challenge.

The well-known correlation between the Human Development

Index, an internationally recognized measure of basic human well-being, and annual per capita electricity use as shown in the figure on page 39 of the April 2002 issue should not be misinterpreted or overrated. Current advances in building technology point toward options for increasing human comfort while diminishing energy consumption. These possibilities are strongly related to advances in materials physics—especially the development of electrochromic materials with optical absorption that can be regulated, reversibly and persistently, by charge insertion and extraction.

Buildings use large amounts of energy for heating, cooling, lighting, and ventilation. Air conditioning has become increasingly important for balancing excessive heat that flows in through glass facades; that excessive heat is a major reason behind the recent energy shortages in California. Architectural trends toward larger glazings—responding to building occupants' wishes for improved indoor-outdoor contact—are likely to lead to even greater demand for air conditioning.

One emerging technology for diminishing the heat load on buildings is "smart" windows, which have multilayer coatings, including electrochromic materials. These windows can regulate the throughput of solar energy and visible light across a wide range of transmittance values by charging and discharging electricity provided by small solar cells. The first of such products has been on the market for a few years, and strong R&D efforts—in the US and internationally—make it likely that less expensive and more durable smart windows will be available within a few years.

Simple estimates show that the energy savings inherent in the smart windows technology are large. In quantitative terms, the lowered electricity demand for air cooling is of the same magnitude as the electricity that can be generated by today's best solar cells, given the same area and orientation as for the smart windows.

The smart windows technology can be less expensive than solar cells. Even more important, the ability to regulate the window transparency alleviates thermal and visual discomfort associated with excessive light inflow while maintaining the primary function of the window: visual contact between indoors and outdoors.

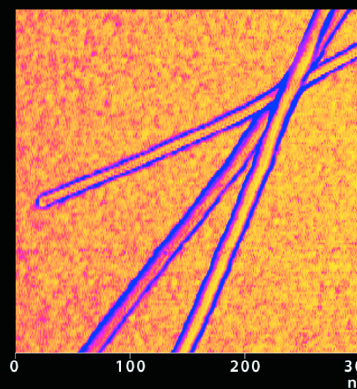
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Twenty years after my last physics experiment, I was pleased to read PHYSICS TODAY's special issue on the Energy Challenge. Having some recent experience with a 300-MW wind farm on the Oregon-Washington border, I would like to add some comments from a utility's perspective to Samuel Baldwin's short treatment of wind energy (page 62). As the article suggests, the current generation of wind technology can be cost competitive with traditional thermal power plants.

Two issues that vex utilities considering wind power are the variability

and the unpredictability of the resource. Power system operators must match demand and generation on a second-by-second basis. Adding to their systems a resource with wind power's characteristics simply makes their jobs more difficult, so the system operators tend to oppose wind power on its face. However, they already deal with vast uncertainties from other generating plants that continually suffer complete and partial breakdowns and loads that fluctuate in significantly unpredictable ways. Demand is not fully

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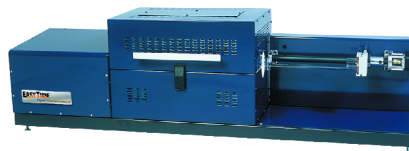


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