Engineering and Science

CALIFORNIA INSTITUTE OF TECHNOLOGY

JANUARY 1972

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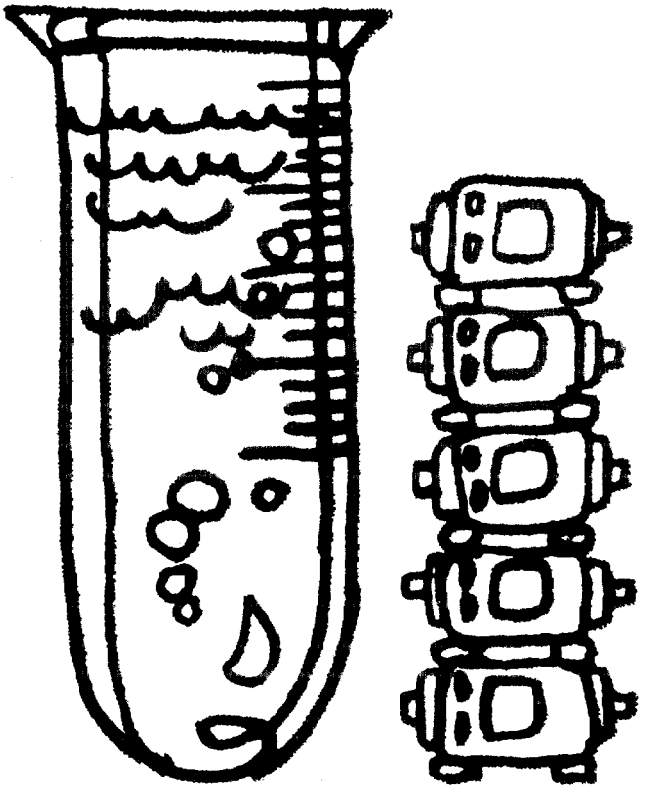

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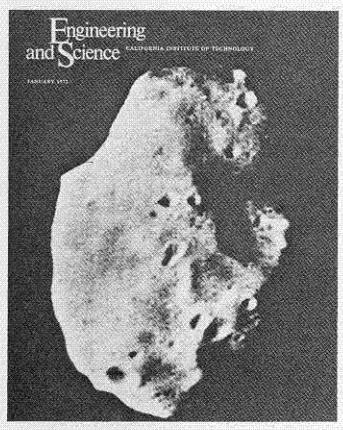

Engineering and Science

In this issue

On the Cover

Man's first close-up view of the Martian moon Phobos. This is a computer-enhanced photograph, taken by Mariner 9 during its 34th orbit of Mars on November 30, 1971. This is our third expedition to Mars. Until Mariner 4 flew past the planet in 1965, all our knowledge of the planet had come from earth-based operations using telescopes. While Mariner 4 came within 6,000 miles of Mars, Mariners 6 and 7, also on flyby missions, came within 2,000 miles of the planet in 1969. Mariner 9 is the first spacecraft to orbit Mars (or any other planet, as a matter of fact). Some of the first Mars photographs to come back from Mariner 9 are on pages 10 to 13.

Ask The President

There have been a lot of changes at Caltech since Harold Brown took over as president almost three years ago. And, in the nature of things, there are more to come. What will they be? What does the president have to say about them? And about Caltech in general? Everyone in the Caltech community has some questions he would like to ask Harold Brown. But even if he *has* all the answers, he obviously can't deal with each personally—which is why *Engineering and Science* assembled a representative group of faculty and students to interview President Brown for this issue. Their questions, and the president's answers, are on page 4.

Mars and Man

On November 12, the day before Mariner 9 went into orbit around Mars, Bruce Murray, professor of planetary science at Caltech and one of the co-investigators on the Mariner 9 television team, organized a panel discussion on the campus on "Mars and the Mind of Man," enlisting the services of two science fiction writers—Ray Bradbury *(The Martian Chronicles)* and Arthur Clarke *(2001)*—and two scientists—Carl Sagan, visiting associate in planetary science from Cornell University, and Murray himself. On page 17—some pertinent comments from that stimulating discussion.

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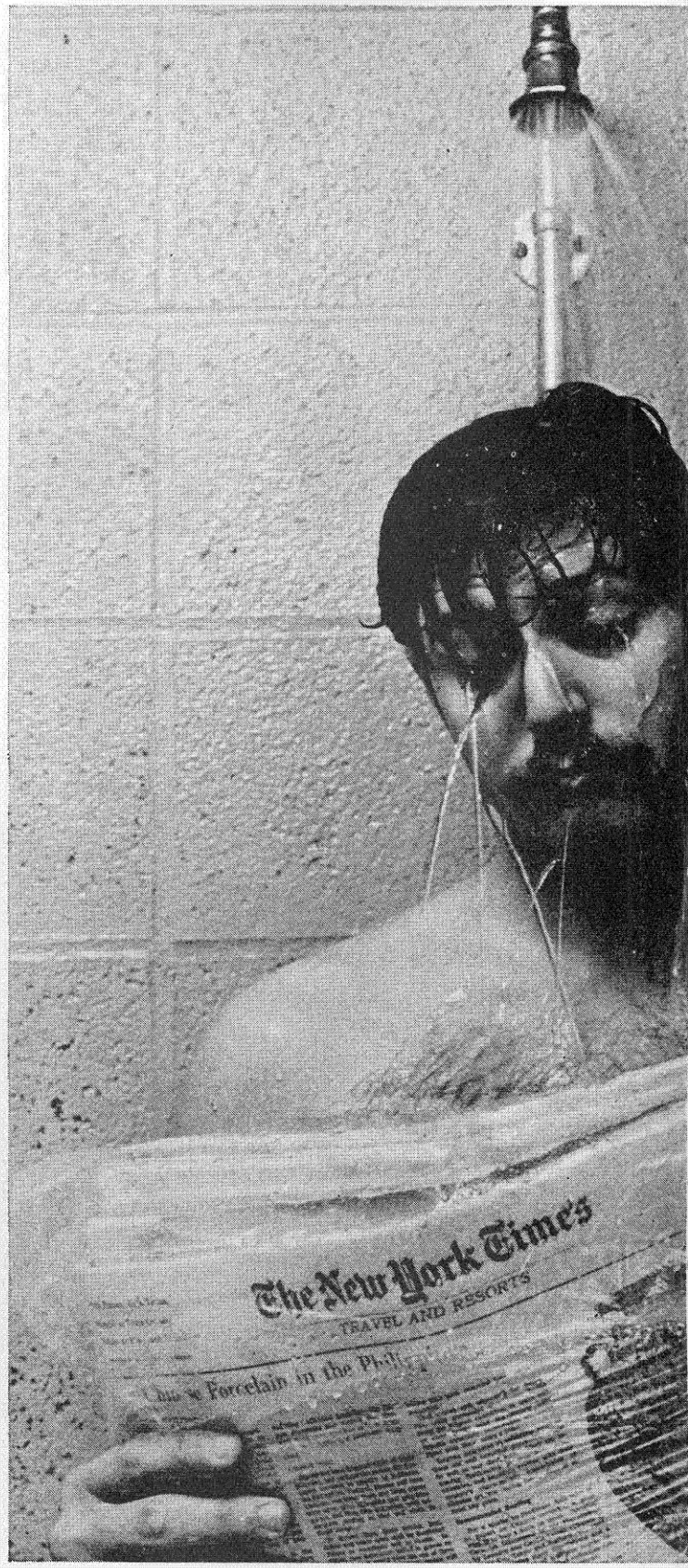
We keep the news fit to read.



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An Interview with Harold Brown

President Harold Brown has been at Caltech for almost three years. What changes has he promoted? What problems does he have? How is he dealing with them? What does he think of the faculty? And the students? How does he like being president?

These are some of the questions Caltech's faculty and students keep asking. Because they can't all get a chance to ask them directly, Engineering and Science *invited representative members of the faculty and student body to interview the president and get his answers.*

The interviewers: Clarence Allen, professor of geology and geophysics and former chairman of the faculty; George W. Housner, professor of civil engineering and applied mechanics and current chairman of the faculty; John Roberts, professor of organic chemistry; George Purcell, a graduate research assistant in astronomy and president of the Graduate Student Council; Paul Levin, a senior and co-editor of The California Tech; *and Steven Watkins, a junior and president of ASCIT.*

ROBERTS: What would you say were the noteworthy developments in your first two and a half years at Caltech?

BROWN: When I think about it day to day, I tend to be depressed by how little I am getting done. But when I sit down and try to write everything out, I am impressed with how much has actually happened, although I wouldn't say that they are things that I have done, particularly. They are things that I hope I have helped along. I would divide them into a number of categories. To start with the academic category, there has first of all been the admission of women undergraduates to Caltech. Then there has been the establishment of an independent study program, where a student can make up a curriculum tailored to himself (if he can get three faculty members and then the independent study committee to accept it). There is the applied physics curriculum—an option which to the engineers may just seem another way of splitting off a piece of engineering, but I think it provides real opportunities for a merging of science and engineering. Before that, of course, there was the turning of the environmental engineering science program into a specific option—a degree option. And I shouldn't omit the splitting of Physics I and II.

Now, in administrative terms—no, before I get to that, let me talk about some things that are not quite academic; they're not curricular, but they combine teaching and research. I would say that the Environmental Quality Laboratory is a very big and important change whose success still hangs in the balance. There has been an increased emphasis on behavioral biology, and a clear decision that we would expand our activities in social science by adding a small number of faculty. The exact way in which that turns into a curricular matter is still being considered. I would say that, in parallel with the EQL, there is a new emphasis on encouraging closer relations between the campus and JPL. The Caltech president's fund and the JPL director's fund, I think, have done quite a lot to develop that.

Now let me say something about administrative action, since the president can't help but be an administrator. I think that we have added somewhat more structure to the Institute. Whether this is good or bad is a matter that everyone will have to decide for himself. For myself, I decided that it was necessary. I think the Institute is past the size where everybody can just report to the president in an administrative way. That's a separate question from his being accessible. So we have straightened out the administrative structure somewhat without, I hope, increasing it inordinately. Another thing that has happened

is that there's much more in the way of advance financial and planning effort. Again, none of this is completely new. Everything has evolved.

ALLEN: In what way is Caltech different from what you thought it was going to be?

BROWN: If anything, I guess the people are even smarter than I expected (though I expected them to be pretty smart). I find it a more closely connected community than I expected it to be, and less connected with the outside world than I expected it to be. And it has proved to be less subject to faculty politics and backbiting than I expected. I would add that it was more chaotic than I expected it to be, too. I find it less so now, but whether that's because it's changed or because I'm more used to it, I don't know.

ALLEN: What do you mean "chaotic"?

BROWN: There was not a very simple procedure for getting things done, you know. I mean I would say to people around me: "This is what I want to do." And they would say, "Well, that's very interesting." But no one offered to help do it or said: "Here's how you do it."

WATKINS: You mentioned Caltech's relations with the outside world.

BROWN: Yes.

WATKINS: More specifically, what do you think the role of the university is—and the role of Caltech—with respect to the outside world, and, even more specifically than that, with respect to defense work or classified research?

BROWN: Let me answer those questions in the order in which you have asked them. I think that you can't

characterize the university as a whole with respect to the outside world because different people and different groups in it have different relations to the outside world. If you must try to characterize the Institute as a whole with respect to the outside world, I think you have to say that it can't successfully affect the outside world quickly. It has to try to do it over a period of time, in two ways: first, by the knowledge it produces and second, by the people it produces. The second takes even longer than the first. Having made that general statement, I would add that there are groups in the Institute—earthquake engineers, for example, and maybe the Environmental Quality Laboratory will be the same way—that affect it very quickly over a period of just a few years.

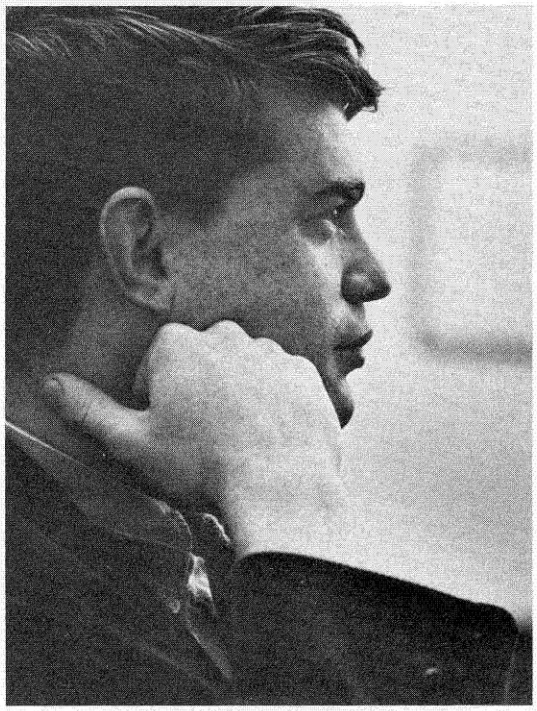
I think one has to ask the question the other way, too. How does the outside world affect the Institute? And there again, it affects it through the attitudes both of the faculty and, even more, the students, who tend to bring along new attitudes. Both these groups are affected by the outside world. The university is affected by the outside world through the outside world's valuation of its efforts and how well the outside world is willing to support it, because the university doesn't support itself at all. The only degree to which the university supports itself is by charging tuition, and in our case that amounts to about 10 percent.

But I don't want to let the second part of your question go by. With respect to classified work and defense research, it seems to me that a university's efforts should be governed first of all by the interests of the people there who conduct research. If a government agency is interested in supporting some kind of unclassified research that a faculty member wants to do, then I don't see any reason why he should be constrained by which government institution offers the support.

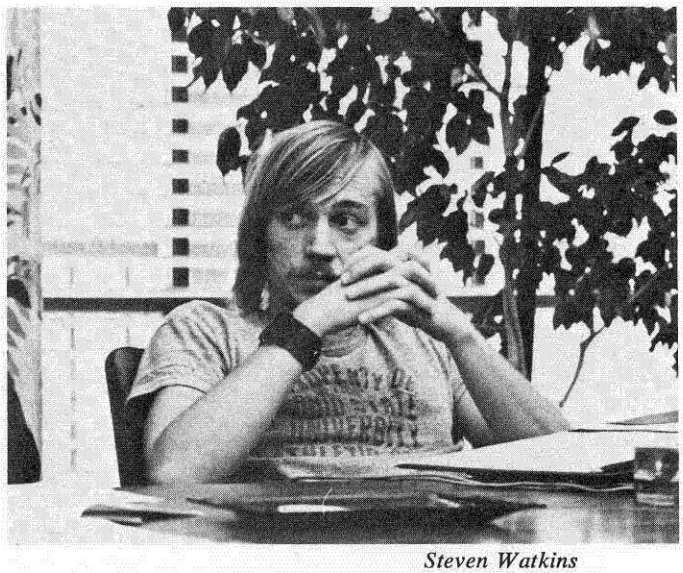
Classified research is a different matter, because I think classified research is not ordinarily accessible to the whole university community, and therefore it violates a very important criterion. This criterion may be relaxed somewhat—but only through clearly defined and rare exceptions—for off-campus laboratories. I think in times of national danger when there is really a national security peril which a university could help avoid by working on classified research—I would see that as a possibility. But that's not the situation now, and I don't think it has been since World War II, so that as a consequence I think Caltech has been very wise since the late forties to prohibit classified contracts for research on campus.

HOUSNER: To get back to the university interacting with the outside community—in engineering, of course, it's easier to do because often the problems come and knock at your door. But the question we face is how much time we should allot to it. Do you have any thoughts on that?

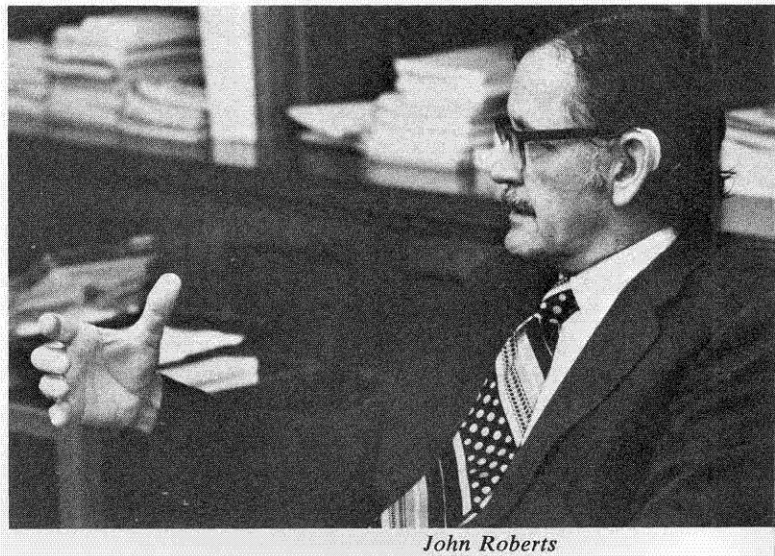
BROWN: My first thought is that probably it will vary with each individual and it will vary both with time and



George Purcell



Steven Watkins



John Roberts

Clarence Allen

George Housner

his own career, and there will be secular variation, depending on what's happening outside. I have a feeling that there's going to be pressure from the outside that says you've got to show that you're contributing your bit to society. By you I mean the Institute. And I don't think necessarily that the Institute should try to codify or reinforce that pressure from the outside. In fact, we should to some extent defend ourselves from it and say that there has to be a core of work on what we think is going to be important 15 or 20 years from now, and not just what the society thinks is important now or next year. Who knows what they will think next year? Yet, I do feel it is part of my responsibility as president of the Institute to make it clear to the faculty that pressure outside exists and we had better be aware of it, and probably for the health of the Institute and for the health of science and technology in general we ought to respond to it more than we did in the days when the money was forthcoming without any strings. Yet every faculty member has to decide for himself.

ALLEN: Could I change the topic a little bit? In view of the faculty's allegedly liberal attitude on national and international politics, have you found them to be surprisingly conservative in terms of their attitude toward possible changes within Caltech?

BROWN: Well, there's a famous quotation by Clark Kerr to the effect that university faculties are the most liberal people in the world, except when it comes to their own business.

ALLEN: Have you found this to be true here at Caltech?

BROWN: In the first place, I think that the Caltech faculty —as faculties go at first-rate academic institutions—is far more careful than average about expressing its views on national and international affairs. Put simply, I would guess that the Caltech faculty is probably (to the extent that you can characterize things in a left-right way, which becomes increasingly difficult these days) is less left than almost any first-rate university faculty in the country. They may not like to hear this, or maybe they *would*, but I think it's true. I would say that the Caltech faculty is reasonably willing to have things changed in its own business—although probably much less so than *I* am.

ALLEN: Then you haven't been *surprised* by the attitude of the faculty toward change?

BROWN: No. I expected them to be rather conservative, and they are not more conservative than I expected. I think it may be, because the tenure of presidents is more like that of students, that the president and students are probably both more willing to see change than faculties who expect to have to live with their mistakes for a longer

When I think about it day to day, I tend to be depressed by how little I am getting done. But when I write everything out, I am impressed with how much has actually happened.

time. I think, for example, that the Caltech faculty showed more willingness to include student participation in committees than was evident at most other places. There was less push for it here, but I think rather more rapid action so far as the faculty is concerned.

PURCELL: I think part of the reason for that was they felt a lot less threatened here than at other places.

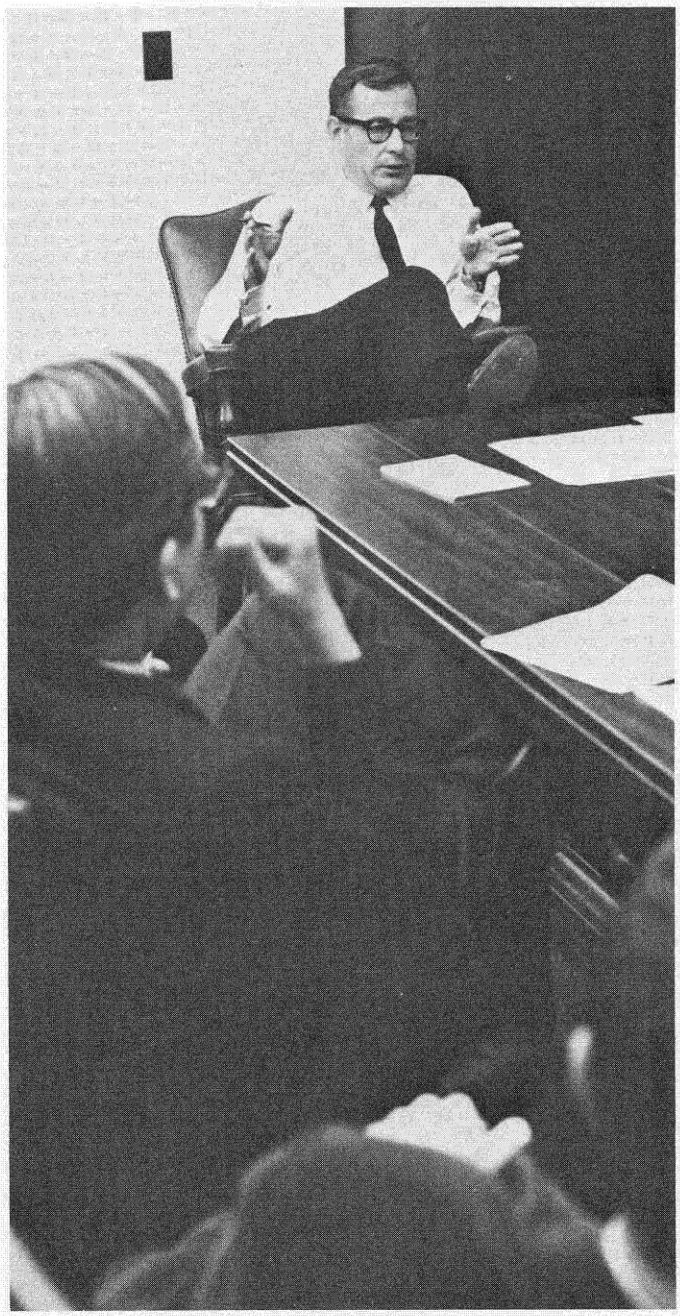
BROWN: They were willing to have somebody else help with the work, too. But I think that they felt less different from Caltech students than faculty feel from students elsewhere, and that is just another way of saying the same thing as you did.

HOUSNER: In the *L.A. Times* the other day there was a big article quoting some of the staff members as saying Caltech was not as innovative as it should be . . .

BROWN: It's probably correct. I think that when you add up what we've done in the past few years it adds up to quite a lot, but there's not an awful lot every day that is new. I think that there is a strong tendency among faculty members, particularly professionally highly regarded faculty members, to go on doing what they are doing. After all, they know they can do that well. Why change?

ALLEN: Well, if you think that we should be more innovative, as I gather you do, how do you suggest we go about it?

BROWN: I don't have a formula or procedure. I tend to think in terms of specific innovations rather than ways of being more innovative. I am very interested to see how the EQL turns out because there's an example of a way to be more innovative. It may work; it may not. My view of EQL—and I will take the responsibility for having pushed it—is that we're not establishing something like that in order to say to faculty members: "Look, you ought to stop doing what you are good at and know about and turn to societal, economic, social, and political problems on which you are likely as not to fall right on your face." What we are trying to do with EQL is to establish a mechanism by which those faculty members who want to branch out, who want to apply technology to other kinds of problems where the way is much less clear, can do so and do it in the Caltech milieu. Not many have taken the opportunity, and that may prove to be wise on



their parts. I don't know. But that is one way to provide for innovative atmosphere.

ROBERTS: Is it really necessary to set up administrative substructure to do this sort of thing?

BROWN: I think it depends on what kind of work you are talking about. For an individual faculty member's research, I don't think new administrative structures are needed, although some may want them as a security, or to give them more leverage, or for various other reasons. It's when you are trying to bring faculty members together, either with each other or with people from outside, that you need a new administrative structure, because the same characteristics of Caltech that make it so easy for a faculty member to do what he wants, make it very hard to get five or ten faculty members to do things that relate very closely to each other, and for that I think you do need to provide some administrative protection.

PURCELL: I'd like to ask a more personal question. You observed in a Town Hall address about a year ago that three of the least popular vocations a person can follow in this country today are that of the military, the university administrator, and the scientist or technologist, and I wonder if you could explain to us how all three of them became involved in your own life.

BROWN: Well, they didn't all happen at the same time. I suspect that I rather drifted into much of what I have done. I drifted into science partly because I had been good at it—well, good at mathematics, when I was in elementary school—and then I went to the Bronx High School of Science because it seemed to offer a very good education. But once I was there, it was rather clear that I was going to be a scientist or engineer. By that time there was a clear pattern. I went to college and first I was an engineer and then I was a physicist and got my doctor's degree in physics. So that's how I got to be a scientist. And I suspect it's not all that unusual even now that people get into science in that way. They are exposed to it, and they are interested in it, and the best way I think you can really get a youngster interested in science in junior high or high school is expose him to it and see whether he's interested in it—even though what he sees there isn't "really" science.

That's how I got into *one* of these despised categories. Then I came out to California after I got my doctor's degree and went to work at the Radiation Laboratory in Berkeley, where they were hiring people to work on military-related projects. It's hard to cast one's mind back to those days, but I have a feeling that—in those days of the beginning of the cold war—I was not uninfluenced by a somewhat simpler form of patriotism than I now have. (I feel I still have it—but in a more complex form.) And I got involved in what was very interesting applied science involving nuclear reactors first, then weapons, controlled thermonuclear research, all those things, and was actively in them as a researcher for another three, four, five years, and then began to become an administrator. I had, I think, decided earlier than that, perhaps in the first year or so after I got my doctor's degree, that I didn't have the combination of brilliance and concentration (narrowness, if you prefer)—willingness to stick with one thing—that it really takes to be a first-rate scientist. So I got interested in applications where breadth even to the point of shallowness is not necessarily a drawback. After moving over into administration, I was strategically situated in terms of the evolution of the development of military—strategic and technical—situations. I was at the Lawrence Radiation Laboratory at Livermore when the hydrogen bomb decisions were made and the first designs were made and when the military depended much more than they now do on what the scientist could tell them about the feasibility of future systems and components. And I got caught up in the corridors of power, and it was a very natural thing to move to Washington. Looking back on it, I would add that—having just read Krushchev's memoirs and, earlier, Halle's book *The Cold War as History*—I'm not prepared to agree with the revisionist school of historians that we did the wrong thing in the late forties and fifties. I am possessed of fairly severe doubts as to whether we didn't continue on the same path too long, but innovation is not any easier in government than it is in a university. In any event, that's how I got to be in the military.

How I got into academic life I think I set forth in my inaugural address fairly accurately. I did have a desire to do something different. And this seemed different and challenging and a way to apply one of the central attitudes or purposes that I was able—or hoped I had been able—to bring to my previous situations, that is, trying to find some reconciliation between the internal drives of a first-rate professional organization and the larger setting in which it exists, whether the organization is a laboratory or a government bureau or military service or an institution such as this one.

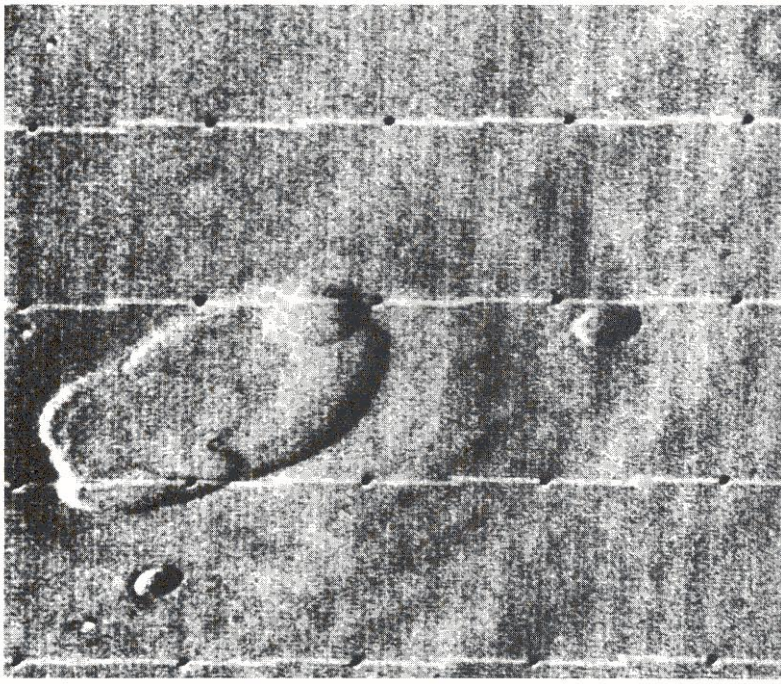
continued on page 28

Mariner Looks at Mars

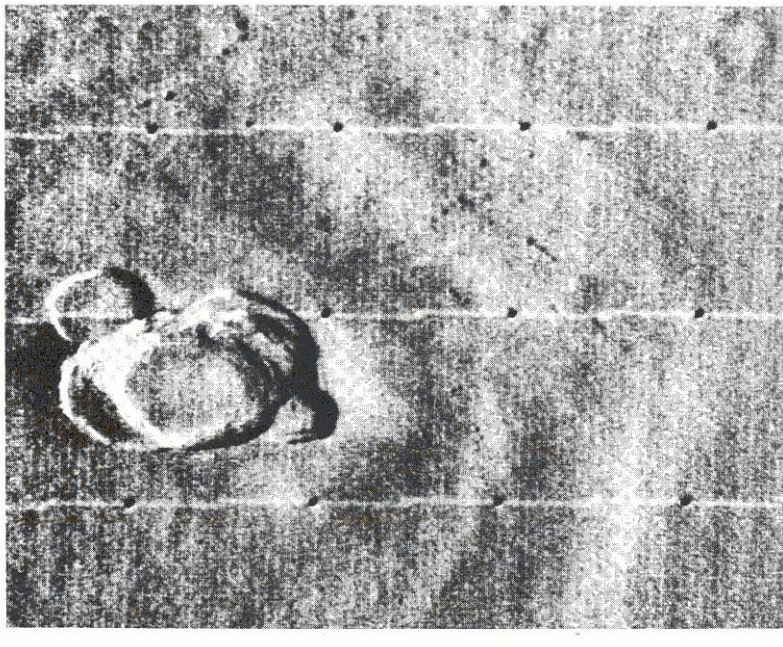
Mariner 9, launched at Cape Kennedy on May 30, 1971, went into orbit around Mars on November 13. It is the first spacecraft to orbit another planet.

For at least 90 days Mariner 9 will circle Mars about twice a day, swinging in as close as 862 miles and out almost 11,000 miles. The mission, which is being managed for National Aeronautics and Space Administration by Caltech's Jet Propulsion Laboratory, will map about 70 percent of the surface of Mars. The composition, density, pressure, and temperature of the atmosphere will be studied—as will the structure, temperature, and composition of the surface. And data will be obtained on the changes in the planet's surface markings.

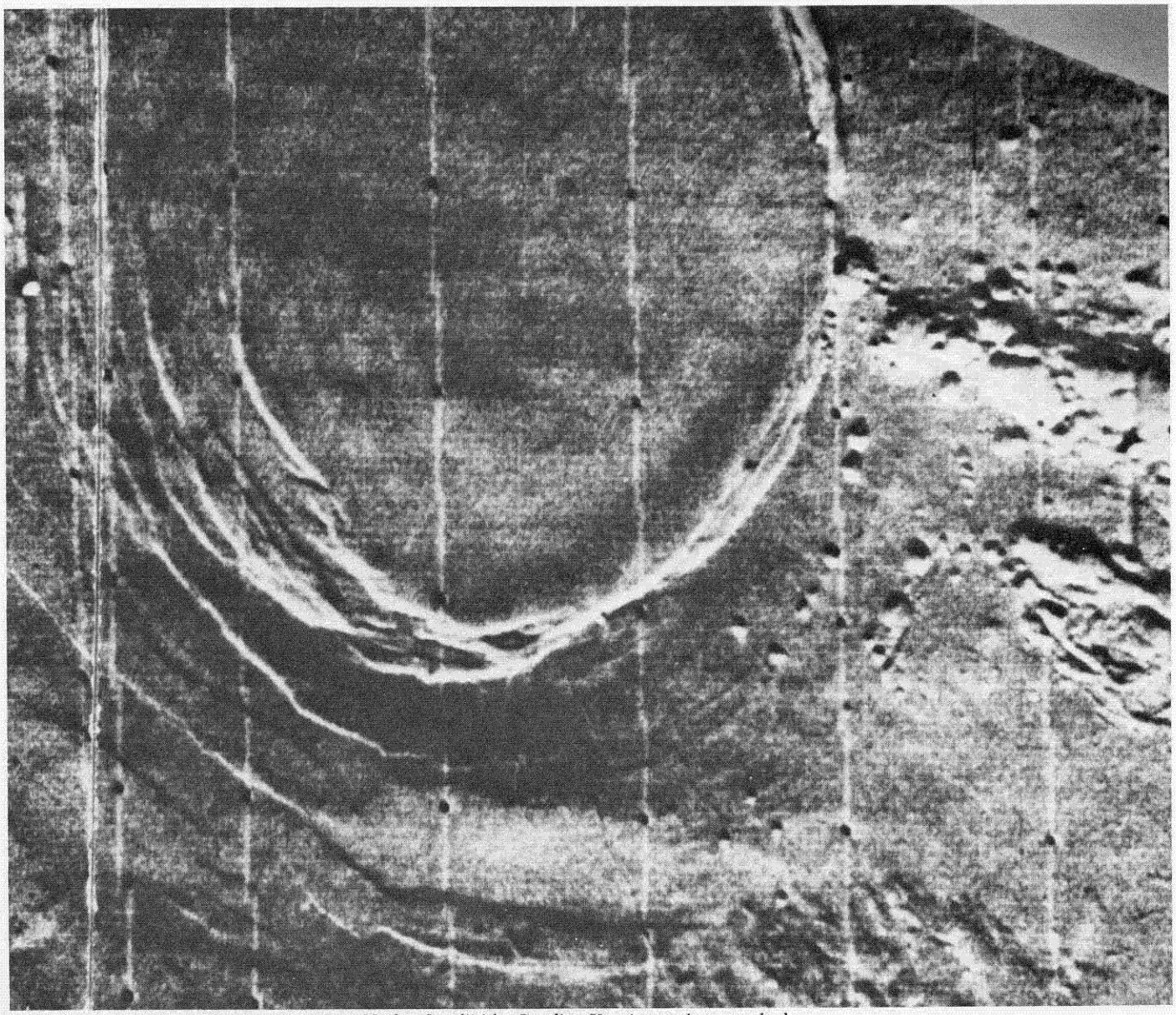
The Mariner 9 mission will provide much more data than all previous planetary missions combined. In 90 days the spacecraft cameras will take more than 5,000 photographs of the Martian surface. Though a violent dust storm was still obscuring much of the planet through the month of December, some of the early pictures received from Mariner 9 were surprisingly clear —and clearly historic.



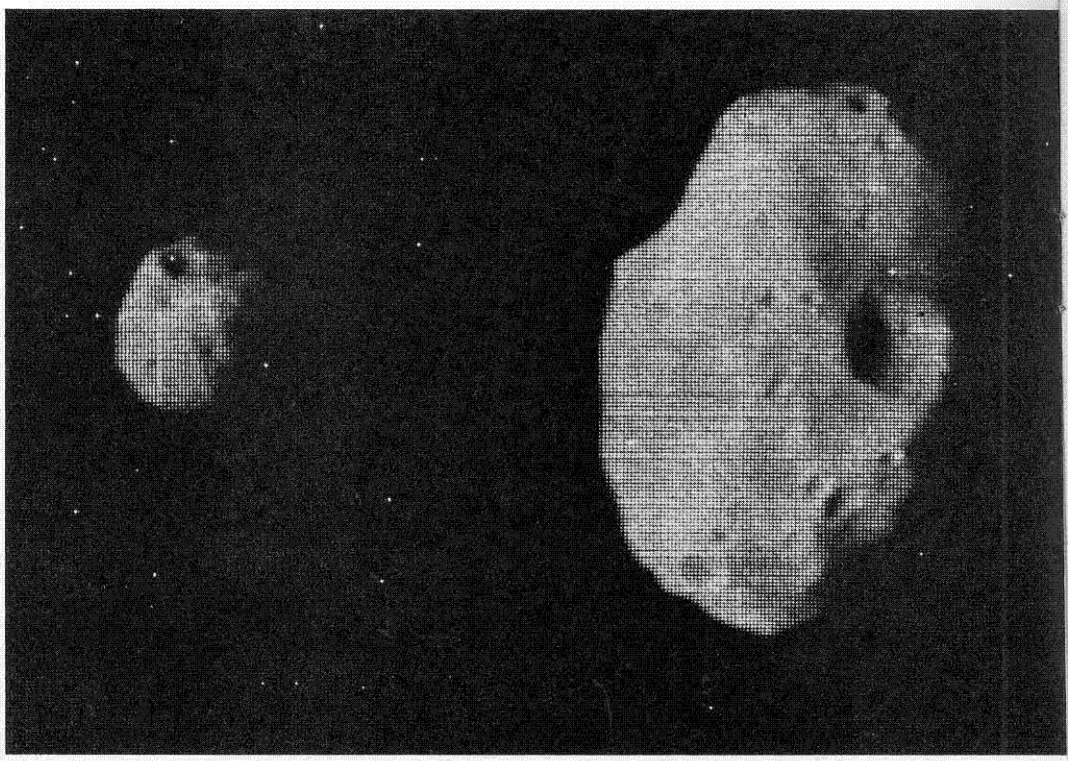
Nix Olympica (Snows of Olympus). In pictures taken early in the Mariner 9 mission, this region shows a dark mountain standing above the Martian dust storm. This higher-resolution photograph shows that the area contains a complex crater nearly 64 kilometers (40 miles) in diameter. The multiple crater form with scalloped margins is characteristic of calderas—volcanic collapse depressions on Earth. In the Mariner 6 and 7 flights in 1969, an outer ring, 1600 kilometers (1000 miles) in diameter, was seen. It is hidden by the dust in this oblique picture. Earth-based radar observations show that this is a high region on Mars and is usually covered by a white cloud when observed telescopically. The picture was taken on November 27.



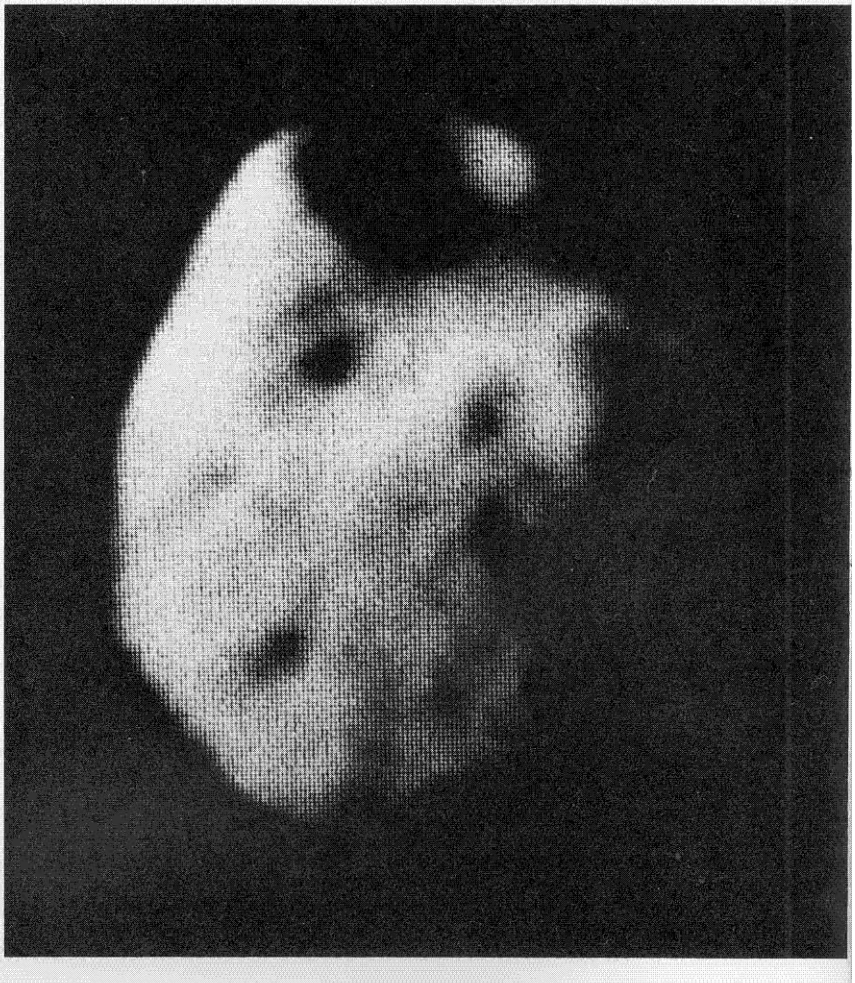
An oblique view of the crater complex near Ascraeus Lacus in the Tharsis region of Mars. This is the northernmost of the prominent dark spots observed by Mariner during its approach to the planet. The spot consists of several intersecting shallow crater-like depressions. The main crater is approximately 21 kilometers (13 miles) across, the whole complex about 40 kilometers (25 miles) across. The crater probably is in a relatively high area of the Martian surface, which accounts for its being visible above the dust storm. The faint circular features outside the crater are probably atmospheric.



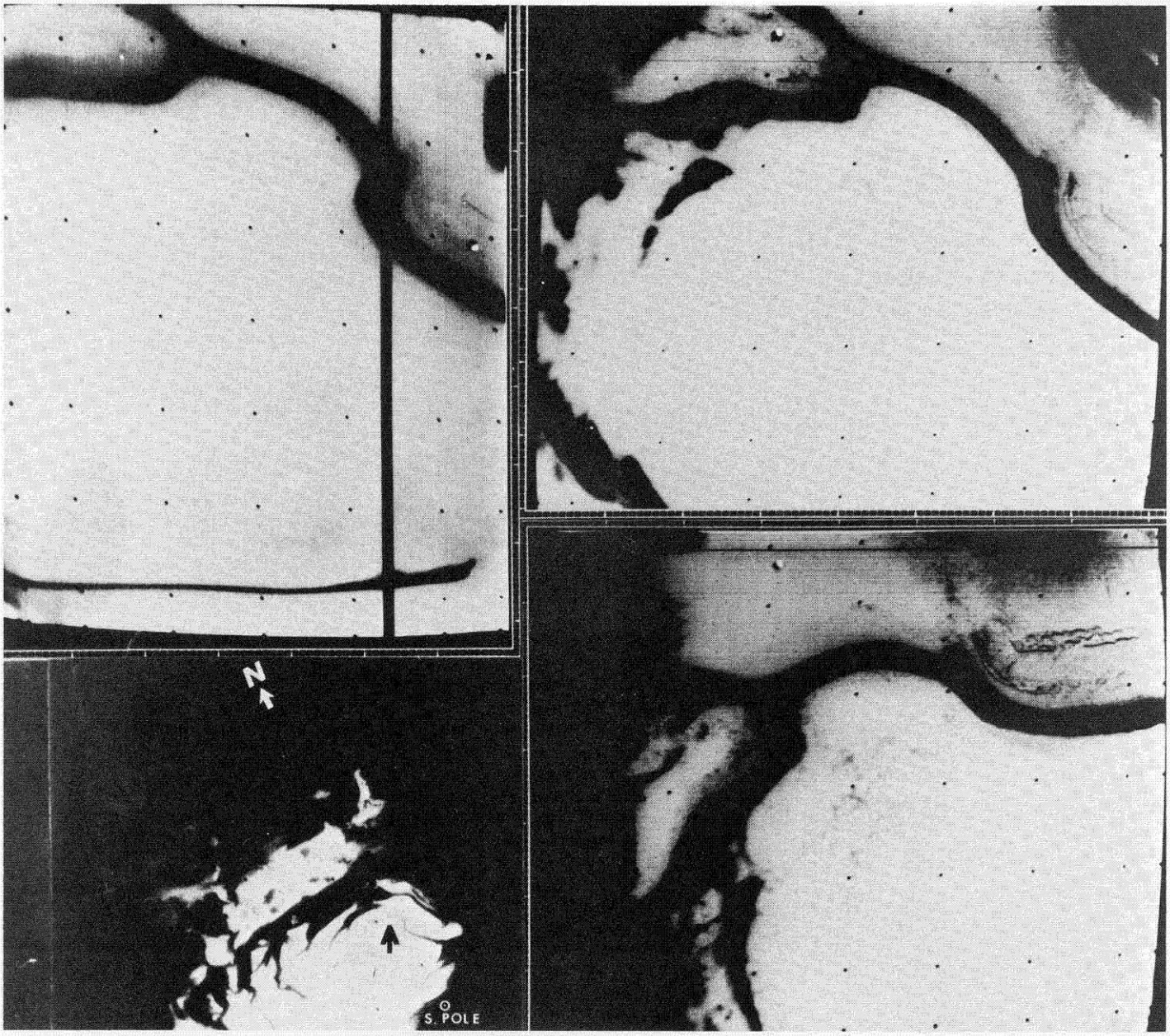
This 70-mile-diameter Martian crater near Nodus Gordii (the Gordian Knot) was photographed by Mariner 9 on November 28. The crater and its immediate surroundings are high ground, emerging island-like from a sea of wind-blown dust. In pictures taken 48 hours later, the edge of the dust cloud had shifted, obscuring the ridges and valleys on the outer northwest rim. Whether the pictures show a smooth crater floor or obscuring wind-blown dust remains to be learned. The multiple concentric fractures on the western rim and the abundant rimless craterlets suggest that this is a caldera, or volcanic collapse crater, equal in size to the largest on the Earth or on the Moon.



Man's first close-up views of Phobos were taken on November 29 (left) and November 30. The dark spot at the top of the left image and at the center on the right is a crater about 6.8 kilometers (4.2 miles) across. Phobos itself is about 21 ± 1 mile high and about 25 ± 5 kilometers (16 ± 3 miles) long. The uncertainty in length is due to the moon's irregular shape and large fraction in darkness in these views. The picture at the left was taken during Mariner 9's 31st orbit of Mars. Range to Phobos was 14,683 kilometers (9,123 miles). Phobos has a different tilt to the spacecraft's high resolution television camera in these two views.



A computer-processed version of Man's first detailed image of Phobos, the innermost moon of Mars. The most spectacular feature here is the large crater at the top, approximately 4 miles (6.8 kilometers) across. The dimensions of this crater are about one-third the height of Phobos in this picture. The small asteroid which produced this crater must have caused major damage on Phobos. The profusion of small craters suggests that Phobos is very old and possesses considerable structural strength. The terminator of Phobos, the region of shading toward the right separating the day and night sides, is irregular. Phobos appears to be rougher than its companion satellite, Deimos. The picture was taken by Mariner 9 during its 31st orbit of Mars on November 29.



The three high resolution frames at upper left, upper right, and lower right were acquired by Mariner 9 on November 19, November 28, and December 1, respectively. The same local area is viewed in each case, but from somewhat different directions, and is indicated with a dark arrow on the accompanying low resolution view. The location of the South Pole of Mars, and the direction of the prime meridian, are shown in white. In the high resolution frames, the maximum dimension corresponds to approximately 100 kilometers (62 miles) on the Martian surface. The low resolution view is printed at 10 times greater scale. At most, only an inch or so of the carbon dioxide frost composing the cap could be expected to have sublimated in such a brief time. Uniform disappearance of thin frost over such a large area indicates that this portion of Mars is exceedingly smooth. Underlying low relief of distinctive character appears to be emerging in the bend of the sinuous dark band.

The Biology of Cancer

Cancer is now the second leading cause of death in America; in 1972 about 345,000 Americans will die of it. Yet, it is surprising that cancer is not more widespread than it is.

Cancer is a group of complex, frequently occurring diseases that now touch every household in the nation. To bring the latest information about cancer to the various communities it serves, Caltech, in cooperation with Pasadena's Huntington Memorial Hospital, is devoting its 1971-1972 series of eight seminars in biology and medicine to the topic: The Biology of Cancer. The seminar series is sponsored by Eli Lilly and Company with assistance from the Damon Foundation.

At the first seminar held on December 7, 1971, Dr. Karl Erik Hellström, professor of pathology of the University of Washington School of Medicine in Seattle, discussed "Blocking Antibodies in Cancer."

Cancer is now the second leading cause of death in America; heart disease ranks first. In 1972, it is estimated that 345,000 Americans will die of cancer; about 32,000 of these deaths will be in California. One of every six American deaths now is due to cancer.

Yet, it is surprising that cancer is not more widespread than it is. Although cancer can occur in the most diverse types of tissue—lung, kidney, skin—all malignant growths share one characteristic: They represent tissues growing out of control. Since an adult human is made up of trillions of incredibly complex cells, and there are numerous things that could go wrong in the control of the growth of each individual cell, one would expect cancer to be even more prevalent than it is.

The prevalence of cancer is not higher, apparently, because the body has a specific anticancer surveillance and defense system—called the *immune system*—that recognizes cancer cells when they arise and destroys them. Much evidence indicates that cancers and the immune system are intimately related. Thus, when the immune systems of either experimental animals or of humans are destroyed or suppressed—by the administration of drugs or by radiation—these animals or humans then show a greater tendency to develop cancer than do animals or humans whose immune systems have not been suppressed. If the administration of immunosuppressive drugs or radiation is stopped, then the immune system recovers, returns to its normal activity, and the tendency to develop cancer decreases.

Similarly, those human patients who exhibit a strong immune response following surgical removal of a cancer show a much better survival rate than do those patients who exhibit a weak immune response following tumor removal.

So, regardless of its cause—exposure to radiation, to viruses, to cancer-producing chemicals—a cancer takes hold and spreads due to some malfunction of the body's immune system.

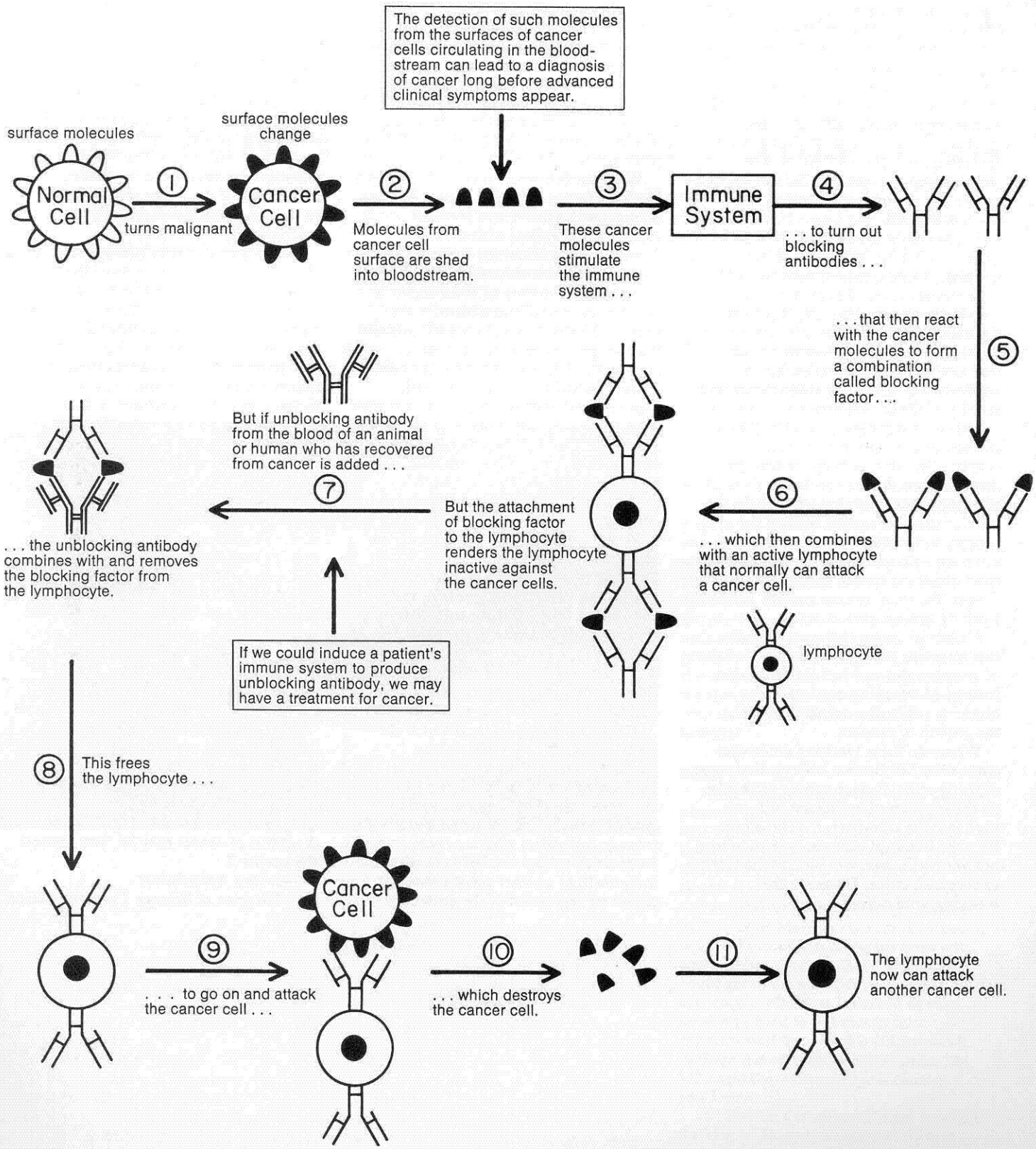
Actually, there are two immune systems. One system consists of *antibodies* that have their origin in the bone marrow or the spleen. They are produced in response to the introduction of a foreign material into the bloodstream. Antibodies are a special class of proteins that can recognize, bind to, and lead to the destruction of foreign invading materials such as bacteria, viruses, or venoms. Because these antibodies are freely circulating molecules dissolved in the fluid part of the bloodstream, this immune system is known as *humoral immunity* (*umor* meaning fluid in Latin).

The other immune system consists of antibodies attached to white blood cells called *lymphocytes*. These antibodies have their origin in the thymus, and they also can recognize foreign invading materials—particularly foreign cells—and can destroy them. Because this behavior involves attack by an antibody-lymphocyte cell combination, this immune system is called *cellular immunity*.

Cellular immunity is the body's anticancer surveillance and defense system. Lymphocytes continually patrol the body and attack and destroy cancer cells which the antibodies attached to the lymphocytes recognize as being foreign. So, even though many normal cells daily may turn into abnormal malignant cells, the lymphocytes eliminate them.

How do lymphocytes recognize the difference between the body's own normal cells—which they do not attack—and cancer cells? The surface of every cell is covered with specific molecules which serve as signals to indicate to the lymphocytes whether the cell is normal or

Cancer and the Immune System



malignant. Thus, the body's own normal cells have surface molecules that are recognized as "self" by the lymphocytes and the cells are left alone.

But, when a normal cell turns malignant, its surface becomes covered with foreign cancer molecules which serve as a specific signal to the lymphocytes that the cell is malignant. The lymphocytes, recognizing the surface of a cancer cell as "non-self," attack and destroy the cell.

Then how do cancers take hold and spread? What has happened to the lymphocytes of a patient with cancer?

In elegant research, carried out in collaboration with his wife, Ingegerd, Karl Hellström has found that the bloodstreams of experimental animals and humans bearing cancers contain an antibody that antagonizes the anticancer activity of the lymphocytes.

This is a surprising discovery. The antibodies of the humoral immune system, since they also attack foreign materials, would be expected to show an anticancer behavior that would help the cellular immune system combat the cancer. Yet, these antibodies actually interfere with and block the lymphocytes from attacking cancer cells. Thus, in cancer, the two immune systems are working against each other.

Hellström refers to these antibodies that interfere with the anticancer activity of lymphocytes as *blocking antibodies.* Instead of attacking cancers, these blocking antibodies actually *enhance* the growth of cancers.

Where do these blocking antibodies come from? Hellström believes that some of the specific, foreign cancer molecules on the surfaces of malignant cells are shed into the bloodstream. This stimulates the humoral immune system to turn out antibodies that will bind to the foreign cancer molecules. These are the blocking antibodies.

When the blocking antibodies combine with the cancer molecules, they form a union or complex that then attaches itself to the antibody attached to a lymphocyte. This prevents the lymphocyte from attacking and destroying cancer cells. The cancer-enhancing combination of blocking antibody and foreign cancer molecule is called a *blocking factor.*

When Hellström extracts and isolates a blocking factor from one cancer-bearing animal and injects it into another experimental animal with the same cancer, the growth of the cancer in the injected animal is enhanced. His laboratory at the University of Washington is now trying to purify and identify the nature of both the blocking antibody and the foreign cancer molecule that, in combination, make up a blocking factor.

But Hellström *also* finds, in both experimental animals and in humans who have recovered from cancers, that there is an antibody in their bloodstreams that opposes and reverses the action of blocking antibody. He refers to this anti-blocking antibody as *unblocking antibody.*

When injected into a cancer-bearing experimental animal or human, unblocking antibody causes the cancer to regress and often to disappear. Presumably, it acts by combining with and removing the complex of the blocking antibody and foreign cancer molecule that is attached to the lymphocyte. This liberates the lymphocyte to attack and destroy cancer cells once again.

The bloodstream of each human or animal that has recovered from a particular type of cancer contains an unblocking antibody that has a specific anticancer effect *only* against that same type of cancer. The unblocking antibody from an individual who has recovered from colon cancer can only antagonize the growth of another colon cancer; it causes no regression of the growth of lung cancer, kidney cancer, or breast cancer.

Obviously, if we knew how to stimulate the humoral immune system of a person bearing a cancer to produce cancer-destroying unblocking antibody—without at the same time producing cancer-enhancing blocking antibody—then we could have an immunotherapeutic technique to treat and cure cancer, particularly if the major mass of cancerous tissue is first removed mechanically by surgery.

But cancer immunotherapy—treatment of cancer by the stimulation of the immune system—is now a hazardous procedure. It could result in the enhancement of cancer growth rather than its regression. Obviously, we need a great deal more research in cancer immunotherapy in animals before we can use such techniques in the treatment of humans.

Although cancer immunotherapy is complex and subtle and seems to lie in the distant future, the use of the immune system to diagnose cancer is imminent.

With immunological techniques it should be relatively simple—using a blood sample taken from a patient—to detect the presence of the foreign surface molecules of cancer cells that are shed into the bloodstream. These molecules are specific for each kind of cancer. Thus, we may soon be able to diagnose whether that patient has a specific form of cancer —colon cancer, lung cancer, breast cancer—long before advanced clinical symptoms of the disease appear. Such an "early warning system" in cancer detection could markedly and favorably affect the survival rate of patients. So, although it may be many years before immune system techniques are used to treat cancer, techniques for the early diagnosis of cancer may be "just around the corner."

—*Irving Bengelsdorf*
Director of Science Communication

Mars and the Mind of Man

A free-wheeling discussion of what we do and don't know about Mars.

It was Bruce Murray's idea. On November 12, the day before the Mariner 9 spacecraft went into orbit around Mars, he rounded up a blue-ribbon panel of experts to join him in a symposium in Ramo Auditorium on "Mars and the Mind of Man." The panelists included two science fiction writers—Ray Bradbury (*The Martian Chronicles*) and Arthur Clarke (*2001*)—and two scientists—Carl Sagan, visiting associate in planetary science from Cornell University, and Murray himself, professor of planetary science at Caltech. (Sagan and Murray are also co-investigators on the television team for the Mariner 9 mission.) Walter Sullivan, science editor of *The New York Times,* served as moderator.

Some highlights from the free-wheeling discussion of what we do and don't know about Mars, and what we might now find out about it:

Five experts discuss their own ideas and some historic conceptions about Earth's neighboring planet Mars.

Sullivan:

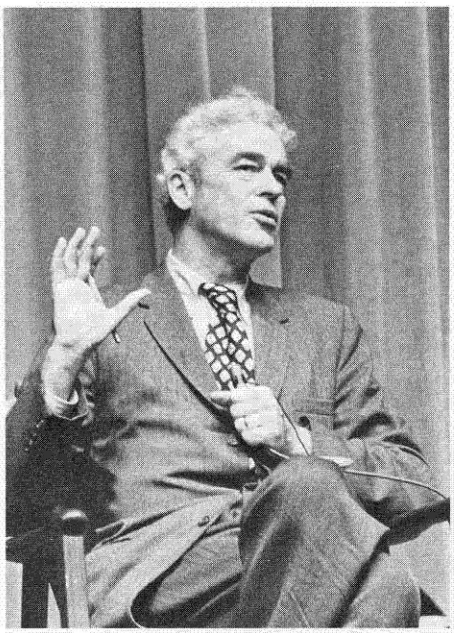
We are on the eve of turning another page in the history of man's understanding of the planetary system in which we reside. At least I hope we're going to turn another page late tomorrow afternoon. Some of our friends here on the platform have as strong and as authoritative views about what we're going to find on that page as anybody in the world. But it is very appropriate that we also have with us two fiction writers who are very scientific as well as fictional.

Sagan:

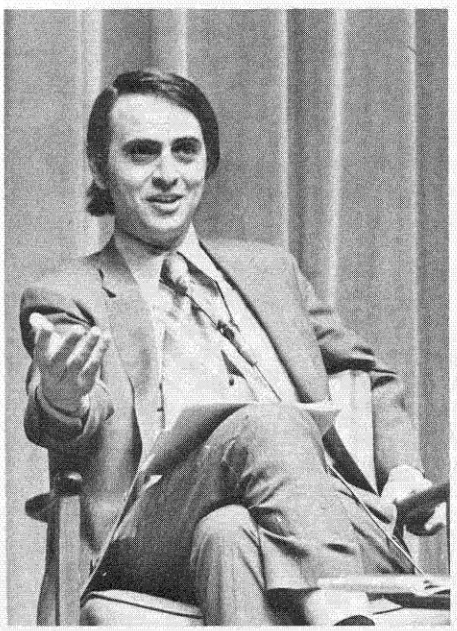
I first became aware that Mars was a place of some interest by reading stories by Edgar Rice Burroughs, who also is known for his Tarzan invention. Burroughs invented a gentleman adventurer from Virginia named John Carter who was able to transport himself to the planet Mars by standing in an open field and sort of spreading his arms out and wishing. At least that's as close as I could get to the method. And at an early age—whatever I was—8 or 9, I tried very hard to put that to the experimental test—and it did not work, perhaps not entirely to my surprise, but I thought there was always a chance, you know . . .

. . . The kind of observational basis for the idea of Mars as a dying world was provided first by an Italian astronomer named Schiaparelli, but it was publicized

"I was hoping we would see a lot of Martians with huge signs saying 'Bradbury was right.'"



Walter Sullivan



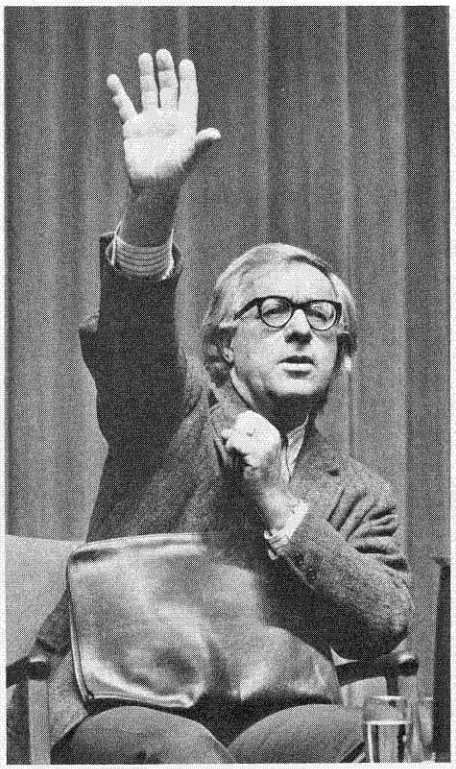
Carl Sagan

consummately by an American Brahmin from Boston, a diplomat to Korea turned astronomer, named Percival Lowell, who was the brother of the president of Harvard and of Amy Lowell, the poetess. And the kind of observations involved meant going to a place where the atmosphere was reasonably steady (where the "seeing" was good) and then, by eyeball astronomy, looking through the telescope and drawing pictures of what you saw.

Lowell was surely one of the worst cartographers who ever sat down at the telescope, and the kind of Mars that he drew was of little polygonal blocks connected by a multitude of straight lines. These straight lines had first been discovered in 1877 by Schiaparelli and he called them "canali," which in Italian means something like channels or grooves, but it got translated as canals and you can see the whole hypothesis right there in the translation. Somebody saw canals on Mars. Well, what does that mean? Well, canal—everybody knows what that is. How do you get a canal? Somebody builds it. Well, then—there are builders of canals on Mars.

Bradbury:

When I wrote *The Martian Chronicles,* I knew there were echoes of Burroughs all through the book—except when I was borrowing the influence of the moralist Jules Verne. I'm a bit of a moralist myself, though I hope not too pontifical, because I like to have a lot of fun with my writing. I like to get my ideas down at the top of my enthusiasm. But right now it looks like we are at a moment in history when, with the Greeks and the Romans, we science fiction authors must retire to the wings and become a part of mythology. I was, in fact, rather pleasantly surprised recently to discover that I was being taught as mythology at one school already, and I like that—because what I am doing is writing fairy stories. *The Martian Chronicles* is mythology and fairy stories



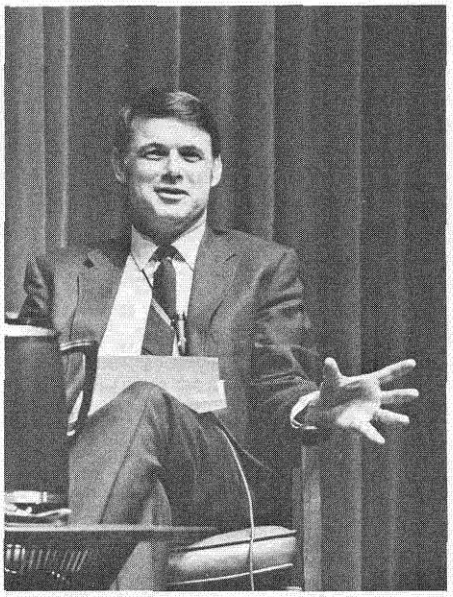
Ray Bradbury

"Whether there is life or not on Mars now, there will be by the end of this century."

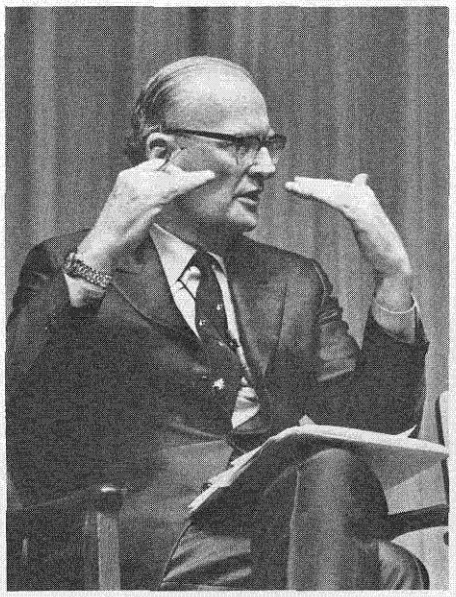
and very much akin to a Bible too. And I was hoping that during the last few days as we got closer to Mars and the dust cleared we could see a lot of Martians standing there with huge signs saying "Bradbury was right."

Murray:

Mars has so grabbed hold of man's emotions and thoughts that it has actually distorted scientific opinion about it. So it isn't just the popular mind that has been misled, but the scientific mind as well. And the reason this has happened is that man as a human species has been guilty of wishful thinking. We *want* it to be like the Earth. This is a very deep-seated desire, to find another place where we can make another start, that could be somehow habitable or maybe we could make it habitable. And it has been very hard to face up to the facts that have emerged and have been emerging for some time—that it really isn't that way; it's just wishful thinking. My point here is that it hasn't just been the popular science writers who have done it; the people who have really fallen on this have been the scientists themselves who misinterpret their observations. This has been going on for a long time. There has been a predilection, when a new observation came in, to try to interpret it in terms of plant life on the planet, rather than an unbiased view. And there are many examples of this—one as recent as 1969, in the Mariner flybys. There was a misinterpretation of one of the instruments on board initially because the person really wanted to believe that he found something that indicated that there was life on Mars. In fact, he had found something that was extremely important, that indicated that the Martian polar caps were not just CO_2 generally, but absolutely pure dry CO_2 with no moisture at all upon them. He had made a very important discovery, but he had initially misread it because he was so hopeful of seeing something else. So this is not just a popular thing. It affects



Bruce Murray



Arthur Clarke

science very deeply, I think, and I'm not sure we're out of it yet. My own personal view is that we are all such captives of Edgar Rice Burroughs and Percival Lowell that the observations are going to have to beat us over the head and tell us the answer in spite of ourselves. Mariner 9 is going to return 5,000 pictures and it will be a step forward in that regard. It will be a stick to beat us with and tell us the answer.

Clarke:

We are in a very interesting historic moment of time now in regard to Mars. I'm not going to make any definite predictions because it would be very foolish to go out on a limb at this moment in time, but whatever happens, whatever discoveries are made in the next few days or weeks or months, the frontier of our knowledge is moving outward inevitably. It has embraced the moon. We still have a great deal to learn about the moon and there will be many surprises, I'm sure. But the frontier is moving out and there is going to be a change of viewpoint. We're discovering, and this is a big surprise, that the moon, and I believe Mars, and I believe parts of Mercury and space itself is essentially a benign environment to our technology—not necessarily to organic life. Certainly it is benign as compared with the Antarctic or the oceanic abyss where we have already been. This is an idea which the public still hasn't got yet, but it is a fact. I think the biological frontier may very well move past Mars out to Jupiter, which *I* think is where the action is. Carl, you've gone on record as saying that Jupiter may be a more hospitable home for at least many forms of life than any other place, including Earth itself, and though this is an arguable point it would certainly be very exciting if it turns out to be true.

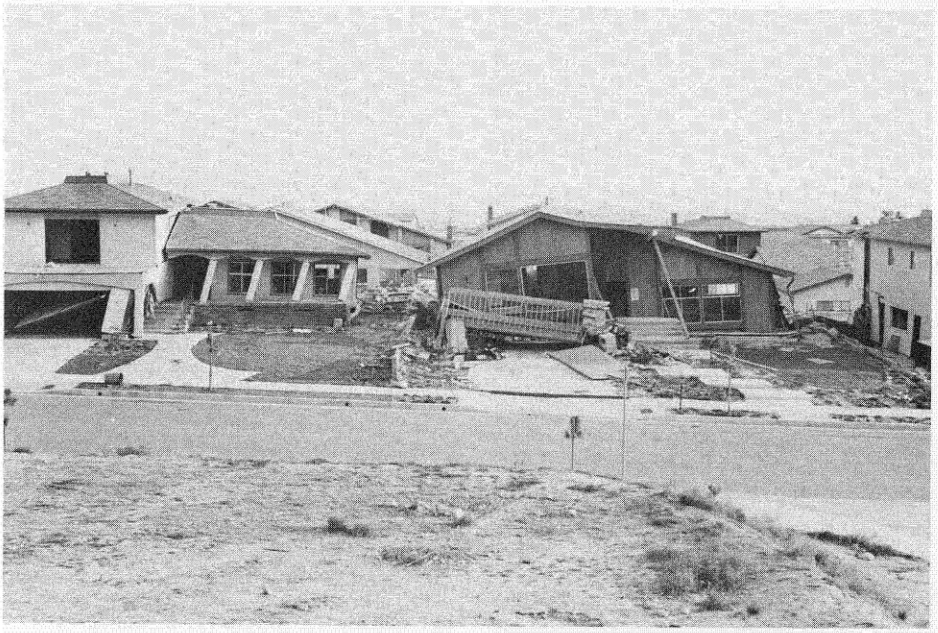
I will end by making one prediction. Whether there is life or not on Mars now, there will be by the end of this century.

An Official Report on the San Fernando Earthquake

Just two days after the February 9, 1971, San Fernando earthquake, the Los Angeles County Board of Supervisors appointed a commission—under the chairmanship of Harold Brown—"to examine what happened during the earthquake, to assemble facts, to draw conclusions and make recommendations as to what actions could and should be taken in advance of future earthquakes to minimize casualties, physical effects and the disruptions of the orderly functions of society." The findings of the Los Angeles County Earthquake Commission, now presented in a 45-page report, represent more than 20 meetings of the commissioners, many individual and group tours of the damaged areas, the reading and discussion of more than 50 reports, and testimony from 36 earthquake and engineering experts.

Without claiming to be the definitive scientific account of the February 9 quake, the report analyzes what took place, and makes urgent recommendations for actions to reduce the hazards to life, property, and essential services in future—and inevitable—earthquakes in southern California.

The most dramatic of the report's conclusions and recommendations is that 20,000 to 40,000 pre-1933 buildings in the greater Los Angeles area should be demolished or rehabilitated. The probability of thousands of these substandard buildings collapsing during a strong earthquake constitutes a serious threat to public safety, and the cost estimates for replacing them exceed a billion dollars. But the commission believes that a phased, well-organized program—encouraged by appropriate tax relief and other incentives—should be undertaken and that full compliance with its recommendations by 1980 is an achievable goal.



Modern residences of "non-typical" design and construction suffered heavy damage in the San Fernando earthquake. These split-level homes near Sylmar did not survive the strong ground shaking.

In addition to 15 specific recommendations and conclusions (page 21), the report includes sections that discuss earthquakes as a general southern California problem, emergency operations for earthquakes, their effects on the works of man, hazardous old buildings, land usage, earthquake insurance, and statistical summaries of casualties and damages in the February 9 earthquake.

Joining Brown on the seven-member citizen panel were Arthur E. Mann, senior vice president of Daniel, Mann, Johnson and Mendenhall; William A. Simpson Jr., chairman of the board of William Simpson Construction Company; John Grindle, president of American National Realty Company; George W. Housner, professor of civil engineering and applied mechanics at Caltech and president of the International Association of Earthquake Engineering; Clarkson W. Pinkham, president of the Structural Engineers Association of Southern California; and Charles F. Richter, professor of seismology, emeritus, at Caltech.

Clarence R. Allen, professor of geology and geophysics; Donald E. Hudson, professor of mechanical engineering and applied mechanics; and Hardy C. Martel, associate professor of electrical engineering and executive assistant to President Brown, served as alternate members from Caltech. Lee A. DuBridge, president emeritus, was a consultant to the commission.

The Los Angeles County Earthquake Commission: Conclusions and Recommendations

1. Hazardous Old Buildings. Thousands of pre-1933 buildings in Southern California constitute the most serious threat to public safety because of the probability of their collapse during strong earthquakes in the future. The San Fernando Veterans Administration Hospital buildings that collapsed are an example. Such buildings should be brought up to modern standards of seismic resistance, or they should be demolished. Because of the economic and human consequences of requiring repair or demolition, a phased program is recommended with those buildings that present the greatest hazard—relative to use, location and nature of construction—receiving the first and most urgent attention. This program also might include incentives to help ease the burden. The Commission believes that full compliance by 1980 is an achievable goal.

2. Unsafe Dams. The severe damage sustained by the old earthen dams, which retained the water of the lower and upper Van Norman Reservoirs, very nearly caused a catastrophe. All existing dams in California should be brought up to modern standards of safety or their use restricted.

3. Highway Structures. Present standards of earthquake design for highway bridges and other roadway structures should be revised and improved to conform with the current state of knowledge of earthquake engineering and should provide sufficient resistance to survive very strong shaking.

4. Code Revisions. Building-code provisions that require earthquake-resistant design have been in effect since the 1933 Long Beach earthquake. The greater survivability and increased protection of human life and limb provided in buildings constructed according to these newer code provisions are testimony to their efficacy. Nevertheless, the results of the February 9, 1971, earthquake indicate that further revision of building codes is needed to insure that the degree of damage will not be so great as to be hazardous to life and limb.

5. Facilities Vital in Emergencies. Certain types of structures and facilities, which are particularly important in post-disaster operations, such as hospitals, emergency power installations, emergency operating centers, public safety facilities and essential elements of key communications systems, should be designed and constructed to withstand strong earthquake shaking and yet be able to continue to function. Building codes should be amended to accomplish this.

6. Federal Construction. Federal action—which may include the enactment of legislation—must be taken to require that all construction by federal agencies, whether of new structures or the remodeling of older buildings, comply with local building-code provisions for earthquake resistance where the federal-agency building regulations are silent on the matter, or where such regulations establish a standard that is below the minimum standard of the applicable local code.

7. Schools. While most modern school buildings performed very well during the earthquake, some potentially hazardous damage was sustained by a few of them. Such damage should be studied and the code requirements for earthquake resistance should be revised to eliminate these hazards. The use of old school buildings, which were not designed to resist earthquakes, should be prohibited until such buildings are brought up to modern standards of safety. If they cannot be made safe, they should be vacated immediately, even if classes must be held in tents.

8. Houses. Most typical, modern, one-story, wood-frame houses performed well during the earthquake ground shaking in that no severe hazard was created nor were the major economic losses widespread. Some modern, non-typical houses were severely damaged by earth shaking. Studies should be made of the applicable building-code specifications to work out practical revisions so as to improve the earthquake resistance of such houses.

9. Earthquake Insurance. Earthquake insurance should be made readily available to the homeowner by its inclusion in extended-coverage riders on "standard homeowners insurance" and on "standard fire" policies. It is recommended that all insurance underwriters use this form and that some method for reinsurance against catastrophic loss be provided, perhaps through Federal reinsurance and/or through a change in allowed reserves. Similar earthquake insurance should be made available to owners of small commercial buildings as well. Lending institutions should establish the principle that earthquake insurance—in California—is as essential as fire insurance.

10. Non-Structural Damage. Damage to non-structural building elements, such as partitions, ceilings and windows, and to electrical and mechanical equipment, was sustained in buildings that had adequate strength to resist the earthquake forces. Much of this damage was costly and potentially hazardous. Earthquake-resistant design and construction of such items must be improved.

11. Utilities. The results of the February 9 earthquake indicate that standards for designing and constructing utility systems—electric, water, gas, telephone, waste and sewers—should be reviewed and revised so that future earthquake damage will be within acceptable limits.

12. Instrumentation of Major Structures. The recordings of the strong-motion accelerographs, located in the general Los Angeles area, provided valuable engineering data about the seismic motions of the ground and of structures. These data will lead to improved methods of designing earthquake-resistant structures.

Many of these accelerographs were installed in major structures in the City of Los Angeles as the result of legislation by the Los Angeles City Council. Jurisdictions, which do not require such instrumentation, should make it mandatory within their boundaries. Satisfactory maintenance and logical expansion of the strong-motion accelerograph network in Southern California must be encouraged.

13. Research. Research on earthquakes and their effects should be continued and encouraged, for only through such research can the understanding of earthquakes be increased and the ability to minimize their hazards be improved. All public authorities should cooperate with private and public agencies in collecting and publishing information concerning future earthquake probabilities. These authorities should support field work and studies in geology, geophysics, soil dynamics and physical response of structures to earthquakes.

14. Strong Ground Shaking and Faulting. Strong shaking during an earthquake typically extends over many square miles, while permanent fault dislocation is a very localized phenomenon. Therefore, a vastly greater number of structures will be affected by shaking than by quake damage, and the locations of faults are often unknown or poorly defined. Nevertheless, the building of structures directly across known active fault traces should be avoided whenever possible. Communications, transportation and utility lines should not be run along major active faults for long distances if feasible alternatives exist.

15. Emergency Operations for Earthquakes. Federal, State and local government agencies, the American Red Cross, and non-governmental groups and associations took effective measures to minimize the disastrous effects of the earthquake and recovery was rapid. However, weaknesses were noted in emergency operations that would have been magnified had this been a great earthquake. Governmental agencies performed independently at a time when coordination and team effort would have been mutually helpful. A need clearly was shown for local governments to provide emergency operating centers where information could be pooled and coordination achieved from a single, central location. Since such disasters usually affect many local governments, provision should be made within Los Angeles County for interjurisdictional coordination and exchange of information in the event of an emergency.

Radio communications systems must be constructed to survive strong ground shaking without loss of function.

On the basis of the February 9, 1971, experience, critical analyses and updating of plans, procedures and measures for coping with the effects of destructive earthquakes should be made. Responsible local officials should apply this experience to preparing for the possibility of an earthquake of very large magnitude.

Minimine Makes Miniflies

The normal fruit fly (Drosophila) is about an eighth of an inch long. Now, Herschel Mitchell, professor of biology, has discovered that injecting the larvae of the fruit fly with a substance found in bee venom, called "minimine," will keep the mature flies to one-quarter that size. The miniflies mature normally in every other way, live a normal lifespan of about 30 days, and produce regular-size offspring.

Minimine was discovered and isolated by Mitchell while studying the regulatory systems of biological processes. He is investigating the effects of various interesting substances, such as components of bee venom, on these systems. Analysis of these components is part of a new field of polypeptide study that is going on in laboratories throughout the world. This includes the analyses of various natural poisons from insects, toads, frogs, and fishes, and their effects on nervous systems and living tissues.

Mitchell and his colleague Peter Lowy, senior research fellow in biology, are attempting to learn how minimine induces miniaturization. Part of the answer is that after the injection of the substance the normally voracious fruit fly larva stops eating.

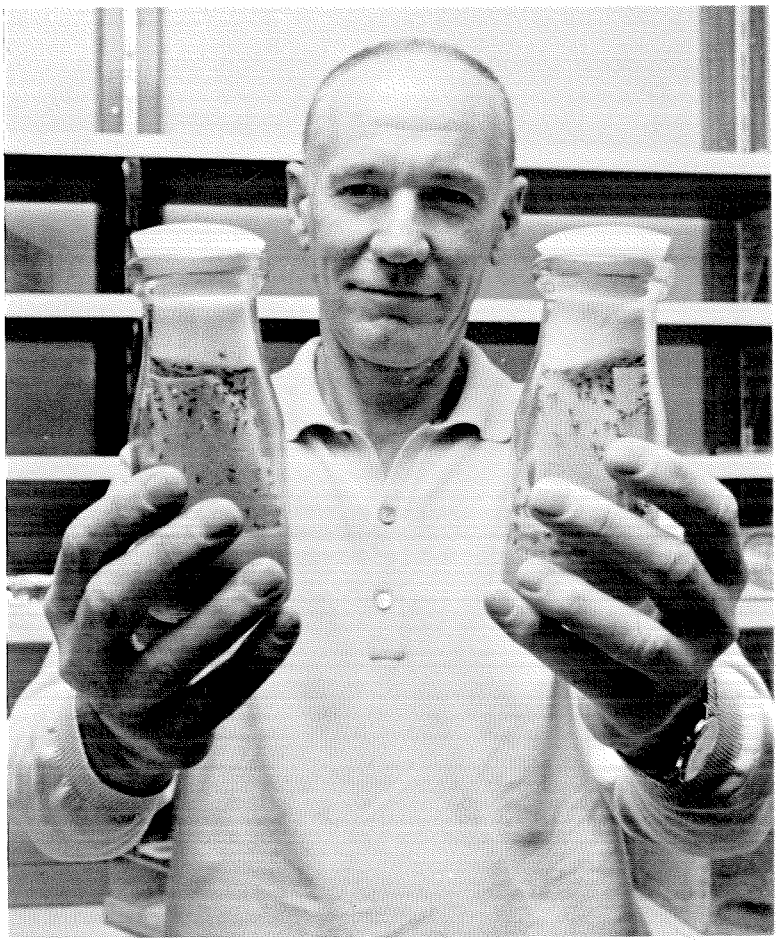
The critical point for the injection of minimine, which is a polypeptide (small protein), is a little more than two days after the larva has hatched from an egg. At this point the larva has everything it needs to become a fly. It will die if injected before this time or if given too large a dose of minimine at this point.

Not only does the larva stop eating after the injection, but it also becomes very lethargic. After nearly two days more, it evolves about on schedule into a pupa. It remains in that stage for four and a half days—a few hours longer than for a normal fly—and then emerges as a fertile minifly that eats and acts normally in every way. The same results can be achieved by simple starvation of the larva, but—in contrast to the "minimined" larva—the starved larva is very active and tries to find food.

About 3 to 5 percent of the venom consists of minimine, which is known to have a number of effects on living tissues; for example, it affects the permeability of the membranes and probably also affects muscular activity. It also inhibits the action of mitochondria, the energy-producers in cells.

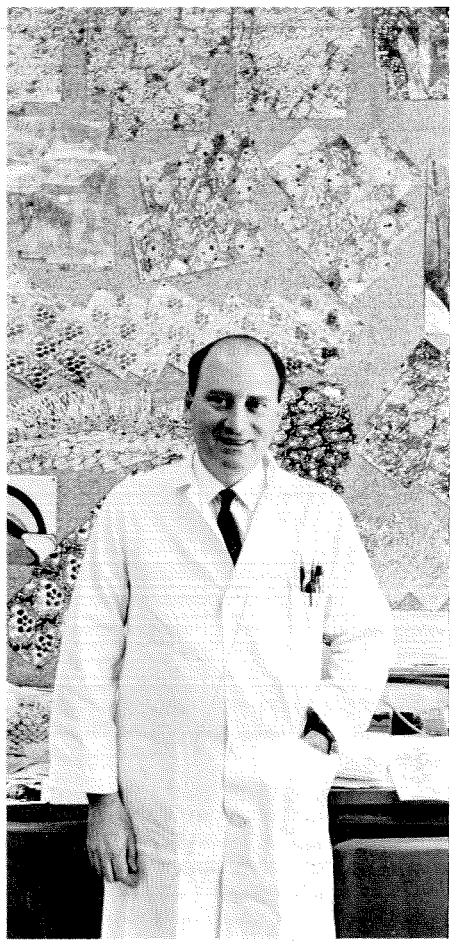
Mitchell and his colleagues undertook a systematic study of bee venom after observing that another of its peptides, melittin, also has interesting effects on fruit flies. The major component of bee venom, melittin, accounts for about 50 percent of its dry weight. It induces very strong muscular contractions on injection and is lethal in very small doses. It is a potent inhibitor of acetylcholine esterase, an essential enzyme in the nervous system, and also has disruptive effects on cell membranes in general.

There are about 15 different peptides in bee venom. Of the four that have been isolated, three—melittin, apamin, and MCD-peptide—have pharmacological effects on mammals, and two—melittin and minimine—affect the fruit fly. In his studies of biological control mechanisms, Mitchell is particularly interested in substances that may alter the genetic controls. His work is supported by the National Science Foundation and the Gordon Ross Medical Foundation of Pasadena.



Injecting the larvae of fruit flies with minimine is part of Herschel Mitchell's research into the effects of polypeptides on biological control mechanisms.

The Month at Caltech



Seymour Benzer

The Albert Lasker Award in Basic Medical Research

Seymour Benzer, professor of biology, is one of three distinguished biologists to share the 1971 Albert Lasker Award for Basic Medical Research. The other recipients are Sydney Brenner of the University of Cambridge in England, and Charles Yanofsky of Stanford University. The award, which includes an honorarium of $10,000, is for their individual studies on genes in viruses and bacteria—studies that are generally credited with establishing the foundations of the field of fine-structure genetics. These experiments demonstrated that a single functional gene was not the indivisible unit of classical theory, but was capable of being split into hundreds of recombining elements that arranged themselves in linear fashion as predicted in the Watson-Crick DNA model.

Splitting and mapping the gene has helped shed new light on the genetic process as a continuous, uninterrupted chain. This knowledge contributes substantially to our understanding of both normal and abnormal cellular events and provides insight into the molecular bases of many diseases. The findings are applicable in research into the causes of such genetic diseases as hemophilia and sickle cell anemia, and the work has led to improvement in the clinical basis for treating these and related diseases.

Benzer received his BA in 1942 from Brooklyn College, and his MS in 1943 and PhD in 1947 in physics from Purdue University. After a year as an assistant professor at Purdue, he went to the Oak Ridge National Laboratories as a biophysicist. In 1949 he came to Caltech and worked for two years as a research fellow in biophysics with Max Delbrück. Benzer then spent a year at the Pasteur Institute in Paris as a Fulbright scholar, and returned to Purdue in 1952. He was a member of the faculty there until he came to Caltech in 1965.

Since 1965 Benzer has shifted his scientific sights from fine-structure genetics to more integrative studies of development and behavior in the fruit fly Drosophila. In 1968 Purdue awarded him an honorary DSc degree. He is a member of the National Academy of Sciences and of the American Academy of Arts and Sciences.

The prestigious Lasker awards were established in 1946. In 1950 George Beadle, at that time chairman of the division of biology at Caltech, was the Institute's first faculty member to receive one of the awards. Other former faculty members who have received it are Renato Dulbecco and Harry Rubin. Twenty-two recipients of the Lasker award have later received Nobel Prizes in Medicine.

New Trustee

John G. McLean, president and chief executive officer of Continental Oil Company, has been elected to Caltech's board of trustees. McLean is a Caltech alumnus (BS '38), a recipient in 1970 of the highest honor the Institute bestows on an alumnus—the Distinguished Service Award—and a member of the Institute Associates.

McLean was on the faculty of the Harvard Business School for 14 years before he joined Continental in 1954, and he also served as a consultant to business organizations and government agencies. He is co-author of the book *Growth of Integrated Oil Companies*, is a contributing author to more than 15 other books, and has written numerous articles for business publications.

Minority Symposium

"Women and Minority Groups in American Science and Engineering" was the subject of a day-long symposium sponsored at Caltech last month by the Division of Humanities and Social Sciences. About 140 people attended the meeting, including representatives of the federal government, business, the academic world, and the Caltech and Los Angeles communities.

At the morning session Daniel J. Kevles, associate professor of history at Caltech, spoke on women, Jews, and Catholics in American science between the World Wars; Andrew Greeley, director of the Center of the Study of American Pluralism at the University of Chicago, discussed the contribution of religious and ethnic groups to science and engineering professions in recent years; and Harriet Zuckerman, a sociologist from Columbia University, described the contemporary situation of women and blacks in American science.

During the afternoon, C. J. Pings, vice provost of the Institute, moderated a panel discussion on the further social diversification of American science and engineering in the 1970's. In addition to the three morning speakers, the panel consisted of Lee F. Browne, director of secondary school relations at Caltech; Rose Brock, contract compliance officer in the Office of Civil Rights of the Department of Health, Education, and Welfare; and Alexis Balmy, manager of human resources development for the Xerox Corporation.

Though views varied on how to increase the participation of women and minority groups in the scientific professions, both the audience and the panelists generally agreed on two points: First, it is necessary—especially in the case of women—for the academic and industrial communities to equalize professional opportunities for the existing supply of PhD's in technical fields. Second, and perhaps more important, ways must be found to increase the supply of women and minority groups who aspire to careers in science and engineering in the first place.

Phi Beta Kappa Visiting Scholar

Frederick B. Thompson, professor of applied science and philosophy, has been appointed a Phi Beta Kappa Visiting Scholar for 1971-72—one of ten men and women who will travel to approximately 83 colleges and universities during this academic year at the invitation of local Phi Beta Kappa chapters. The program, established in 1956, enables undergraduates to meet and talk with distinguished scholars in different disciplines.

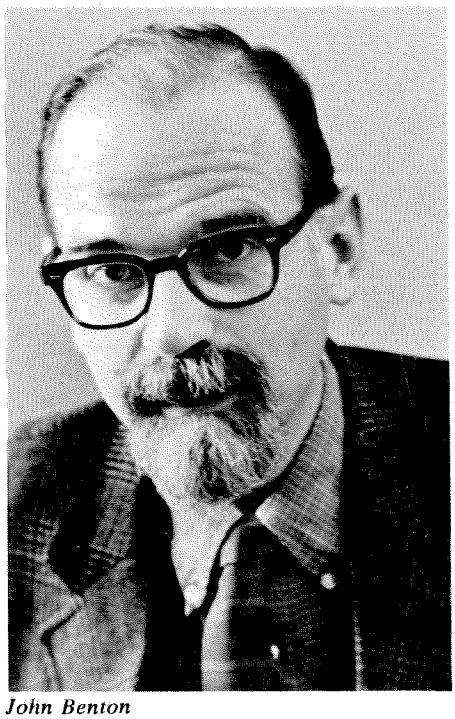
Thompson's AB in mathematics—with highest honors—was granted by UCLA in 1946, and his MA in 1947; he got his PhD from UC Berkeley in 1952. Before coming to Caltech in 1965 he held positions as senior mathematician at the Rand Corporation, manager of operations analysis of the computer department at General Electric, and member of the technical staff of TEMPO at General Electric.

The Rapidly Extensible Language (REL) system for talking to computers in ordinary English, which was originated by Thompson, is an example of his special interest in investigating and working out solutions for the problems brought about by the advances in the technologies of communications and information processing.

Thompson will visit eight schools in the course of the Visiting Scholar program: the University of Idaho, and Colby, Hobart, Whitman, Marietta, Albion, Wells, and Macalester Colleges. During each two- to three-day visit he will meet with students and faculty in classroom discussions, seminars, and public lectures. His talks will be on topics such as whether the human brain is a computer, a quantitative and humanistic foundation for the social sciences, and syntax and semantics from the point of view of a computations linguist.

Sir Fred

Fred Hoyle, visiting associate in physics at Caltech and Plumian Professor of Astronomy and Experimental Philosophy of the University of Cambridge, was knighted by Queen Elizabeth II in the annual New Year's honors.



John Benton

Social Studies

John Benton, professor of history, has received Fulbright and Continental Oil Company fellowships for a year at the University of Reims in France to study late medieval social conditions. Under sponsorship of the United States - United Kingdom Education Commission, he will also give lectures at three Scottish universities.

Division Chairman

Robert A. Huttenback, acting chairman of the division of humanities and social sciences for the past year, has been appointed chairman. Huttenback is professor of history and has also been serving as dean of students at Caltech since 1969. A member of the faculty since 1958, he was master of student houses from 1958 to 1969.

Number Please

A new color photograph of Beckman Auditorium may get the widest distribution of any Caltech picture ever taken. It's on the cover of Pacific Telephone's 1972 directory for L. A.'s Northeastern Area—and that adds up to about 310,000 volumes.

Dreyfus Foundation Teacher-Scholar Grant

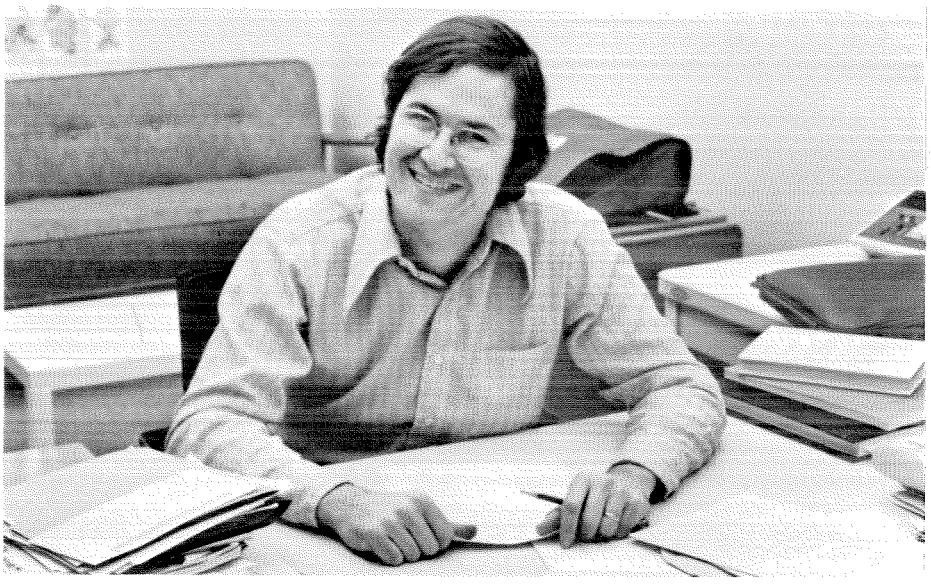
Jesse L. Beauchamp, associate professor of chemistry, is one of 16 young chemists in the United States to be awarded a Camille and Henry Dreyfus Teacher-Scholar Grant for 1971. The award of $25,000 is intended to give its recipients maximum opportunity to develop their potentials as teachers and scholars at an early period in their careers.

Beauchamp, who is now 29, fills the prerequisites for the award nicely. He got his BS in chemistry at Caltech in 1964, and his PhD from Harvard in 1967. Coming to the Institute as an instructor in the fall of that year was, in many ways, a homecoming. From personal experience Beauchamp is aware of the problems faced by Caltech undergraduates, and to a certain extent feels that he understands their mentality. As a teacher he adds energy and enthusiasm to his understanding. The result has been that the half-dozen courses he has taught in the last four years have proved to be useful and appealing to the students. Students even admit—though sometimes not until they are engaged in graduate research and looking back—that his physical chemistry laboratory course (Ch 26) is one of the most useful courses in the curriculum.

Being aware that Caltech students—along with a lot of other scientists—tend to get enthralled with complicated instrumentation and want to do work that is basically just exercise for the equipment, Beauchamp tries to help his students realize that it's not the instruments but what you do with them that really counts. Thus, Ch 26 is structured to provide research-oriented experiments, and the outcome is that students who take the course often become deeply involved in really significant problems. Several of the undergraduates who have worked with Beauchamp have turned out publishable results. And for each of the last three years Caltech's George Green Memorial Prize for creative scholarship by a graduating senior has been shared by one of his students.

Beauchamp manages to get to know his students and their problems, both scholastic and personal. Even in what are officially lecture courses, he often presents material in the form of problems for discussion so he can increase student participation.

Though a productive career in science requires concentrating on research, he enjoys teaching and would like to have more time for it. "It's a learning experience for me," he says, "and I find it most rewarding when I'm challenged to teach something I don't completely understand. I get excited about learning something new, and that excitement is the most important thing I can communicate to students."



Jesse Beauchamp

As a research scholar Beauchamp's main interest is in ion cyclotron resonance (ICR) spectroscopy, which is a tool for studying the chemistry of ions in the gas phase. From the results of these studies, which he began about five years ago, and with the aid of a number of what he calls "serendipitous" discoveries, Beauchamp and his research group are able to use ICR spectroscopy to examine many details of the interaction of ions with neutral molecules in the absence of any of the effects which complicate similar studies in solution. For example, says Beauchamp, cooking an egg is a complex process in which thousands of reactions occur. As is frequently the case in experimental chemical science, it is difficult to separate out and study a single reaction, but ICR spectroscopy offers a new approach that makes such studies feasible. By observing individual events in the interaction between an ion and a neutral, Beauchamp and his students are able to infer details of the chemical transformations that result from that interaction, including the motion of atoms and rearrangement of chemical bonds. The results of such studies, in conjunction with properties of neutrals and ions also measured with ICR methods, are of general use in that they allow chemists to predict and control chemical reactions.

Beauchamp is first and foremost a chemist, but he is also a talented designer and builder of instruments to further his research. He plans to use a substantial part of the Dreyfus grant for some badly needed equipment for several new areas in which he and his research group are interested: the chemistry of inorganic ions in the gas phase, the photochemistry of ions, and the chemical transformations that are associated with the formation of an ion when a molecule swallows an energetic photon. This last program has involved Beauchamp in a joint Caltech-JPL project that is beginning to produce results that will be of value in understanding chemical reactions in planetary atmospheres and interstellar space.

Though the Dreyfus awards were established only a year ago, Beauchamp is neither the first member of the Institute faculty nor the first Caltech alumnus to receive one. Last year Robert Bergman, associate professor of chemistry, was among the first 14 young chemists to be given one of the grants. And one of this year's 16 is Peter C. Ford (BS'62), who is assistant professor of chemistry at the University of California at Santa Barbara. Ford teaches and conducts research in the areas of ligand field theory, kinetics, and the mechanism of inorganic reactions.

Letters

Swiss on Wry

Gumligen bei Bern
Switzerland

FRIENDS:

All my friends here in Switzerland are howling with laughter at the superbly reproduced photographs of the gesturing professors in your October issue. As for myself I think that this issue will help sell my books and give me some retirement income in addition to that pitiful TIAA pension. But not only that, people will be tempted to invite me in person to see that body style. In fact the Scots want me up there next year for six months, not only to improve their English but also to limber up their bodies, both for lecturing and for skiing and mountain climbing.

Next week I am supposed to give a speech in Berlin, under the auspices of the Mayor of Berlin, and as a courtesy of the Los Angeles-West Berlin "Sister Cities." That might be lots of fun if I do not have to buy or rent a tuxedo for the occasion. Mine, which I bought for the 75th anniversary of Caltech and wore just once, is back in Pasadena.

Hoping that the minister of finances at CIT did not give you a talking to for spending so much money on my grimaces, and with best wishes.

FRITZ ZWICKY
Professor of Astronomy
Emeritus

Communication Gap

San Francisco

SIRS:

Many of us in the sheltered industrial world have difficulty keeping pace with academic terminology. This is especially the case with the language of the humanities.

I write to inquire if you could obtain a translation from Dean Huttenback of the profound expression at the top of the outside column, page 35, of the C. J. Pings account of "The Life in a Day with the Faculty Board" in the November *Engineering and Science.*

D. C. CAMPBELL
Bechtel Corporation

We refuse to believe that the sheltered industrial world is so far removed from the hurly-burly groves of academe that its inhabitants are unable to translate such an elementary expression as Dean Huttenback's "@#≃/%&!"

New Year's Resolutions—Memnon of Nineveh and His Effort to be

Pasadena

EDITOR:

Illness has confined me to my home in recent weeks and, during this time, I have been reading again some of the writings of Voltaire. (I have a complete set of his works, by the way, 45 volumes bound in the original calf and printed just 200 years ago. This was a prized possession of my maternal grandfather, William Joseph Kerr, a member of the same Scottish family as that of the physicist who discovered the Kerr effect.)

This story, in particular, so pleased me, and seemed so appropriate for this time of year, when we all make long lists of virtuous resolutions for the New Year, that I have translated it and hereby send it on to you in the hope that you can share it with all your readers, who have, of course, just finished making *their* long lists of virtuous resolutions.

JESSE W. M. DUMOND
Professor of Physics
Emeritus

•

Memnon conceived one day the well-nigh unattainable ideal of becoming perfectly wise and prudent. There are in fact very few men to whom this sort of foolishness has not occurred at one time or another. Memnon said to himself: To be very wise and prudent and consequently very happy is very simple! It is sufficient to be devoid of passions or desires; and nothing could be easier, as everyone knows. In the first place I will never become infatuated with women; for upon seeing a gorgeous beauty I will say to myself: Those rose-petal cheeks will some day be wrinkled, those magnificent eyes will be bordered with red, that appealing throat and bosom will become flat and pendant, that beautiful head will lose its glorious hair. So all I have to do is to look at her at present through the same eyes with which I must expect to see her later and without doubt her head could not conceivably succeed in turning mine.

In the next place I resolve always to be strictly sober. I shall never permit myself to be tempted by excesses of delicious food and excellent wine nor by the attractive seductions of elegant society. I will need only to bear in mind what results from such excesses—a heavy head, an embarrassed stomach, the loss of one's reason, his health and his precious time. I will eat therefore only just enough to meet my need; my health will consequently always be good and my ideas always pure and brilliant. All the foregoing seems to me so easy that, to tell the truth, there will be little merit in achieving it!

Next, said Memnon, I must think a little about my money. My desires are moderate, my portfolio is securely invested with the treasurer general of finances of Nineveh. I have enough income to live on independently; this is one of the greatest pieces of good fortune imaginable. I shall never be under the cruel necessity to ask favors of anyone; I shall envy no one and no one shall envy me. Here again is something exceedingly easy to attain.

I have friends, he continued; I shall keep them because they will have no cause for dispute with me. I will never be angry with them, nor will they be vexed with me. All that should present no difficulty whatsoever.

Having thus formulated his little plan of prudence and wisdom in his chambers, Memnon looked out the window. He saw two ladies sauntering under the plane trees near his house. One was quite young, very attractive, and seemed deeply upset about something. She was sighing and weeping and as a result looked only the more fetchingly adorable.

Our sage, Memnon, was naturally deeply touched, not by the beauty of the young lady (he would of course not have permitted himself to indulge in such a weakness) but solely by the afflictions from which she was obviously suffering. He came downstairs and accosted the young lady, with the intention of consoling her with wise advice. The beauty recounted to him in the most naive and touching manner all the wrong being done to her by an Uncle (who did not exist); with what dishonest artifices he had stolen from her certain property (which in fact she had never possessed), and all the fear she felt of violence which he might inflict upon her.

"You seem to me to be such a wise and trustworthy young man," she said to Memnon, "that if you would consent to come to my house and examine my affairs, I feel certain that you could help me escape from the embarrassing situation in which I find myself at present." Memnon showed no hesitation in following her to investigate the matter and give her his considered council.

The afflicted young lady escorted him to a perfumed chamber and had him sit down beside her politely on a large sofa. The young lady spoke with lowered eyelids, from beneath which occasionally tears touchingly escaped, and which, as she raised them, invariably encountered those of our wise and sympathetic friend, Memnon. Their discourse was full of such tenderness and sympathy that it redoubled every time their eyes met. Memnon took her affairs extremely to heart and felt, from one moment to the next, an increasing desire to oblige and assist so honest and so unhappy a young thing! Almost unconsciously they came

closer and closer to each other. Memnon in fact counseled her so intimately and gave her such tender advice that neither the one nor the other were able to talk or think about business, and indeed they lost complete track of where they were!

At this precise juncture, the Uncle arrived, just as one might well have expected. He was armed from head to foot. The first thing he said was that, for good and sufficient reason, he would kill both our sage Memnon and the beautiful Niece; but his last remark was that he could pardon them for consideration of a very large sum of money. Memnon was obliged to give him all the cash he had. In those days one was lucky to escape from such a scrape so cheaply! America had not as yet been discovered and afflicted ladies were far from being as dangerous as they are today.

Memnon in shame and desperation returned to his home. There he found a note inviting him to have dinner with some of his intimate friends. If I stay alone at home, he said to himself, I will be depressed thinking of this unfortunate adventure of mine; I won't eat and will fall sick thinking about it. It will be wiser to go and dine frugally with my intimate friends. Thus I may be able to forget, in the sweetness of my society with them, the foolishness I have gotten myself into this morning.

Thus Memnon went to the rendezvous, where his friends found him distinctly depressed. They offered him some of their best wine to cheer him up. A little wine in moderation is a remedy for both soul and body, thought Memnon, and as a result he became inebriated. His hosts proposed a game of cards after the meal. "A well-regulated game with one's good friends is an honest pastime." So they played and won from him everything in his purse and four times as much again against his word. A dispute arose about the game and they became angry; one of his intimate friends threw a dice box at his head and put out one of his eyes. They carried the wise Memnon home, drunk, penniless, and minus one of his eyes!

After recovering somewhat from his wine, he sent his valet to get some more money from the treasurer general of the bank of Nineveh, to pay off the debt to his intimate friends; he learned that his debtor, with whom his capital was invested, had that morning gone into a fraudulent bankruptcy, putting a hundred families who had invested in his business into grave alarm. Memnon, in outrage, went to the Court with a plaster on his eye and a plea in his hand to demand justice from the King against the fraudulent bankrupt. . . .

Memnon hid himself in a corner waiting for the moment when he could throw himself at the feet of the monarch. The moment arrived, he bowed thrice to the ground, and presented his plea. His gracious majesty received him favorably and turned the memoir over to one of his Satraps to investigate it. The Satrap drew Memnon aside and said with insolent official sarcasm: "You are an amusing one-eyed guy! To dare to address your complaint to the King instead of to me—and, even funnier yet, to demand justice against an honest bankrupt whom I honor with my protection, and who is the nephew of one of my mistresses' chambermaids. I advise you to drop this affair, my friend, if you wish to preserve the one eye you have remaining."

Memnon, having thus that morning renounced women, all excesses of the table, gambling, quarreling, and especially pleading in court, had, before nightfall, been deceived and robbed by a beautiful woman, become stone drunk, gambled away his funds, had a quarrel, got one of his eyes blinded forever, and been to court where he had been mocked at as a laughing stock.

Petrified with astonishment, suffering from physical and moral pain, he went back home with suicide in his heart. He tried to enter his home and found the sheriff, sent there by his creditors and removing his furniture on their orders. He remained well-nigh unconscious, fainting under one of the plane trees . . . Night fell with Memnon sleeping on a bed of straw beside the wall of his house.

He was seized by a fever, and at its height he fell asleep and a celestial spirit appeared to him in a dream.

The spirit was resplendent with light. It had six beautiful wings but no feet, head, or tail and resembled nothing that we mortals are familiar with. "Who or what art thou?" said Memnon to this vision. "Thy good Genie," replied the other. "Give me back my eye, my health, my wordly possessions, my wisdom, and my prudence," said Memnon as he recounted how he had lost all these things in a single day. "Well those, you see, are adventures that never happen to us in the world we live in," said the spirit. "And what world *do* you inhabit?" said the poor afflicted human. "My country," the spirit replied, "is at five hundred million leagues from the sun in a tiny star in the neighborhood of Sirius, which you can see from here." "What a beautiful country that must be!" said Memnon. "Do you truly mean to say that where you live there are no gold diggers who are out to do a poor fellow out of his wealth, no intimate friends who cheat him at poker and make him blind in one eye, no fraudulent bankrupts, and no Satraps who make fun of you and refuse you justice?" "No," said the inhabitant of the star, "nothing like that. We are never deceived by women because we don't have any; we never indulge in excessive culinary delights because we never eat; we don't have bankruptcies because where we live there is neither gold nor silver; no one can put out our eyes because we do not have bodies fashioned as yours are; and the Satraps never do us injustices because in our little star everyone is equal."

Then said Memnon: "My good Lord, without women or banquets, how do you good souls pass your time?" "Taking care, to the best of our ability, of the other worlds which are confided to us," replied the Genie. "Thou findest me here to console thee now." "Alas," replied Memnon, "if you could only have arrived last night, to have prevented me from making so many mistakes!" "I was with Hassan, your elder brother," said the celestial spirit. "He is worse off than you. His Gracious Majesty the Sultan of India, at whose court he had the honor to be serving, has had *both his* eyes blinded on account of a minor indiscretion, and at the present moment he is in prison with his feet and hands bound in chains." "Huh," said Memnon, "what's the use of having a good Genie in the family if, among two brothers, one has lost an eye and the other is totally blind, one sleeping outdoors on a bed of straw, the other in prison?" "Your luck will change," replied the creature from the star. "It is true that you will always be missing one eye, but except for that you'll be happy enough, provided in the future you never again try to attain the crazy ideal of being perfectly wise and prudent." "Is this therefore something beyond man's capacity to achieve?" "As impossible," replied the other, "as to be perfectly skillful, perfectly strong, perfectly powerful, or perfectly happy. Even we are very far from this. There is indeed a globe where all this perfection is to be found, but in the hundreds of millions of worlds that are dispersed through the depths of infinite space everything is ordered by degrees. There is less wisdom and pleasure in the second than in the first, less in the third than in the second, and so on down to the last, where everyone is completely demented." "I am sorely afraid," said Memnon, "that our terrestrial globe may be precisely one of those little mansions of this universe to which you refer!" "Not exactly," said the spirit, "but it is not far from it; everything has to be where it belongs." "Oh, but," said Memnon, "certain poets and philosophers make a terrible mistake when they say that 'everything is for the best.' " "No, they are entirely correct," said the philosopher from above, "if we consider the total arrangement of the entire Universe." "Ah, I shall believe in that," replied poor Memnon, "only when I shall have regained my lost eye!"

An Interview with Harold Brown

continued from page 9

PURCELL: Do you still feel the same enthusiasm about the opportunities Caltech offers you now that you did when you came?

BROWN: Yes, somewhat to my surprise. I find—you know, I *expected* to like it, but what I didn't expect was to like it more and more as time went on. Now, such a curve always turns over, but it certainly hasn't done so yet and I don't see any signs of it. One of the things that surprised me about my own reaction to Caltech was how quickly I became extremely proud of the place. It's a very infectious spirit, and as you get to see what's going on, you see the quality of the research in science and technology, its variety, and the really outstanding nature of the people. You inevitably become very proud of the place, very protective of it, very loyal to it.

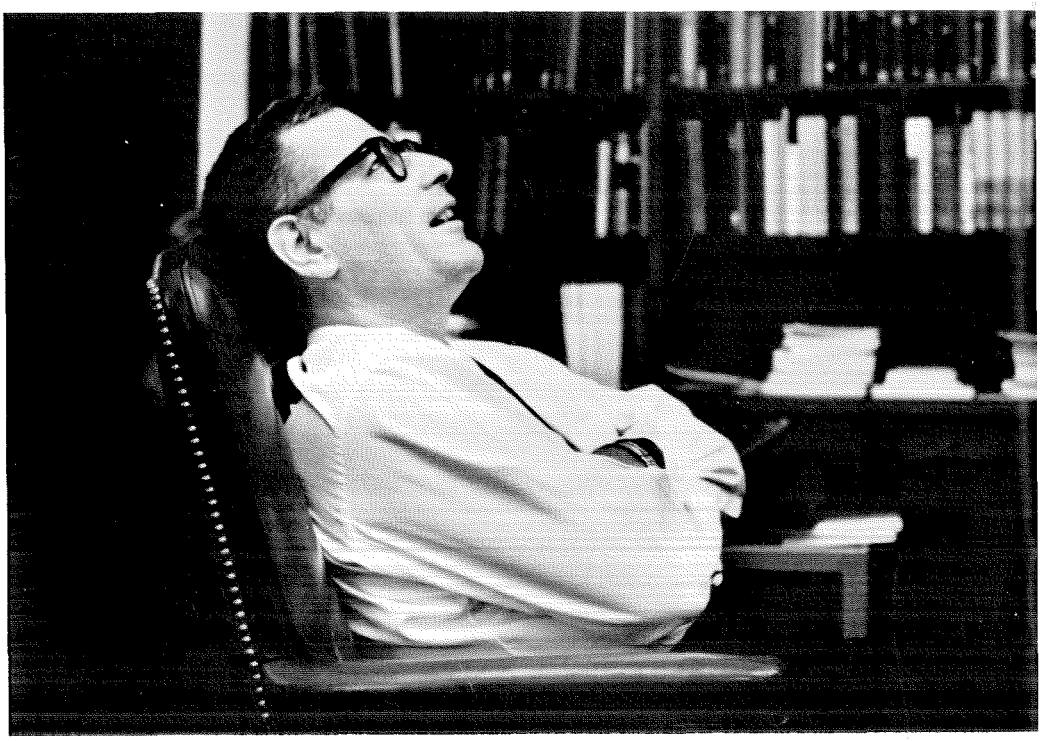
WATKINS: Caltech, as you say, seems to be innovative, but even though this independent study program does exist, still they've only let a few people into it. Maybe it's just a kind of a figurehead program.

BROWN: Well, one of the reasons they let only a few people into it is that of the 40 who applied, something like 20 turned out to have presented programs that were identical with programs that you could follow outside of the independent study program except that they didn't include Physics II. That was, I think, a little bit too much for the independent study committee to swallow. Nevertheless, I think that you raise a sensible point, because it's not enough for something to be available. You do have to have a certain number of people who are able to take advantage of it. So far I think there are only three people in the independent study program. My own guess is that it's never going to be more than ten a year because in order for the program to be useful, it has to be extremely challenging. If it's simply an easy way out, then it's a fake. I guess what I'm really saying is that it's not enough to say that the Institute or the curriculum has to be innovative; the student has to be willing to do some of the work to *make* the innovation. To me that means that there are unlikely to be more than, say, ten or so in such a program.

WATKINS: What about something that seems to be more innovative—along the lines of Antioch's work/study program where you go somewhere else and work for six months or so and get credit?

BROWN: You know, that last phrase of yours—get credit—is something that would be a great innovation, but I'm not sure I'd like it. There are a lot of things that students want to do—and many that they do—about which they would be much happier if they got credit for doing them. In some sense giving credit for that kind of activity puts a seal of approval on it. It's a way of saying it's really all right. But you shouldn't *ask* us whether it's all right; if you want to do it, *do* it.

But let me go back to the work/study question. That would be a big innovation here, and I'm not sure about it. It presents real problems because I think it is in a way antithetical to what Caltech stands for—giving students a broad enough base that they can go out and do various things. If you are really narrowly directed toward a work/study program, it's pretty well determined what the rest of your career is going to be before you ever



leave school. I don't think that ought to be the case with Caltech students.

PURCELL: You said before that you liked it here more and more as time goes on. Let me ask you—how does a university president know when to quit? What's a reasonable tenure?

BROWN: Those are two different questions, but I think many presidents know when to quit because the events make it clear to them that they should. In quieter times there was nothing to give that signal, and as a consequence many of them didn't know when to quit—to the detriment of their institutions. I don't think those days will come back, at least not for quite a long time. I can give you an example of how things have changed as follows: I am a member—Caltech's a member—of the Association of American Universities. There are 48 universities in this group, and by and large they are the universities with the outstanding graduate programs. I have been a member for two years and nine months, and I am now either 17th or 18th in seniority of these 48. So there really has been a very substantial change. I think length of presidential tenure is going to swing back, but I think it fairly important that we not let it swing all the way back. Therefore, I think that it is probably a good idea, in some modified form, to do what Kingman Brewster suggested at Yale—that at the end of five or seven years there be a formal reexamination on the part of both the president and the institution as to how he has done and whether it makes sense for him to continue. It's not as easy to do as to say, but some method ought to exist that forces both the individual and the institution to take a fresh look at their relationship before retirement age.

I think it is probably a good idea that at the end of five or seven years there be a formal reexamination on the part of both the president and the institution as to how he has done and whether it makes sense for him to continue.

ROBERTS: How do you feel about this problem—which must be your worst one—of raising funds for the Institute?

BROWN: I dislike it less than I expected to. There are some related things I don't like. I hate making speeches.

HOUSNER: Kissing donors?

BROWN: That's not so bad, in some cases. I don't like formal speeches, and yet I know I must make some. Very few people have more than three or four good speeches in them over a period of five years, and the consequence is that they make each one about 50 times. Even when the audience can stand it, I don't know how the speechmaker can, and it makes plain why so many university presidents become stuffed shirts. They just anesthetize themselves to say the same things over and over again.

That part I find a little bit trying, but dealing with outside people, explaining Caltech to them—and that's what fund raising really has to flow from—has its attractive as well as its difficult side.

ALLEN: A great many educators these days are very pessimistic about the long-term outlook for private higher education in this country. Do you share that pessimism in general and with regard to Caltech in particular?

BROWN: I think that private education is in a very difficult time, and I don't see it getting better very soon. I don't think that the private schools have successfully made their case as to why they should be supported along with public schools. They haven't adequately shown what I believe to be the case, that the diversity they have produced has really set a standard that has raised the level of U. S. education enormously in the past 20 years. The good state universities are as good as they are only because they have had the competition of the private schools, but whether we can make that case adequately, I don't know. I have just issued a president's report that says something about how I see the financial future as well as the financial past. It's not a rosy picture, but it's not a hopeless picture, and I guess that is as far as I feel I can predict it.

ROBERTS: When you were in the Defense Department you were strongly identified with working out the cost effectiveness of programs. I see some traces of this now being brought into the Institute; and if we are going to be concerned about cost effectiveness of academic programs, while we can measure the cost, how are we going to measure the *effectiveness* of academic programs?

BROWN: I believe in cost effectiveness as *a* way of partially describing alternatives. It is not necessarily a way of deciding what to do. The answer you get usually depends on what you take as your measure of effectiveness. But not knowing how to measure academic effectiveness certainly limits the utility of this method when you apply it to purely academic questions. Now, I think we have been careful around here to start by applying it not to academic questions but to matters of support, where you can at least measure output. I don't think we have applied cost effectiveness to purely academic functions, and I don't know how you make those judgments. I have made the judgment, and I think that the Institute Administrative Council as a whole has made the judgment, that there are some programs (behavioral biology is one) that offer the highest chance of being the thing that 20 years from now we will look back on—unhappily or happily—and say that's the one we should have done, or, that's one we did. The coherence of a division's program and the relative strength of backing by all the people in it influence me and other people in deciding what makes sense. If everybody in the division thinks a program is good, the rest of us will be more likely to agree.

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How to call a stereo buff's bluff.

A buff will probably tell you you've got to drop a bundle to get a really great stereo system.

Nonsense.

Stereo is all in the ear. It's how it sounds, not how it costs, that makes a stereo system great.

So next time some buff hands you that old line call his bluff. See if he can figure out how much you paid for your Sylvania matched component stereo system. Just by listening.

Pick your favorite record. Put it on the BSR micro-mini turntable. (If tape's your thing, slip one into the 8-track cartridge playback.)

Then balance the bass and treble on the FM stereo FM/AM tuner and amplifier. And let him have it.

Make sure he digs those round low notes from the two six-inch woofers. And those high sweet ones from the two three-inch tweeters. They're all air-suspension speakers, so they sound as good as standard speakers two sizes larger.

Your buff won't have a chance. He'll stand there, surrounded by sound, completely bluffed. Trying like crazy to figure out how much you laid out for a stereo that sounds that great.

But don't tell him.

After all, you just want to call his bluff. Not destroy his ego.

GTE SYLVANIA

An Interview with Harold Brown

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PURCELL: Let me ask another personal question. How has your family responded to being in Pasadena and a part of the Caltech community?

BROWN: I think my daughters have flourished. They are tennis players, bicycle riders, skiers. As soon as they found you could swim all year round, they stopped swimming, so that didn't work. But I think they have been academic successes and athletic successes and even social successes. My younger daughter has been giving an annual party for her class now for three years. Sixty kids come over to our house every year, and so far we have survived. Our 16-year-old attends lots of Caltech events, and my wife, of course, has plunged deeply into Caltech matters, as many of you or your wives know. She has found Caltech to be just about the right size. The Air Force was such an enormous institution that it was hard to interact on an individual basis. She interacts very well on an individual or small-group basis. She had been able in some of those other jobs to go around and meet the wives of my immediate staff or give a series of teas and so on, but that doesn't really plug you into an organization. Here she has gotten into lots of substantive things. She charges right in although occasionally something blows up in her face, but that's all right. She just moves on to the next project when that happens. But she and Caltech, I think, have been an ideal match, and I think we had almost forgotten how pleasant it is to live in California. We lived in northern California before, and it was very pleasant indeed. Southern California is even better.

Now I'm sure some of the students have some nasty questions about why are we mistreating graduate students or why do we have a quota (which is nonexistent, in fact) for women

PURCELL: Yes, I do. It's my observation as a graduate student that in generalized studies of the condition or the development of the university the special problems of the graduate students are often passed over with hardly more than an apologetic shrug, and I wonder what you think are the particular problems of Caltech's graduate school at the present

time and what visible change there is going to be in the next ten years or so.

BROWN: I think external circumstances are going to force us into a very careful consideration of this, because graduate student support has been subjected—from the outside—to a more precipitous drop than any other funding category during the past few years. The federal government has reduced its traineeships and fellowships by more than a factor of two in the past three years, and intends, apparently, to phase them out, except for the National Institutes of Health ones, almost entirely. So we are going to have to look at graduate education more carefully. In the past it has been, I think, largely an apprenticeship, and an adjunct to faculty research. That may be an unfair characterization, but to the graduate student it must have looked like that. And maybe that is the way it ought to be, but if it has been that way just kind of by accident, we are going to have to reevaluate it in view of the change in support levels. Have I incorrectly characterized it, do you think?

HOUSNER: No—you're right.

BROWN: This drop in support forces us to ask what is the purpose of graduate education because when the money dries up, you have to ask yourself whether you are willing to put out some of your own, or whether the graduate student is willing to put out some of his, or if we are going to try to persuade the federal government to give some of it back to us directly or fund us so that we can use more graduate research assistantships.

You ought to know what it is you are selling in order to sell something. Is graduate education to help the research of the faculty? Is it to provide a continuing supply, or an increasing supply, of university faculty in the future? Is it to provide the highly trained people who will work in industry and government in science and technology? Since I suspect the answer is going to be a combination of these things, what is the right combination for each school? I'm convinced that the situation in which university faculties continue to expand by 10 or 15 percent a year is over for quite a while, and since this was the basis on which graduate education in the best institutions was being carried on, that is going to have to change somehow. I believe that it will be a very bad mistake for the country for the best universities to cut back on the graduate enrollment as much as I think some of them are going to have to do—or have done.

HOUSNER: Doesn't it seem that in the future somehow there has to be enough money to support the graduate students in science and engineering?

BROWN: How many? You see, the

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An Interview with Harold Brown

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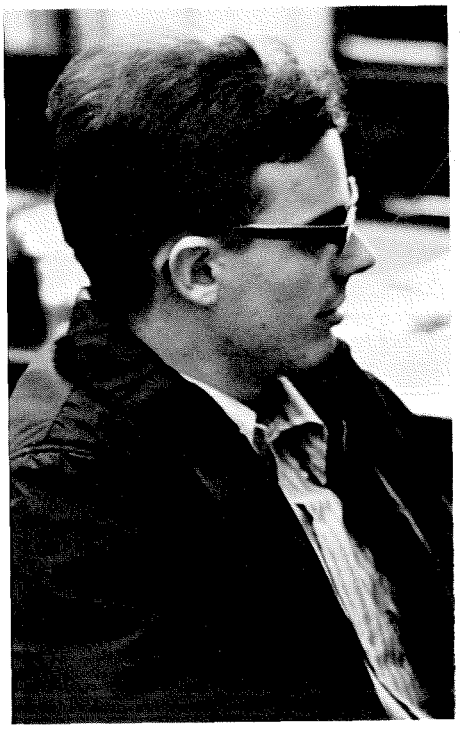
national administration's argument is that because there are scientists and engineers out of work you should rather sharply cut back the production of scientists and engineers. On the average there is something to that, but I'm afraid they have got it out of phase; the effects of the cut will come just when people appreciate that they need more scientists and engineers. In other words, what I argue for is a more gradual adjustment so that we can be a little bit surer of where we are going. My own guess is that when the time comes that you need a lot of scientists and engineers—it might be five years from now—relatively few of the ones that are out of work right now will be the right ones then. The ones you can train now will be more adjustable and more flexible and more able to do those things than the ones who have been doing the same things for 20 years. They are a real resource and pose a real human problem; the nation should do all the re-training it can, but the long-range solution to new problems is new people.

I think for the next few years we are going to need to try to make our graduate students broader and more flexible—give them other strings to their bows. From now on our astronomers are going to need to know quite a lot about instrumentation, for example, and a PhD in high energy physics may need to be able to do very sophisticated computer programing if he has to. In that way our graduates are more likely to be able to respond to what I think is going to be a very rapidly changing set of demands—maybe even self-contradictory demands.

LEVIN: When you came to Caltech, what did you expect from the Caltech undergraduate? What did you expect him to be—aside from his academic capability? Have you been surprised or disappointed in any way?

BROWN: I had been told about Caltech students' practical jokes, and I have seen some of those come off pretty well. I had been told that quite aside from their academic proficiency, they were also very, very intelligent—which is not the same thing. They are very good at spotting flaws in arguments, any arguments, and they are not easily put off by authoritative but incorrect statements. And I have been



Paul Levin

quite satisfied, pleased, and impressed with what I have seen. I would add that Caltech undergraduates have turned out to be somewhat less self-assured and socially at ease than I had expected. But that has a certain charm; it's not a total loss. There is something rather appealing about ingenuousness and straightforwardness and occasional embarrassment.

WATKINS: Actually, I think it goes deeper than that. From my vantage point, it's really a serious problem, and I'm noticing it more and more the longer I'm here. We turn out, it seems to me, a completely disproportionate amount of some really socially maladjusted people.

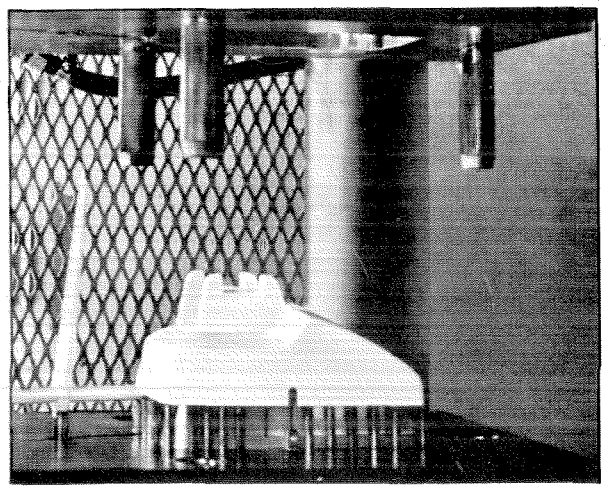
BROWN: It is not impossible that this is connected with great intellectual ability, and it seems to me that it's not something the Institute can take care of entirely during undergraduate years. I don't think we are doing as good a job as we should, but I think that it's too much to expect that when somebody leaves here, he's going to be all set in that area.

HOUSNER: How shall we do that job better?

WATKINS: I think if you talk to the school psychologist he will probably tell you it's very much linked with the competitive atmosphere around here.

BROWN: I have a view on this question, but I don't have a solution. My view is that a way to ease this is to have a sufficient variety of activities which the faculty and the students view as worthy of praise and admiration and respect so that every student is good at one of those things. So long as the students value academic success much more than they value everything else, a large fraction of them will feel unworthy and under pressure and harassed, and they won't grow up. In other places, of course, the athlete gets at least as much praise. I'm not sure that's what we want to cultivate here, but the social lion, the success with the opposite sex, the athlete, the chess player, the person who takes an active interest in the outside world—if we could encourage students to respect things like that, then I think that will help this problem.

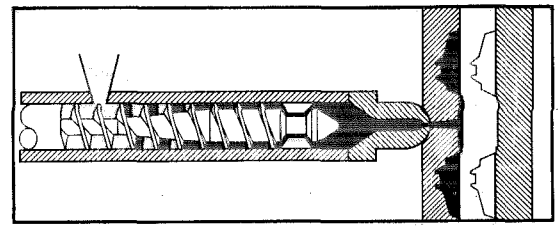
WESTERN ELECTRIC REPORTS



Molding by the millions. Western Electric people produce some 8 million phones a year. Molded plastic is used for housings and many other parts. So there is a constant investigation into the most effective way to use these materials.

$$A^*(z,t) = A_e^*(z) - [(A_f^* - A_i^*)/(1 - e^{-\beta N t_r})]e^{-\beta N t}$$

In developing the model at Western Electric's Engineering Research Center, it was found that melting behavior can be described by this formula which includes terms for shear heating and conduction heating effects. Other models were developed for temperature and pressure profiles.



End of molding cycle. At this point, the screw is stationary and heat is conducted into the plastic on the screw. After the plastic solidifies, the mold is opened as shown. The parts can then be ejected.

Solving the mysteries of molding with mathematics.

Even though plastics have been around for many years, there's still a lot to be learned about these versatile materials and their processing. So they are the subject for continuing studies by our engineers.

Some of their recent investigations have brought forth new and highly useful information about a relatively unexplored area: *the melting behavior of plastics in* the injection molding process.

One result of these studies is the mathematical formula, or model, above.

The model helps us predict melting behavior along the length of the injection screw molding machine used to mold telephone housings and other parts. Melting behavior is extremely important, because plastic pellets should be completely melted but not thermally decomposed before injection into the mold.

This information on melting is then used to investigate screw designs, operating conditions, machine sizes and plastic properties. All of which is aimed at obtaining optimum processing techniques.

Predictions obtained from the mathematical model have checked out closely with experimental observations. So the resulting screw designs are now undergoing evaluation by engineers at our plants in Indianapolis and Shreveport.

Conclusion: For new designs and materials, the model can help reduce the development cost for new molded parts and materials. For manufacturing current products, operating costs can be reduced.

Perhaps most significant is that we're getting information about molding temperatures not available experimentally. And many other types of information can be obtained without the use of costly, time-consuming experimental work.

The end result will be more efficient plastic molding and therefore a better product for the lowest possible cost.

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To help cut that toll, high-speed saws with a cutting edge of GE Man-Made diamonds are used to cut narrow, parallel grooves into concrete highways. Especially at hazardous curves. The grooves are only an eighth inch deep. But they give tires something extra to hold onto in the rain. And a nine-year study in California shows they cut wet-weather accidents 85%.

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That's why, at General Electric, we judge innovations more by the impact they'll have on people's lives than by their sheer technical wizardry.

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Because, as our engineers will tell you, it's not so much what you do that counts. It's what it means.

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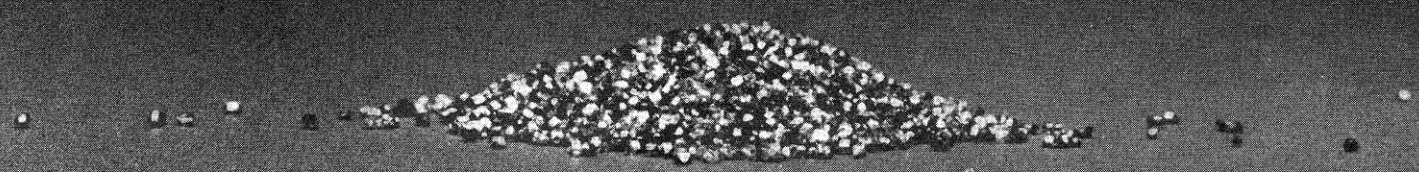

Diamonds shown are magnified 6.3 times.