The Answer Is Not Necessarily the Solution

by Robert L. Sinsheimer

Robert Sinsheimer pinch-hit as the commencement speaker for Willy Fowler, Nobel laureate and Institute Professor of Physics, whose wife's death compelled him to cancel his speech. Sinsheimer had been a faculty member at Caltech for 20 years and was professor of biophysics and chairman of the Division of Biology, when he left in 1977 to become chancellor of UC Santa Cruz. Now chancellor emeritus, he returned to Caltech last year as a visiting associate. He is now a professor in the Department of Biological Sciences at UC Santa Barbara.

I want to talk today primarily to the graduates. If faculty and others wish to draw inferences, they are encouraged to do so. Graduates —this is your day—a celebration for you and your families.

What I want to say reminds me of a bit of humor that was current a few years ago. It concerns the later stages of the French Revolution, when paranoia had become rampant and the intellectuals were being systematically executed.

One morning there were three intellectuals who were to be taken to the guillotine—a surgeon, a lawyer, and an engineer. The surgeon was led up first and it was explained that he had his choice—he could be face down or face up. Being a macho type, he chose face up. The executioner then pulled the rope—but the guillotine jammed and the blade did not fall.

Well, under the rules, if your life was thus spared by Divine Providence, you were allowed to go free—so the surgeon was released.

Next came the lawyer, who had to show that he was just as brave as the surgeon so he also lay face up. And the guillotine jammed again. So he was set free.

Then came the engineer. He also lay face up. But then immediately he pointed up and said, "I see the problem. The third bolt is loose and . . . "

The moral is: It's fine to make use of your technical expertise, but you should always be aware of the context.

You have received at Caltech a superb technical education provided by some of the finest scientists and engineers on the planet. This

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knowledge will serve you all of your life as an invaluable foundation. You are, deservedly, fortunate. You will have the privilege of a life on the frontier of knowledge—a life ever enriched by new vistas of new worlds. You will have the opportunity to participate all of your life in the ongoing, enduring process of scientific discovery and technical invention.

This is a privilege—one that we critically need to extend to representatives of all the diverse segments of our American society. In a democratic society, in a technological age, every sector must have the opportunity to participate in the creation of the future.

This is a golden age for science. Building upon the cumulative discoveries of the past, using ever more powerful instruments, the rates of discovery and invention continue to accelerate. You will not—you cannot—ever cease to learn. The one certainty for the future is change. I have no doubt that more will be learned in the next 20 or 30 years in most areas of science and technology than in all previous times.

When I graduated from the East Coast version of Caltech—back in the late Stone Age—computers and lasers and nuclear power did not exist; quarks and leptons and hadrons were unknown, as were quasars and pulsars and black holes. No one knew the chemical structure of a protein; the nature of the gene was as mysterious as was the surface of Mars. You can be sure that—when you return to Caltech for your 50th reunion in the year 2038—comparably great discoveries and inventions will have been made. The deepest mysteries of matter, of the cosmos, of the mind still await your inquiry.

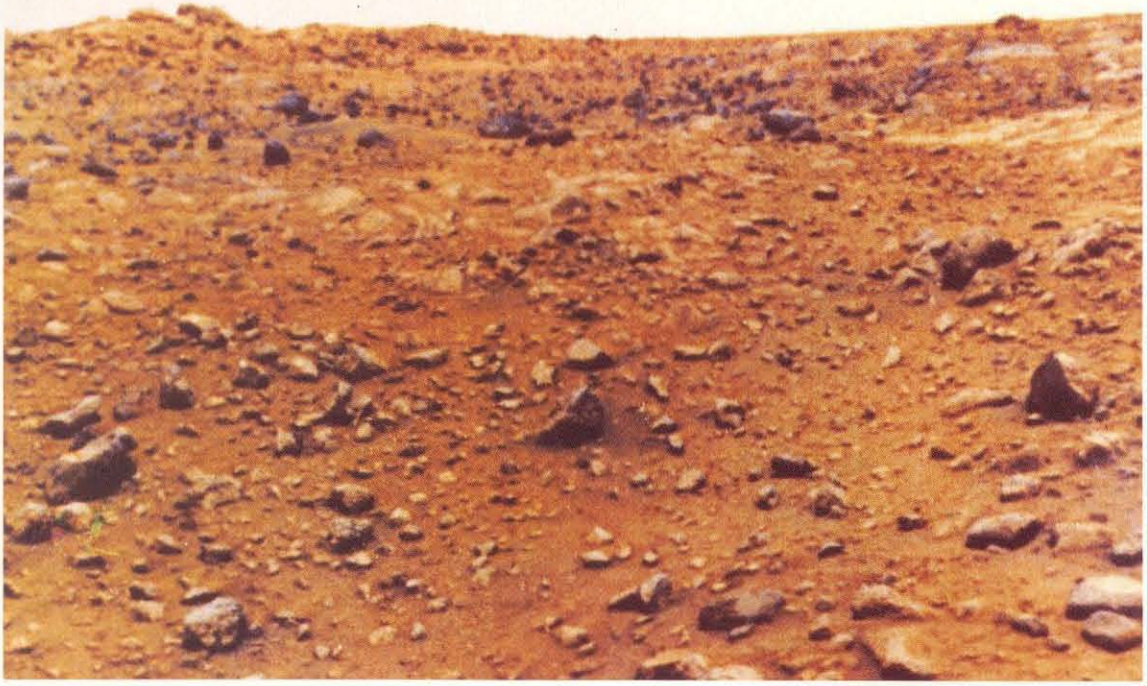
Caltech has many extraordinary strengths: the exceptional quality of its students and faculty; its small size, which minimizes bureaucratic delay and incomprehension; the resources available to it; and, I would mention particularly, its relative homogeneity. Primarily devoted to science and engineering, the Caltech community largely shares a common outlook, a common perception of the world, which greatly facilitates agreement and action. This homogeneity has its manifest benefit—but it may also have its cost. You may not be fully prepared for the tumultuous and diverse world outside these cloistered, cerebral quarters.

I was a member of the Caltech faculty for 20 years and then I served for 10 years as the chancellor of a campus of the University of California, which likes to refer to itself— probably, correctly—as the greatest public university in the world. And so I bring perhaps an unusual perspective in which to view Caltech—and the larger world into which many of you will now enter.

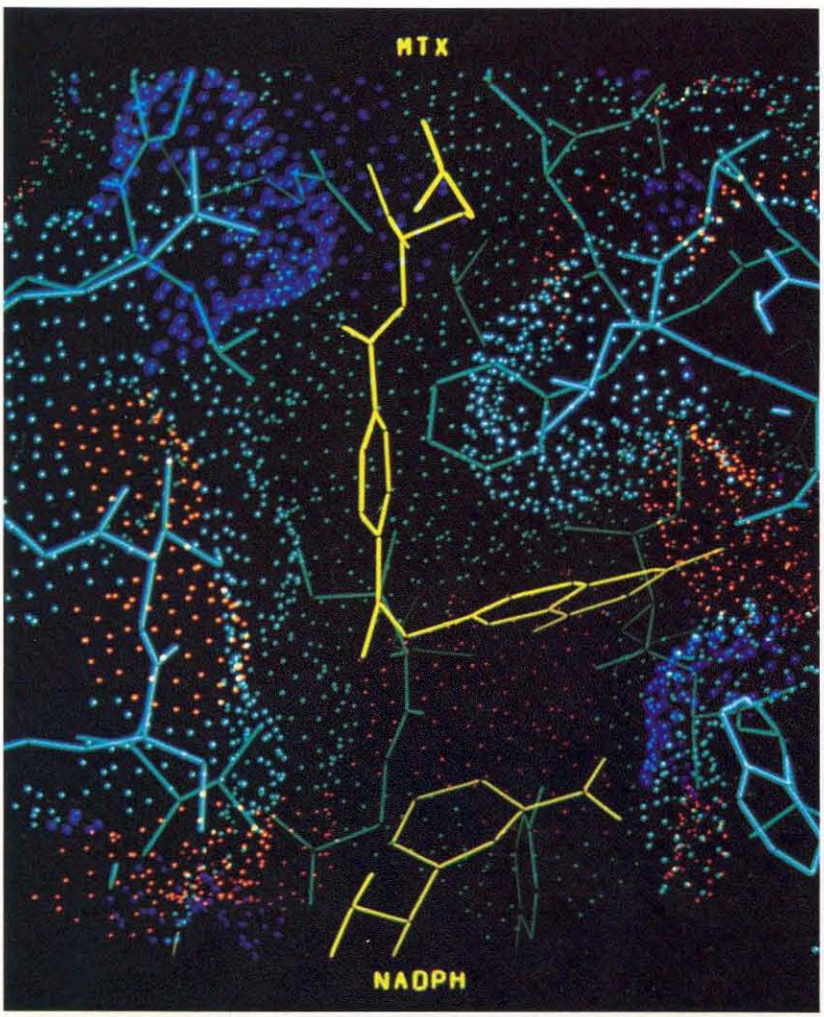
As chancellor of UC Santa Cruz, one of my more interesting but perplexing tasks was to interact intellectually with representatives of disciplines that maintain very different—and very diverse—views of the world and of the value structures appropriate thereto: with artists, who value above all the creative act—on canvas, in stone, on stage, in film; with humanists, who celebrate grace of expression and depth of understanding of the human condition and of the preconditions of human knowledge; with the social scientists, who view science and technology through a very different lens—who wonder about our societal antecedents and about the consequences of our perturbations of the social order.

These varied academic disciplines do at least share a common faith in rationality. Such a belief is by no means universal, as witness the dedicated acolytes of the modern religions, who couch issues not in terms of how or can, but in terms of should or should not, of hubris and humility, of good and evil, of Faust and Pandora. Or witness the animal rights people who presume, on moral grounds, to set animal welfare above the alleviation of human misery; or the reflexive environmentalists who at times can elevate the preservation of an obscure species above manifest human need; or the fundamentalists who firmly believe in an ordained eternal order which we dare not perturb; and so forth.

Bertrand Russell said, "Sin is geographical." Today we might well add, "Sin is occupational."



Before the "golden age of science," no one had seen the surface of Mars (shown here in the first color images from Viking 1) or the structure of a protein. The crystal structure here (depicted and modeled using BIOGRAF simulation tools) shows the active site of the enzyme dihydrofolate reductase, which binds an inhibitor (methotrexate) and a cofactor (NADPH), both shown in yellow. Studying these interactions was the work of Adel Naylor, grad student in chemistry.



I cite these to suggest that in addition to continuing to keep pace with your science or technology you will also, to be effective, need to learn to comprehend—and to match wits with—the advocates of worldviews very distant from your own. For these causes do each have a germ of truth. We should have compassion for animals; we should not heedlessly diminish the diversity of species, for each (as are we) is the inheritor of 3 billion years of evolution; and we should not tamper thoughtlessly and grossly with established tradition. But when these germs of truth sprout into obsession, conflicts arise.

To comprehend other perspectives it is important to recognize your own preconceptions, often unspoken but shared by most scientists and engineers. The credo of scientists is—indeed must be—that knowledge is good and that more knowledge is better and that the quest for knowledge itself is one of the highest forms of human endeavor. You should know that others are not so sure—especially in a world in the thrall of an ethic that strongly favors the swift application of new knowledge to practical purpose. They think of Hiroshima and Chernobyl and Love Canal—and they fear. As Robert Penn Warren wrote, "The end of man is knowledge, but there is one thing he can't know. He can't know whether knowledge will kill him or save him."

Scientists believe firmly in a physical causality even if, in certain circumstances, probabilistic in nature. The initial state determines the secondary state. Things are as they are because they were as they were. Much of the world does not

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share this belief. Witness the daily horoscopes, Las Vegas, the cults of Nostradamus, and so on. Scientists believe there is a truth that can be found in nature. Others, in their frames, confounded by the distortions of image and the biases of preconception, are not so sure a truth even exists, much less that it is accessible. Scientists have a peculiar and distinct conception of the nature of truth and its relation to falsifiability—which is also not widely shared. And scientists know of the impermanence of the world—the long history which preceded the emergence of our species—the course of stellar evolution which produced the very elements of which we are made, the evolution of the planet as seen in the geological record and the ongoing movements of the tectonic plates, the evolutionary chain of life as recorded in the fossils and even more evident in our very genes. Yet much of the world recognizes no history before the written record and no order beyond that currently accessible to our senses.

The advances in science and technology have released or even engendered vast forces in our society. As one consequence, all of the major problems of our time have a significant scientific or technological component. Consider the following:

- Defense—Star Wars, verification of arms reduction.
- Industry—high tech (while education is distressingly low tech; we have been brilliantly successful in the use of our powerful means of communication for entertainment but we have been woefully unsuccessful in their use for education, thereby creating a grievous imbalance.)
- Health—merely consider the challenges of AIDS and drug addiction and cancer and mental disorder.
- The environment—pollution, the greenhouse effect, the depletion of the ozone layer.
- Ethics—how best shall we manage our new ability to intervene at the genetic level in the living world, which includes *us*.

Those of our persuasion are sure that these problems can only be solved by more knowledge, by better science and engineering. But others, who would somehow selectively retreat from today's reality, will argue that we would merely compound the evil. Thus, all of these problems have other nontechnological components as well, other important, very human dimensions—economic, ethical, ethnic, racial, religious, political, the thrust of ego, the lust for power—which are often of great importance.

Choices will be made; priorities will be set. Good or evil will, indeed, be served. As the custodians of the cumulative knowledge of science, it must be your responsibility in our society to provide the voice of that knowledge—the voice of quantitative projection, of reasoned wisdom—into the din of special pleadings and often fanatic views so abundant in our society. To do so, with any effect, you must understand, you cannot dismiss, the other perspectives. In a conversation I had with David Gardner, the astute president of the University of California once remarked, "The problem with you scientists is that you don't realize the answer is not necessarily the solution."

That sounds paradoxical, but it isn't. As a scientist or engineer you may derive the optimal, analytically effective answer to a problem. But in reality, the answer may not be optimal because it may simply not be politically or socially feasible in our time. And then one must fashion a solution—an alternative answer to the problem—that is attainable. And that requires that you comprehend the other perspectives—and their points of divergence from your own.

Finally, in conclusion, in accord with the spirit of the time, I will cast your horoscope. Your stars have risen in the house of Millikan and Feynman, on the cusp of Everhart, under the sign of the Beaver. You are about to enter the Constellation of Prometheus where you will grow in knowledge and blaze in the firmament of science to guide us into the new millennium. Beware the black holes of ignorance and intolerance. Strive to spread the warmth of compassion and understanding to all in your corner of the universe. □