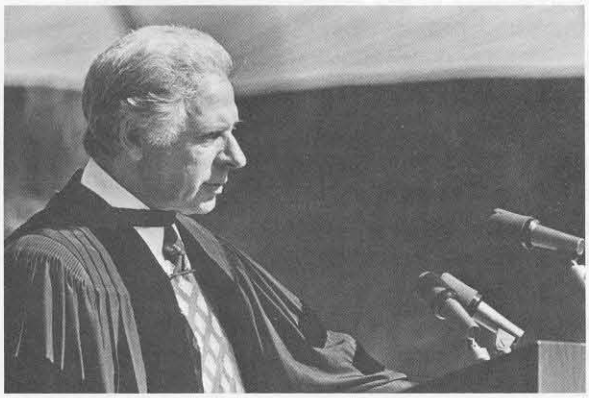

Caltech: Harnessing Science and Technology with Wisdom

by Marvin L. Goldberger

Thanks to all of you for coming here to be part of this occasion. Some of you are my family, some of you are my oldest friends, some of you are my newest friends, some of you represent institutions I've had the privilege of being associated with in the past, but all of you are friends of Caltech—one of the greatest centers of research and education in the world. All of us here are proud that you have taken time to be with us today.

As most of you know, I have not been here very long—only since the first of July. In these past four months I've had a lot of catching up to do. Unlike many of my wiser (or luckier) colleagues, I had never had any professional connection with Caltech. Of course I have known many people on the faculty and had for over 25 years known and admired the two previous presidents—Lee DuBridge and Harold Brown. But everyone who works in scientific research soon learns about the California Institute of Technology through following the contributions to one's own field that are made here, through meeting all the outstanding people who have Caltech associations—the former undergraduate or graduate students, and the postdocs, whom one encounters in leading institutions all over the world.

In January of this year I came, at the invitation of the search committee, with my wife for a two and one-half day exposure to the whole Caltech constituency: faculty, staff, administration, students, and trustees. This was at least as difficult as a PhD exam, and I frequently wondered how well I was answering their questions. At the same time, the whole experience was tremendously exciting, simply because I was actually being considered as a serious candidate for the presidency of this institution. Furthermore, the social events we attended gave both my wife and me the feeling of being welcomed by new friends, rather than being looked over critically. After March 6, 1978, at 2:37 p.m. eastern time, when I received a telephone call from Stan Avery telling me I had in fact been chosen for the presidency, we visited Pasadena several times before moving out for good. As you can see, the elapsed time has been short, but we already feel very much at home in the Caltech community and even in the larger community of which Caltech is an important part.

Since that day in March I have been faced with the reality of being the fourth chief executive officer at Caltech. I have been trying hard to learn how the Institute works, and how it came to be what everyone knows it is—namely, the best at everything it does. I have been pondering some of the questions addressed to me last January about what I would do if I got the job. I've done some reading and lots of talking to all the different kinds of people who have a stake in Caltech. I've been sorting out some of the ideas on education and research acquired in 35 years of experience. I've been worrying about recent national trends and the attitudes in Washington and elsewhere toward support of research. I'd like to share some of these reflections with you.

It seemed reasonable to begin reading about Caltech by going to Robert Millikan's autobiography. In an early address he gives a definition of the Institute that is still very much to the point: "The Institute is a university in the sense that it has a graduate school in which profound scholarship and the highest order of creative work are found.

"It is a college in the sense that it confers a

bachelor's degree and aims to cultivate intensively the humanities through devoting special attention to English, including literature, history, and economics.

"It is a technical school in the sense that it is attempting to give the men (*and now we add, obviously and most emphatically, women*) who go out from its walls with such a cultural background and so thorough a training in the fundamentals upon which all engineering rests as will enable them to take an outstanding place in the progress of industry and science."

He went on to say that the Huntington Library, and particularly the Mt. Wilson Observatory, were of special importance: "These three things—fundamental and creative science, applications of science, and cultural background make this a unique research and educational enterprise." Aside from some obvious omissions such as JPL and the full panoply of the Hale Observatories, this 1921 definition of Caltech sounds remarkably fresh and accurate.

How do we change, staying vital and at the forefront of research and education, without much growth?

A number of noteworthy things have happened since Dr. Millikan made these remarks, and he played an important role in many of them. One of these was the establishment of a division of biology in 1928 under the leadership of Thomas Hunt Morgan. We shall celebrate the 50th anniversary of this occasion next month with an international symposium. Another was the building in collaboration with the Carnegie Institution of Washington of the great 200-inch telescope at Palomar. The Jet Propulsion Laboratory dates from 1936, when a small group led by Theodore von Kármán developed an interest in the basic principles of rocket propulsion. JPL became affiliated with NASA in 1958 and has played and will continue to play a central role in the nation's space program.

More recently, beginning about 1968 a strong group in the social sciences has developed here which includes economics and political science, and both of these activities have vigorous graduate programs. Finally, I should mention the Environmental Quality Laboratory (EQL), which was established in 1971 to carry out multidisciplinary policy studies of important environmental problems.

So much for the past. What now for the future? I once received a letter from a colleague recommending a particular postdoc which ended with the following statement: "Dr. I. is small of stature, but he has a fighting heart." Caltech is small in size, certainly not in stature, and it has and will continue to have a fighting heart. This is fortunate because the competition for the very best people is fierce and, as in other arenas, the strong take from the weak, but the smart take from the strong. I agree strongly with James Conant that the way to wreck a university is to make good appointments. Good appointments are not good enough; it must be only the very best that we care about.

One of the great virtues of Caltech is its smallness. I don't envisage any substantial growth in the near future. At our present size, we can avoid the inertia of larger institutions, and we can move quickly when we decide what we want to do. Nevertheless, if there is a good idea in research or in education, our stature gives such innovations great influence.

The basic problem we face is the following: How do we change, staying vital and at the forefront of research and education, without much growth? Sir Lawrence Bragg at Cambridge sometime during his long career enunciated two important principles that are worth recalling in this connection: First, don't try to re-create the glories of the past, and second, don't follow the crowd. We must be sure that the argument that begins with the statement, "Caltech has always been strong in . . . ," doesn't force us to neglect new initiatives in order to preserve ancient traditions. As for following the crowd, we obviously cannot neglect certain popular demands when we have educational obligations to meet. But in the research area, it is often unprofitable to make radical shifts just to accommodate what may be transient swings. More important, I don't want to be in the position of playing catch-up if it can be avoided. I'd prefer that others be trying to catch us.

In the course of changing without growing we must occasionally be daring. We have to be prepared to seize opportunities to strike out in new directions, to bring people or programs to Caltech that will make real qualitative changes. This may call for an occasional discrete jump in the size of a particular staff and for special funds. I'm eager to respond to such initiatives from the faculty, and I cannot promise to forbear doing some needling if they are not forthcoming.

In a more modest vein, I'd like to mention a few conventional areas that I see as immediate targets for improvement and perhaps even a little change. The first of these has to do with undergraduate education. Our undergraduates are phenomenal. Historically, they have been phenomenally successful, using any criteria of success. Since I haven't been here very long, it's not clear that all the impressions I've gathered are entirely accurate, but I feel there is enough truth to what I've heard to express some concerns. In spite of the initiation of the pass-fail option for the freshman year, we lose too many students. No institution can hope to graduate its entire freshman class, but Caltech ought to be able to hold most of the students it selects with such care. There are many reasons for the losses. Let me draw attention to the one that concerns me the most, which is also the one we can do something significant about immediately.

The material in the undergraduate curriculum is necessarily difficult, but it is also frequently boring and the students become disillusioned and impatient. In an institution like this, where the faculty are engaged in important and absorbing research and scholarship, it is often tempting to avoid giving undergraduate teaching the attention it requires to instill a sense of excitement in the students. I want to urge the senior, most distinguished, faculty to undertake this task, but I warn you, it is much more difficult than graduate teaching. I'm sure that our faculty, some of whom I'm told have never taught undergraduates, can cope with the difficulties. Because our students are so exceptional, they deserve the best we have to offer.

It's worth remembering what we are trying to achieve with our undergraduate programs. Some significant fraction of our students will go on to graduate school. Some, particularly in the applied sciences, will go to work in industry. Some will go into law or medicine or politics. The latter is an area where we desperately need technically trained people. As part of the educational experience of all of these different groups, I want to suggest that the faculty consider a requirement of independent study leading to a senior thesis for all students so that they can experience the reality of research and the exhilaration of accomplishment that goes with it.

While I'm on the subject of education, I must say that while our graduate programs are extremely successful, there is no room for complacency. There are some areas in which, to my positive knowledge, we are not attracting the very best graduate students, and we must understand the reasons for this and take corrective steps.

"Science is at best knowledge; it is not wisdom. Wisdom is knowledge tempered with judgment."

I anticipate significant change in some other areas of our educational and research endeavors in the near future. In his definition of Caltech, Dr. Millikan stressed the importance of the humanities. This is a concept that I feel very strongly about. Lord Ritchie Calder has said, "Science is at best knowledge; it is not wisdom. Wisdom is knowledge tempered with judgment." The study of the humanities can help us immeasurably in our quest for wisdom. There are those at Caltech who believe there should be a major restructuring of the relationship between science and the humanities. I shall work hard with them in the coming months to understand these views. In the meantime I plan to move swiftly to replace the losses we've suffered in recent years in this area. I've promised the new chairman of the Humanities and Social Sciences Division a significant number of senior appointments in the humanities including the currently vacant Dreyfuss Professorship. We will work to put together a group that has the typical Caltech uniqueness and distinction. We shall try to capitalize on our great local asset, the Huntington Library, to help us attract scholars of distinction.

We have another great local asset which has not, in my opinion, been exploited by Caltech as effectively as it might be. This is the Jet Propulsion Laboratory. JPL is part of Caltech. It is, of course, far larger than the campus. It has special roles, missions, and obligations to its sponsor, the National Aeronautics and Space Administration. The NASA/JPL association has been an enormously fruitful one for the nation, and we look forward to many more years of collaboration on exciting programs. What I would like to see, however, is an even closer relationship between the campus and JPL than we have now. A substantial number of professors and students are already involved with various aspects of JPL work, but I look forward to our seriously taking advantage of the extraordinary educational opportunity JPL provides us with. To have available a real live

laboratory doing technical research, development, and systems implementation at the very limits of technology gives us an incredible advantage over any other educational institution in the country. I shall urge the faculty to look into means by which a solid work-study program—call it what you will—can be instituted for students of applied science, both undergraduate and graduate. I hope we shall also take steps to encourage and increase joint campus/JPL research activities, particularly in the field of energy.

Finally, before leaving this subject of new initiatives, I want to mention that we are about to begin construction on the Braun Cell Biology and Chemistry Laboratories. This will give added impetus to our major programs in biology, immunology, and the neurosciences. We shall also very soon see the start of the Thomas J. Watson, Sr., Laboratories for Applied Physics, which will enable us to broaden research activities in this important area. We are initiating a major effort in the physics department aimed at the detection of gravitational radiation. We have a vigorous and growing program in computer sciences. We are embarking on a major new program in resource geology, an area in which we already have considerable strength, but one to which we are giving new emphasis. This year, as a result of generous support by our trustees, we have also established the Robert P. Sharp Professorship in Geology.

This all sounds very upbeat, as it is, and I have every confidence that we will succeed in all of these programs. There are, however, some clouds on the horizon of which we must be aware. Consider the outlook for continuing federal support of research, upon which we count very heavily, just as all the nation's principal research universities do.

For many years after World War II, basic research in the physical sciences was heavily supported by the Department of Defense and the Atomic Energy Commission. In spite of the disclaimers on the part of the scientists that no new super weapons, like the atomic bomb, were likely to result from the research, many of the defense agencies still secretly believed such weapons might emerge. Right up to very recent times the Congress held those beliefs.

A few years ago the following interchange took place between Senator Pastore and Dr. Robert Wilson, the director of the Fermi National Accelerator Laboratory, at a hearing in connection with that laboratory's 500-billion-electron-volt proton accelerator:

Senator Pastore: "Is there anything connected with the hopes of the accelerator that in any way involves the security of the country?"

Dr. Wilson: "No, sir; I do not believe so."

Senator Pastore: "Nothing at all?"

Dr. Wilson: "Nothing at all."

Senator Pastore: "It has no value in that respect?"

And then Dr. Wilson said something which I feel expresses the fundamental aspects of basic research better than anything I've ever heard before or since.

Dr. Wilson: "It has only to do with the respect with which we regard one another, the dignity of man, our love of culture. It has to do with those things. It has to do with are we good painters, good sculptors, great poets? I mean all the things that we really venerate and honor in our country and are patriotic about. It has nothing to do directly with defending our country except to help make it worth defending."

Basic research sponsored by the mission-oriented agencies, both defense and non-defense, has dropped off enormously, although there are some hopeful signs of new initiatives being taken by the Department of Defense to once again support research in the universities. Unfortunately congressional pressure in recent times has forced agencies like NASA and the Department of Defense to drop scientific programs. Of even greater significance and importance is the question of principle involved here, that mission-oriented agencies should be concerned only with applications and not with basic research. This is an incredibly short-sighted view.

Let me give one example of the kind of thing that can and did happen because of such short-sightedness. For many years the Advanced Research Project Agency (ARPA) in the Department of Defense supported major programs in materials research in universities. Now, just at a time when materials play such a critical role, in solar energy, nuclear energy, controlled fusion, fluidized-bed coal combustion, to name just a few areas, the programs no longer exist.

One of the frontier areas of science is high-energy physics. The annual operating budget for the whole effort in the United States is about $200 million. The work is carried out at three major national laboratories: Brookhaven, Fermilab, and the Stanford Linear Accelerator. The people who do the work have been trained in the universities and are mostly members of university faculties. The program has been phenomenally successful by any measure; the field is dominated by United States scientists; there are important contributions to technology, such as superconducting magnets, high-powered microwave tubes, advances in electronics and computer utilization; and Nobel Prizes have been won. But shrinking support is beginning to slow the program significantly. The European laboratories in Geneva, known as CERN, and in Hamburg, called DESY, are growing rapidly both in facilities and research support. At the present time, Western Europe is spending almost twice as much as the United States.

Now, in all honesty, I must admit that the world will not come to an end if some important discoveries in high-energy physics are made in Europe. But I dislike relinquishing supremacy in a fundamental field, and I resent policies that inevitably mean we are going to come in second.

An atmosphere of tight spending in scientific research has many unfortunate consequences and dangers. First, good people are discouraged from entering the fields. Second, only the most powerful and best established people get to work with the limited funds, and thus the careers of young people are blocked. Third, federal agencies tend to support their investments in national facilities to the detriment of the universities; this sets up a chain reaction leading to a decline in the quality of research, which in turn leads to a decline in the training of a new generation of scientists. Fourth, cutbacks in the funding of new instrumentation are particularly dangerous to big science, little science, and to industry; obsolescence of equipment means a decrease in cost effectiveness; training students on such dying equipment makes them less useful to industry; innovation is stifled and what used to be our hallmark—our ability to respond to technological challenges from abroad—is threatened. For example, our computer industry is going to be sorely tried in the near future to stay ahead of Japan. Finally, fifth, in an atmosphere of tight funding there is a tendency to do what is safe and to steer away from the true frontier areas where we can make real quantum jumps in our understanding.

Now what can be done to fight this trend? For too long the scientific community and the universities have adopted the attitude that what they were doing was so obviously good that no arguments had to be presented and that the money would just roll in. This is evidently no longer true, and it is not going to be true in the future. Nothing is accomplished by sitting back and wringing our hands about the failure of Congress to appreciate and support research, even in the face of a very strong effort on the part of the Carter administration to increase significantly research funds. Nor can the professional societies or the National Academy of Sciences be counted on to plead the case. We as individual scientists and as university administrators have to take the initiative. We have a great product to sell. We must write articles, give interviews, volunteer to testify before Congress, enlist the help of technologically based industries, enter into arrangements with the media to bring to the people the truly exciting case we have to present about science and education. The future of our country and even that of the world depends on our ability to harness science and technology with wisdom for the common good and to continue to push forward the frontiers of knowledge.

We at Caltech have our work cut out for ourselves. We must continue to rely heavily on federal support for research, and we must help create the atmosphere that will earn it. We must seek innovative methods for interactions with industry and support from it for both basic and applied research. We must win support for our programs in the humanities by both deepening and, perhaps at some future time and in some daring fashion, broadening them. We must continue to be the leaders in all of our areas of scientific research. Research carried out in conjunction with teaching forms the cornerstone of the American educational system—in my opinion, the best in the world. We must train students who will be the new and wise leaders in industry, in public affairs, in the universities, and in extending the forefront of knowledge.

This is a heavy responsibility for one small jewel-like institution. But we stand on the heritage of Robert Millikan, Lee DuBridge, and Harold Brown. I'm honored and proud to have the opportunity to follow in their footsteps and to build upon the solid foundation of greatness laid by them. I'll do my very best, and with the help of the whole Caltech family, I think we can reach our goals. ❑