How scientists can really help

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The priority need is to develop a systems analysis with heart that society can rely on to choose between possible technologies.

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Last fall I had the honor of speaking at the dedication of a new physics building on the University of California campus at Santa Barbara. As I arrived for the occasion, it struck me how lucky the physicists at Santa Barbara are to be living and working in such a glorious place. The day was clear and I could see the mountains, which contain the surviving frayed specimens of the majestic California condor, and the channel, with the islands on the other side. I had been sailing in the channel and had seen it sometimes sparkling in the sunlight, sometimes shrouded with fog, full of dolphins and sea lions. The campus is built on what used to be my favorite bird-watching place in Southern California, with its curlews, godwits, and phalaropes. Now, for the males of our species, it is a favorite girl-watching place. In any case it is bustling with young Californians presumably seeking knowledge and wisdom, and some older people who are supposed to be able to impart such things.

I think a campus like Santa Barbara is a very suitable place indeed to work on science, because for me the two things are inseparable, the love of the beauty of Nature and the desire to explore further the symmetry and subtlety of Nature's laws. I have an innocent view of pure science, of inquiry driven by wonder and curiosity, and the thrill of learning enough to make predictions that are astonishingly fulfilled. People have had in times past innocent views also of applied science and of engineering—of conceiving and building, based on scientific understanding, devices that are to enhance the life of man and free him from slavery to toil, hardship, ill health, and early death.

But somehow these are not the typical visions of today. Some of our most successful institutions are in trouble, under attack, and even despised, sometimes by intellectuals and frequently by educated young people. Universities are being challenged in many countries. In our country, in particular, science is in ill repute, together with such gigantic and impressive feats of engineering as the manned flight to the moon. Furthermore, scientists and engineers are finding themselves occasionally unemployed; funds for research are sometimes hard to find; and particularly the flow of brilliant students into these fields is declining.

Of course, considering the rapid exponential growth in a decade and a half, some leveling off of the effort in science was inevitable. The growth of science would have to follow an S-curve as so many other things do when exponential rises begin to saturate resources and talented people. However, we deal here in fact not with an S-curve but with a truncated S-curve, suddenly become flat and even declining.

And that is not all. We are seeing among educated people a resurgence of superstition, extraordinary interest in astrology, palmistry and Velikovsky; there is a surge of rejection of rationality, going far beyond natural science and engineering. In my opinion, some of the adverse reaction to science and engineering and even to rationality is understandable.

There are the unfortunate effects of carelessly deployed or carelessly diffused technology, the recognition of massive unintended adverse effects on the planet and on its living things, the possibility of massive unintended effects on human individuals and on our social institutions from already existing technology and especially from things that we can see dimly in the future. These effects are interpreted, and quite correctly, as being connected with a kind of narrow rationality, that takes into account in decision-making only things that are very easy to quantify, and sets equal to zero things that are hard to quantify. But sometimes those latter things are of paramount importance, like beauty or diversity or the irreversibility of change, in the case of the environment; like privacy for the individual; for our institutions, an analog is the quality of giving people the feeling that they are in control of the rapid change that is occurring in their world. We see narrow rationality in the making of some government decisions of great importance. We see facts and figures marshalled in huge arrays that have failed somehow to include inputs from common sense or from human values.

There is also, especially at the universities, a tendency to indulge in thinking that is narrowed by exclusive concentration on a single discipline, and the fear of being called bogus or arrogant if anyone sticks his head out of his own

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building to comment on someone else's problems.

Let me mention too the widespread failure to explain the overwhelming relevance of learning, of understanding, of analyzing, of using reason to approach the world and its problems, and the absolute necessity of using science and technology no matter what we want to do with our technically complex world, even if we want to make it less complex. "Learn this because I tell you to learn it, memorize pages 23 to 54," so what is what we say, instead of explaining how learning helps us to be complete and effective human beings.

I believe that narrow rationality, pervading government, universities, industries, and other parts of our national and even international life, is provoking a wave of insufficient rationality. Youngsters tired of the tyranny of badly programmed computers, and of people who act like badly programmed computers, are turning to tarot cards and charlatans.

What scientists can do

Are we destined to be squeezed to death between bureaucratic automatons on the one hand and superstition or raving on the other? I hope not, and I think we can all work together to strengthen the cause of humane rationality, an approach to the world that utilizes reason and an understanding of the principles of our world. Whether the approach is through inquiry while at the same time celebratifying the great importance of human, of natural, of spiritual values difficult to understand in the technical world, an approach that tries to reconcile all of these in planning the future.

We can see a need for humane rationality and, in some cases, an opportunity for scientists to participate in a number of activities, some of which will require increased support from our society if they are to succeed.

First, activities requiring the cooperation of people from many disciplines, including engineering, natural science, social science including economics, law, medicine, as well as representatives of government at various levels, business, and the concerned public, to plan for a wider use of our awesome technical capabilities. Some of this work can be done under the rubric of technology assessment and control—trying to understand in advance some of the human, social, and environmental consequences of the introduction of new technologies or of the widespread diffusion of existing ones (which can be of much greater importance even than the introduction of new ones on a small scale), and then trying to influence society to create positive incentives for the introduction and diffusion of those that seem on balance to be beneficial and to create negative incentives against those that seem to have dangers or unpleasant features that outweigh their benefits.

We needn't consider only this general class of proposed work, but also other ways of slicing the subject; for example, one can consider strategic planning for the environment, trying to take into account the complex interrelationships among human industrial activity, our air and water, the creatures that share our planet, and the quality of human life, recommending courses of action that can reconcile prosperity (narrowly defined) with quality.

Whether the approach is through technology assessment and control, or through environmental management, urban planning, or other rubrics, there is a clear need here for the cultivation of humane rationality, because we have great technical complexity in all of these questions combined with an intimate involvement in conflicts of human values. These conflicts must be settled ultimately by the political process, but experts may nevertheless have a great deal to say about the differing relevance of various kinds of values to the problems at hand. Some systems of values may be far more appropriate to the situation than others.

The technical complexity means that we need something like what is called systems analysis, to take into account all the factors. As a familiar example in the environmental field we can consider the problem of controlling Southern California's photochemical smog. The contribution of automobiles to this problem was recognized more than twenty years ago, when my colleague Haagen-Smit showed how unburned hydrocarbons and oxides of nitrogen were both required for the photochemical reactions which produce smog. It was decided very early to try and control hydrocarbons as being easier. It was also decided at the same time by the other authorities that health problems might be associated with the existing emission levels of carbon monoxide, which has no known connection with smog. Regulations resulted in curbing both carbon monoxide and unburned hydrocarbons. The natural response of the automobile industry was to raise the flame temperature in engines to maintain the so-called high performance of cars, thereby increasing the emission of the oxides of nitrogen and largely cancelling the benefit of the regulation of hydrocarbons. If we include the increase in car population, we find that smog has not been reduced at all. We may hope that in the coming decade we will do better with a different strategy of regulation.

One can look at the problems of generating electric power, which are even more complex than the smog problem, and see how involved the technical issues are.

Clearly we do need something like systems analysis, but can we stand to live with much of what now passes for systems analysis, in which people are reduced to personnel and wild creatures to resources, the places where poor people are to live become dwelling units, and with all of the calculations that are associated with this kind of jargon? With anything hard to quantify set equal to zero, a highway can be driven straight through a neighborhood or through a rare wilderness because
"We want to feel free to [develop] technologies that we can then re-nounce as inappropriate on total human appraisal"