VOLUME 10, NUMBER 2, MARCH 1976

CALTECH NEWS

PUBLISHED FOR ALUMNI AND FRIENDS OF THE CALIFORNIA INSTITUTE OF TECHNOLOGY

Over three years

The Exxon Corp. pledges $300,000 to Caltech

The Exxon Corporation has made an initial grant of $100,000 to Caltech for the 1975-76 academic year. President Harold Brown said Exxon has indicated its intention to continue that level of support each year for the next two years, so that its total commitment to the Institute will be $300,000.

Brown explained that the Exxon grant is intended to support research and policy studies related to energy. He said the funds will be used primarily to help faculty members begin research on energy-related projects while permanent or supplementary funds from other sources are being obtained.

Brown stressed that Caltech has made a major, long-term commitment to fundamental energy research. "Providing the technological base for future energy needs is one of the most compelling challenges that society faces," he said. "Furthermore, the challenge is one Caltech is particularly well equipped to meet. We're grateful for Exxon's response to our request for funds to help us work in this important area."

Terming the grant a "major contribution to the support of studies in energy technology," he said the grant will enable Caltech to respond to new research opportunities with flexibility and speed.

In commenting on the terms of the grant, F.A.L. Holloway, vice president for science and technology, Exxon Corporation, said the selection and conduct of research projects will be entirely the responsibility of Caltech.

Brown noted that more than 30 faculty members at Caltech are involved in research projects in such areas as better fuels, cleaner and more efficient combustion, low-drag cars and trucks, geothermal energy, improved air quality, fusion, windmill power, high-energy laser technology, chemical catalysis, solar cells, semiconductors, gasification and liquefaction of coal, fuel desulfurization, and systems studies of environmental and economic implications of new energy technologies.

"Tomorrow's energy will be provided through scientific and engineering advances on many fronts," Brown said. "Caltech scientists and engineers — and their students — will be instrumental in these advances."

Leal awarded Dreyfus Teacher-Scholar Grant

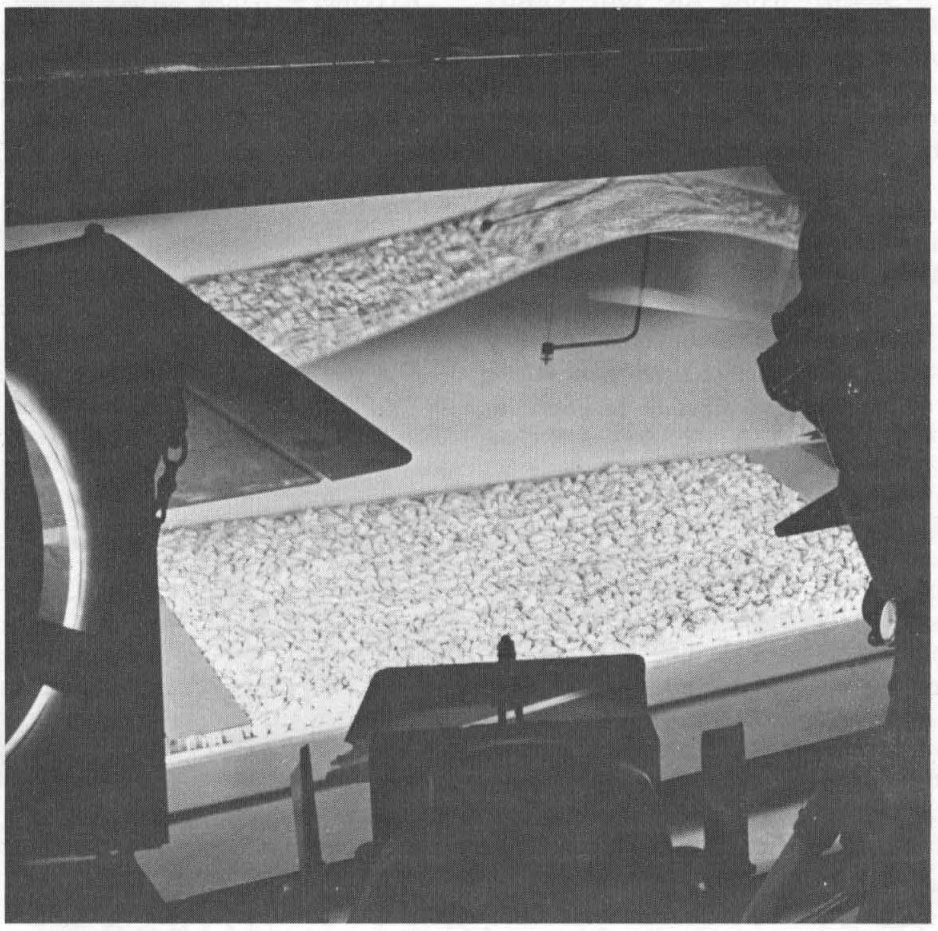
L. Gary Leal, associate professor of chemical engineering, is recipient of a $35,000 Camille and Henry Dreyfus Teacher-Scholar Grant for his outstanding teaching and research in fluid mechanics. He may use the money in any way he wishes over a five-year period in connection with his teaching and research.

The Dreyfus Teacher-Scholar Grants have been in existence since 1970, and Caltech is the only institution that has produced a winner each year. Leal, 32, is one of 15 young faculty members selected this year from 112 applicants from universities all over the country.

Since he joined Caltech's faculty in 1970, Leal and his research group have been working on the motion, suspension, and disposal of particles in fluids — important in relation to the dispersion of contaminants in the ocean and atmosphere and how they behave when subjected to heating and cooling.

Leal received his BS degree from the University of Washington in 1965 and his doctorate from Stanford University in 1969. He is the author of some 38 scientific papers.

An opportunity to learn about Caltech research through talking informally with faculty and students is given members of The Associates at luncheons in the Athenaeum about twice a year. Here, Associate Francis L. Moseley, right, talks with Robert B. Leighton, professor of physics. Some 55 members of The Associates attended the luncheon where they were seated with members of the division in whose work they were most interested. Afterward, many of them visited research labs on campus.



By studying miniature man-made tsunamis, such as this one in a wave tank in Keck Laboratory, engineers are learning more about the behavior of the deadly sea waves that are caused by seismic activity.

By making miniature tsunamis

Engineers study behavior of seismic sea waves

Some of the most destructive effects of an earthquake may be experienced thousands of miles away from its epicenter. These effects are called tsunamis (large seismic sea waves), and they are a major natural consequence of earthquakes, landslides, and volcanic activity.

How these waves are generated and cause coastal waters and bays to oscillate is being studied at Caltech by Fredric Raichlen, professor of civil engineering, and his associates, through the creation of miniature tsunamis in a wave tank in Keck Laboratory. Their work should provide information helpful in reducing the dangers from tsunamis.

Long waves that may measure 100 to 200 miles from crest to crest, tsunamis generally rise only a foot or two above the surface when they are in the open ocean. But when they reach the coast they may damage objects as much as 100 feet above the normal tide line. Their speeds vary, for they move faster through deep water than through shallow water. Their effects are particularly troublesome in harbors and near harbor entrances, so an important goal of Raichlen's work is to find out how tsunami wave energy is dissipated at these sites.

The tank used in Raichlen's studies measures approximately 100 feet long by 15 inches wide by 2 feet deep. One end is fitted with a 2-foot-long movable bottom that can be manipulated to simulate an undersea quake. By studying and mathematically describing the way in which the water responds to the motion, the researchers can determine the speed and frequency of the waves that have been generated.

Raichlen and his co-workers have learned that the heights of the waves generated by a quake are strongly influenced by the ratio between the time a wave is produced and the time it takes to move away from its source. If this ratio is small, then the amplitude of the wave will be much greater than if the ratio is large.

Raichlen also points out that the likelihood of a coastal area being damaged by tsunamis depends on several factors. One is the orientation of the area in relation to the direction in which the waves are moving. But an even more important factor is how the sea floor is contoured, because the contouring of a harbor floor can focus the intensity of the waves; or it can have the opposite effect, and smooth out the waves entirely.

Still another factor is the frequency at which the waves resonate. This resonance is an effect similar to that of coffee sloshing back and forth in a cup. The frequency of the "sloshing" has a great bearing on how far the waves may travel beyond the normal shoreline.

Raichlen and his associates plan to investigate the effects of continental shelves on tsunamis. To help with this project, their wave tank has been modified so that it can produce up to five or six groups of waves. The engineers plan to study what happens when these waves run together or when they move through regions where the depth changes suddenly—as it does along a continental shelf.

Scientists probe mystery of newly discovered star

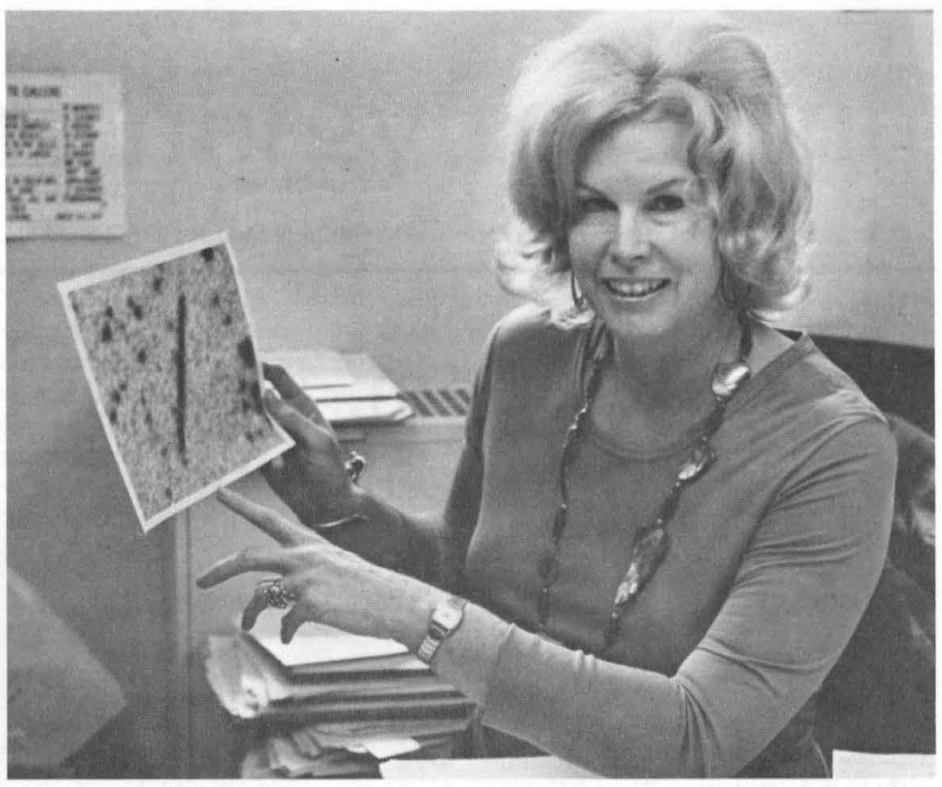
"There is nothing in the farthest star that is not contained in the body of man," wrote the 16th-century physician, Paracelsus. His statement was more correct than he could know, for since his day, scientists have discovered that stars, like man, go through their own successive stages of birth and life and death.

Astronomers do not yet know whether the very small hot star found by Caltech graduate student William W. Westbrook is being born or dying. And unhappily the brilliant young 26-year-old Westbrook reached his own final stage before conclusions about his star could be reached; he died six months before the publication of his discovery in the December 1975 issue of the *Astrophysics Journal*.

The newly detected star (CRL-618) is located in the Constellation of Perseus, between 2,000 and 16,000 light years away from the earth. Westbrook found it while searching for infrared sources.

Its center — whose surface temperature is more than 32,000 degrees Kelvin (or more than 57,000 degrees Fahrenheit) — is surrounded by a dense cloud of gas and dust that stretches out to more than 10,000 times the star's diameter. CRL-618 and its surrounding cloud can be seen indirectly by the light reflected off two other dust clouds that lie on each side of it but farther away.

The star is located above the plane of the Milky Way Galaxy, where there is little of the gas and dust necessary for the formation of new stars. This leads astronomers to believe that CRL-618 may be approaching its third and last stage. At this point, some stars lose their shells of gas and dust through explosion and enter their final stage of life as white dwarfs. Stars with these nebulous shells are called planetary nebulae.



Eleanor Helin shows a photograph of her discovery — an asteroid with an orbit nearer the earth than any known body besides the moon.

New asteroid: good site for deep space landing?

Caltech planetary scientist Eleanor Helin has discovered a new asteroid whose orbit is nearer the earth's orbit than that of any other known body besides the moon. And Eugene Shoemaker, professor of geology, thinks the newly discovered object would make an ideal spot for man's first landing in deep space.

A rock about two miles in diameter, the new find is an Apollo asteroid and the 20th member of this group to be detected. It was observed by Helin on January 7 by means of Palomar Observatory's 18-inch Schmidt telescope. It is the second Apollo asteroid to be found within a two-week period. Charles Kowal of Caltech and the Hale Observatories used the same telescope to find the 19th Apollo asteroid on December 26.

Shoemaker said the object probably is a planetesimal, the term given to the small chunks of matter that become the building blocks of planets.

Because it is so close to the earth, it provides a prime target for spacecraft exploration, according to Shoemaker, who heads an Apollo asteroid survey funded by NASA's planetology program.

"The asteroid is an attractive target for man's first venture into deep space because a landing could be made on it in a simple way," he said. "Because its gravity field is so small, landing on it would be like docking with another spacecraft. And learning whether it's the nucleus of a defunct comet would be of great scientific interest. If that's what it turns out to be, it's an example of one of the most primitive bodies in the solar system. And in this event, a careful study of its surface should provide clues about how solid matter precipitated out of the solar system's primordial nebula and collected together to become larger bodies."

The goal of Shoemaker's NASA-sponsored survey is to learn more about the Apollo asteroids, including their number and location. If his estimates are correct, some 800 of them are moving through the solar system in orbits that occasionally intersect that of the earth. They differ from the ordinary asteroids that are found in the main asteroid belt between Mars and Jupiter.

Brian Marsden of the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, and James Williams at JPL have calculated that Helin's new discovery travels around the sun every 347 days. Its orbit ranges between 73 million and 106 million miles from the sun, compared with an average of 93 million miles for the orbit of the earth. At the time of its discovery, the asteroid was of 13th magnitude—much too faint to be seen with the unaided eye.

Although it is closely associated with the earth's orbit, the asteroid only comes near the earth a few times every 20 years, Helin explained. It will be in good observing positions this year and next, but after that scientists will have a long wait before an opportunity for another good view.

But in 1996—20 years from now — it will be back. "And that," said Shoemaker, "will be the time to coast up to it in a spacecraft."

The asteroid, named 1976AA, has a mean life expectancy of about 24 million years — long by human standards but short in comparison with the age of the earth. Shoemaker estimates that the chances are three out of four that 1976AA will slam into the earth at some time during those 24 million years. If so, it will gouge out a crater about 20 miles across — much larger than the great Meteor Crater in Arizona formed by a much smaller asteroid that struck the earth about 25,000 years ago.

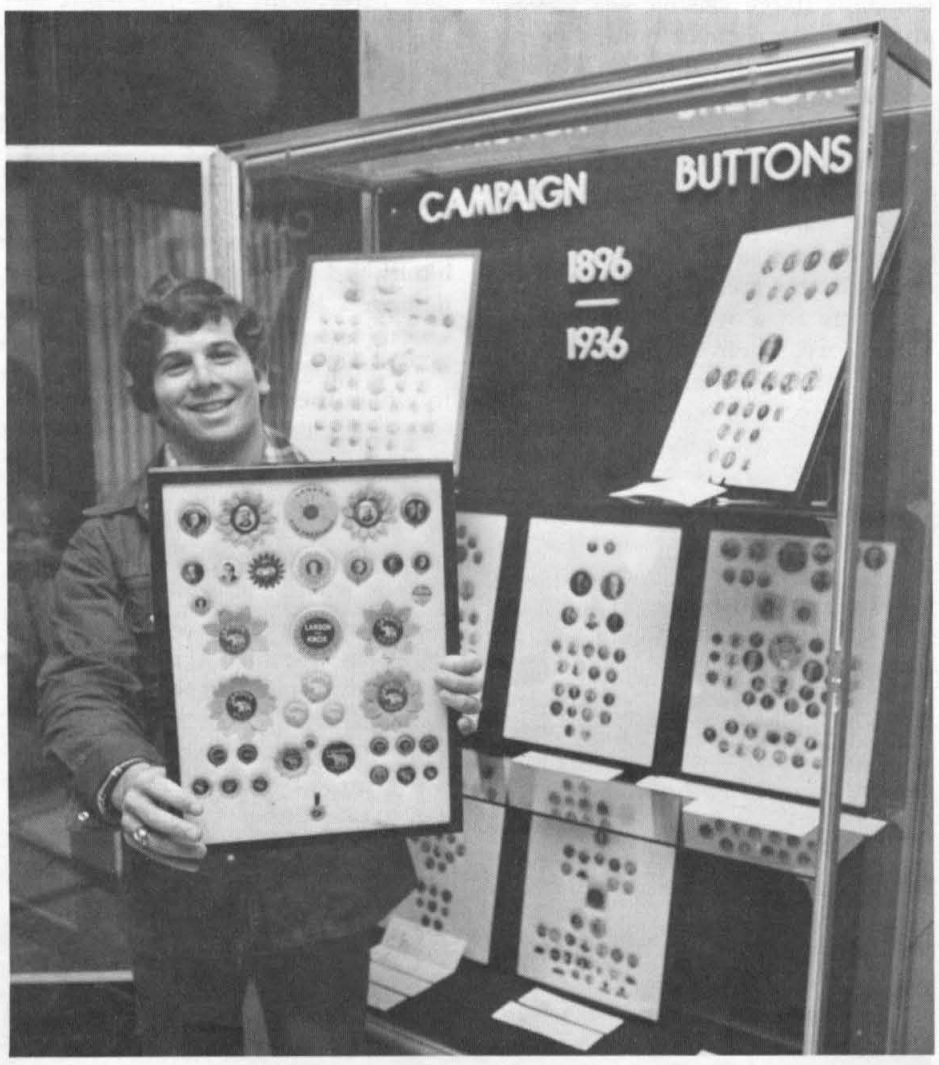
3,000 campus locations

Energy-saving devices installed in light fixtures

"Phantom" fluorescent tubes that save substantial amounts of electricity and money have been installed in 3,000 locations on the Caltech campus, and 2,000 more are scheduled for installation. The Institute expects to save about $35,000 in operating costs every year by using the device.

Invented by James A. Westphal, associate professor of planetary science, the phantom tube is designed for use in hallways, corridors, storage rooms, and similar areas that are often over-illuminated. Its main advantage is that it distributes light evenly while decreasing energy consumption.

A phantom tube replaces a normal fluorescent tube in a standard two-tube fixture. The phantom produces no light itself, and the normal tube that remains in the fixture produces about 70 percent of its former illumination. Thus, two-thirds of the power is saved, and the illumination level is only about one-third of that normally derived from a two-tube unit.



Graduate student Jeffrey Shellan, BS '75, has a thorough knowledge of U.S. presidential candidates since 1896 — Republicans, Democrats, and principal third parties. For 1896 was the year the first campaign buttons appeared, and Jeff is one of 3,000 serious collectors. Above, Jeff holds a tray of Alf Landon buttons, circa 1936, in front of a portion of his collection that formed an election-year exhibit in the lobby of Millikan Library. He says the rarest button of all is for the Cox-Roosevelt ticket in 1920, now worth $2,000 in collectors' circles. Jeff became interested in campaign buttons in 1964 when Goldwater and Johnson were the principal candidates.

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Vol. 10, No. 2 March 1976

Issued nine times a year (Sept., Oct., Nov., Dec., Feb., Mar., Apr., June, and July) and published by the California Institute of Technology and the Alumni Association, 1201 East California Blvd., Pasadena, California 91125.

Second-class postage paid at Pasadena, California.

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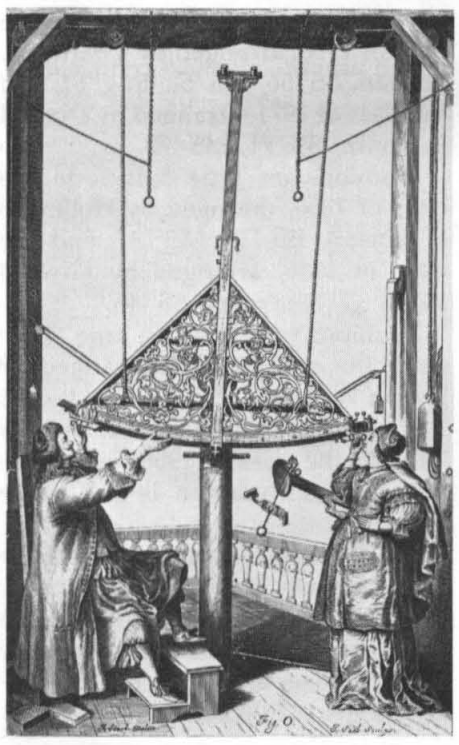
Pogo: a rare man and his books

Everybody knows that Caltech and the Hale Observatories share a staff of distinguished astronomers, astrophysicists, and planetary scientists. But probably few people are aware that they also share a librarian who is the honorary curator of their rare books. With his broad scholarship in the history of science and a command of many languages, Alexander Pogo makes an ideal custodian for the valuable volumes acquired over the years by both institutions. And, at 83, he is still devoting himself to their acquisition, cataloging, and arrangement.

Born in St. Petersburg, Russia, in 1893, Pogo came to Pasadena in 1950 as the editor and librarian of the Mount Wilson Observatory of the Carnegie Institution of Washington. He retired from that position in 1959, but he remains on the Carnegie roster as a staff member on post-retirement study, currently dividing his time between the rare-book room in Millikan Library on campus and the Hale Room at the Santa Barbara Street headquarters of the Hale Observatories.

Small, spare, erect, and with quizzical politeness overlaying good humor, Pogo brings a wealth of fascinating reminiscences to his conversation. For example, of his proficiency in languages, he says simply, "I read the main European languages," but then he explains what he means. His studies as a schoolboy in St. Petersburg included — in a six-day school week — six hours of Latin, six hours of ancient Greek, and language and literature studies in Russian, German, and French.



Johannes Hevelius and his second wife, Elisabeth, are observing at a six-foot brass sextant, made to his order. This view of the two rather well-dressed astronomers is an illustration from Hevelius's Machinae Coelesis Pars Prior *(1673), gift of Earnest Watson to Caltech's rare book collection. Interestingly enough, for a place like Caltech, the bookstore has two series of note cards that reproduce such illustrations — one scientific and one signs of the zodiac.*

At the age of 18, he began attending the University of Liège, Belgium, where French was the spoken language. World War I interrupted his studies, and at 21 he began five and a half years as a prisoner of war in Germany — developing, of necessity, his facility in that country's language. Finally, at 26, he returned to the University of Liège and belatedly earned, in 1920, diplomas in electrical engineering and mechanical engineering. He spent the next two years in Greece, where he made use of four languages — modern Greek, French, German, and Russian — depending, he says, "on the person I was talking to."

He also reads and writes Italian and Spanish because they were the cultural languages of the Renaissance, and anyone in his field must be able to read the writings of that period in the original. His conversational ability in some of all these languages has deteriorated, he ruefully admits, from sheer lack of use.

This rare book, Astronomical and Geographic Essays, *published in 1790 by George Adams the Younger, was presented to the Millikan rare book collection in honor of its curator, Alexander Pogo. Joanna Tallman, director of libraries, made the presentation. The book has a remarkable series of folded plates illustrating the various articles.*

In 1922, Pogo came to the United States, and so he immediately learned English. Of course, neither the fact that he was new in this country nor that he already held several academic degrees kept him from going on with his formal education. He earned an MA degree in mathematics at Columbia University in 1926 and a doctorate in astronomy at the University of Chicago in 1928. He then became a staff member of the Carnegie Institution, working under its auspices both at Harvard's Widener Library and at the Library of Congress before becoming Mount Wilson's librarian.

Today, most of the rare books in Pogo's care at the Hale Observatories offices in Pasadena concern the history of science, astronomy, and physics. Caltech's collection complements that of the observatories. Most of the original volumes were published in Latin, Italian, French, English, Dutch, German, and Russian. The Millikan Library has a set of the *Acta eruditorum,* Leipzig 1682-1731, containing reviews, in Latin, of books in several languages on science, law, medicine, natural history, and theology. Thus, it is possible at Caltech to read a copy of the first edition of Newton's *Principia* and the contemporary reviews of that work.

The Institute's library also includes the Rocco collection of books on Copernicus, Kepler, and Galileo — books by them, books about them, criticisms, answers, plagiarisms, and controversies. The Rocco collection, purchased on the recommendation of Earnest Watson (former dean of the faculty at Caltech), who was no mean judge of fine books, has increased greatly in value over the years.

The Institute is also indebted to Watson for the bequest of his own collection of first editions, which deals with science in general, beginning with the Newtonian period at the end of the seventeenth century and continuing through the early years of the nineteenth century. A few books from the Watson collection are nonscientific, so the rare-book room houses gems like first editions of *Alice in Wonderland, Through the Looking Glass,* and *A Christmas Carol.*

Dean Watson was interested in art in science and science in art, which brings to mind another of Pogo's accomplishments — a phenomenal and very specialized kind of memory. He is gifted with a *memoria loci* (memory of places), which is not only exact but enduring. Watson once asked him for help in compiling a list of spectacles portrayed in works of art, and Pogo told him of a portrait of a bishop wearing the round eyeglasses in use at the end of the late fourteenth century — the first picture of reading glasses. Pogo had once seen the bishop's portrait hanging in the Boston Museum of Fine Arts. Inquiring about it for Watson, he was able to send the museum a sketch of the portrait and a description of precisely where it had hung in relation to gallery, doors, windows, and so on. The museum responded promptly: The portrait had been part of a loan exhibit, of which no one had kept any records. Watson included it in his list anyway; Pogo's memory was not to be doubted.

In fact, though he left Russia in 1911 and has never been back, Pogo retains a clear memory of the art that hung in the Hermitage and the Museum of Alexander III in St. Petersburg. When the exhibition from the Hermitage was on display at the Los Angeles County Museum recently, he went twice to see it. Calling it "a reunion on Wilshire," he remembered not only the pictures but the very places in which they had hung in the Russian museum 64 years before.

Besides his professional absorption in his two libraries of rare books, Alexander Pogo has one special personal interest. He studies are — particularly early Flemish tapestries — from the artists' preparatory cartoons to the finished woven masterpieces.

He also has what one can understate as a "disinterest." He has not, does not, and never will — drive a car.

Seamans chosen as Seminar Day speaker

Robert C. Seamans, Jr., administrator for the U.S. Energy Research and Development Administration, Washington, D.C., will be the featured speaker at Alumni Seminar Day on Saturday, May 15. Seamans will address the general session in Beckman Auditorium at 2 p.m. and will be introduced by Carel Otte, MS '50, PhD '54, general chairman of the Seminar Day Planning Committee.

Previously the president of the National Academy of Engineering, Seamans is a former Secretary of the Air Force, was visiting professor and Hunsaker Professor at MIT, deputy administrator of NASA, and chief engineer of both the airborne systems department and the missile electronics and controls division of RCA.

Seamans received a Distinguished Service Medal from NASA, and his many other honors include the Distinguished Public Service Medal from the Defense Department, the Exceptional Civilian Service Award from the Air Force, and the General Thomas D. White U.S. Air Force Space Trophy.

During the morning and after Seamans' talk, alumni and their guests will have the opportunity of hearing about some of Caltech's newest developments in research and education from 12 outstanding faculty speakers.

Notice of Annual Meeting:

NOTICE IS HEREBY GIVEN that pursuant to the bylaws of the Alumni Association, California Institute of Technology, the annual meeting of the members thereof will be held on Thursday, the seventeenth day of June, nineteen hundred and seventy-six, at 6 p.m., in the Athenaeum, 551 South Hill Avenue, Pasadena, for the purpose of receiving results of the election of officers and directors and for the purpose of transacting any and all business that may properly come before such meeting of the members.

William J. Carroll, BS '48, MS '49,
President
G. Louis Fletcher, BS '56, MS '57,
Secretary

Placement Assistance To Caltech Alumni

The Caltech Placement Service may be of assistance to you in one of the following ways:

(1) Help you when you become unemployed or need to change employment.

(2) Inform you of possible opportunities from time to time.

This service is provided to alumni by the Institute. A fee or charge is not involved.

If you wish to avail yourself of this service, fill in and mail the following form to:

Caltech Placement Service
California Institute of Technology
Pasadena, California 91125

Please send me: (Check one)

☐ An application for placement assistance.

☐ A form indicating a desire to keep watch for opportunities although I am not contemplating a change.

Name .....

Degree(s) ..... Year(s) .....

Address .....

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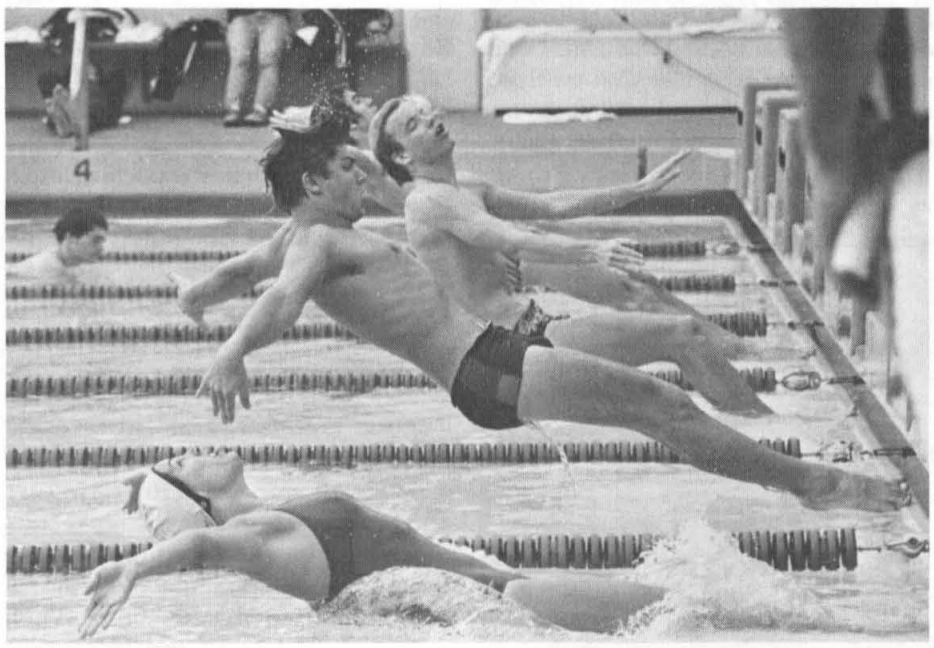
Competition's a challenge

Caltech athletes relish the odds



Between two opponents, freshman Werner Pyka, second from bottom, gets off to a fast start in a swimming meet with Redlands.

Swimming

by Rebecca Hartsfield
Class of 1978

To paraphrase the words of a vintage popular song, the Caltech swimming team has been swimmin' in the rain, as heavy showers poured down on southern California during the SCIAC competition.

Although it won only one meet (against Ambassador College), the swimming team showed promise and will lose only two of its members who are graduating this year. Covering all four major strokes, some talented freshmen — William Buchanan, Stanley Chen, Werner Pyka, and John Reimer — added strength to this year's team and will form a strong nucleus for the coming season.

Throughout the nation, swimming has been one of the first competitive sports in which women have participated, and Caltech has been no exception. Three years ago, as a freshman, Francine Wetter began to swim with the squad, and this year four out of 15 members were women. Interest has been expressed in forming a women's team, although planning is still in the early stages.

Fencing

by Edward Bielecki
Class of 1979

Clad in white canvas suits, members of the Caltech fencing team add a touch of classic relief to the normal round of activities in the gymnasium as they lunge at one another in practices at 8 p.m. on Tuesday and Thursday nights. Everyone is welcome and there's no shortage of seats for spectators.

The fencing team is coached by Delmar Calvert and some of his top students from the Los Angeles Athletic Club, including two national champions. This season the team defeated Pasadena City College in foil competition, lost to PCC in foil, and lost to Cal State Los Angeles in both foil and saber. Consisting of six freshmen, six sophomores, and five juniors, the team has junior Paul Whitmore as its captain.

If the present level of interest continues, we should be able to field an épée team and a women's foil team next year. This would let us return to the Southern California Intercollegiate Fencing Conference for the first time in three years.

Wrestling

The 1975-76 wrestling team has performed well this season and could finish in a two- or three-way tie for second place in SCIAC standings, according to Coach Tom Gutman.

"This year's team has developed into a skilled and spirited unit," Gutman said. "Our inexperienced members have become formidable competitors, and the ability of our experienced members is evident in our won-lost record."

Gutman said the team's only major weakness has been in the upper two weights, because none of its members weighs more than 190 pounds. "But junior Arthur Gooding has done well in the 190-pound class even though his natural wrestling spot is at the 167-pound level," Gutman said.

Team captains, 142-pound Robert Loveman and 167-pound sophomore Thomas Snyder, led Caltech to victories over Los Angeles Trade-Tech, La Verne College, Whittier College, and Cal Lutheran. Caltech lost to East Los Angeles Junior College, Pasadena City College, Cal State Los Angeles, Redlands, Cal State Northridge, and Pomona-Pitzer. One match remained when this was written.

"The most promising wrestler on the squad is Tom Snyder with a record of 9 wins and 1 loss," Gutman said. "Snyder has an excellent chance of winning both the Conference and NAIA District III Titles in his weight class, and he has the potential for developing into a national-class wrestler."

Basketball

by Norman Nelson
Class of 1976

As the varsity basketball squad trots confidently onto the court, the crowd in the Caltech gymnasium bursts into wild applause and cheerleaders wave brightly colored pompons . . .

Too bad. Those are visitors, and they're cheering for the opposing team.

Playing on your home court with a majority of the fans cheering for your opponents is just one of the challenges in Caltech basketball. Another is that your team loses consistently — and by wide margins. So why do we come out for basketball — and stay out, in the face of such adversities? To find the answer, it's only necessary to go back to the first time someone dipped a ball through an inverted peach basket: The game is a lot of fun, even if you lose.

Still another motivation lies in the personality of the typical Caltech student: a proud individual, challenged by the odds. And what a challenge it is to compete against the schools that Caltech plays in basketball.

Practice time for Caltech players is short — one and a half hours a day — and often students can't make practice because they have to study. And during finals and holidays in the middle of the season, the Techers take a three-week vacation while their opponents are playing in tournaments and practicing as usual. Caltech players accept this challenge and sometimes almost overcome the odds. Last year, Tech lost to league-leading La Verne by only 10 points, and three years ago to Claremont by only 4 points.

This year has been a time of building for the varsity team. Only one of last year's starting five players — Captain John Pender — is back. With an excellent season to his credit, Pender is leading the team in scoring and is contributing much to its board power. Because of the loss of players due to graduation, the squad has had to go with several freshmen, but they've produced well beyond what was expected of them. Next year's team should be much improved, and possibly even victorious over the challenges that face every Caltech basketball player.

Alumni plan 5-year reunions in May, June

The members of the class of 1926 will celebrate their 50th reunion with a luncheon on Friday, June 4, in the Huntington-Sheraton Hotel, Pasadena. Spouses and guests are also invited to the luncheon, where class members will be inducted into the Half-Century Club.

Donald P. MacFarlane, BS '26, and Theodore C. Coleman, BS '26, are helping the Association with arrangements for the reunion, which will include campus tours at 4 p.m. from the Athenaeum and a buffet dinner at 5:30 p.m. at the Coleman's.

Class of '51 reunion

Plans for the 25th reunion of the class of 1951 are shaping up "smashingly well," according to John R. Fee, BS '51, chairman. "More than 150 graduates of '51 and their wives are expected to participate in Tech's latest and most boisterous reunion ever," Fee predicted with his usual restraint.

A campus tour on Friday, May 14, will begin the festivities, followed by a cocktail party in the Athenaeum where memorabilia will be displayed in keeping with the reunion theme, "Nostalgia isn't what it used to be." After a prime-rib dinner, the alumni will dance to the music of the Tommy Vig Band.

Participating in the evening's program will be Bradford C. Houser, BS '51, who will show slides, James T. Luscombe, BS '51, who will recount experiences of the '51'ers over the past 25 years, and Oliver H. Gardner, BS '51, who will present awards.

Members will congregate in Dabney Gardens on Seminar Day, May 15, for a lunch organized by Hiroshi Kamei, BS '51, MS '52. Several popular members of the faculty, circa 1951, will be special guests at a cocktail party in the Millikan Board Room. Arrangements for this event are the responsibility of C. J. Pings, BS '51, MS '52, PhD '55.

The remaining classes will hold their reunions in the Athenaeum on June 4, 5, and 12. Those on June 4 include the class of 1931, arranged by Edwin F. Green, BS '31, MS '32; the class of 1956, arranged by Charles A. Bodeen, BS '56, MS '59, Eng '61; and the class of 1971, arranged by Donald L. Smith, BS '71, MS '72.

Reunions on June 5 include the class of 1936, arranged by Holley B. Dickinson, BS '36, MS '37; and the class of 1946, arranged by Edward "Ted" G. Neale, Jr., BS '46.

Reunions to be held on June 12 include the class of 1941, arranged by Joseph W. Lewis, BS '41; the class of 1961, arranged by Charles A. Ray, BS '61; and the class of 1966, whose arrangements chairman is still to be named.

All of these reunions will include campus tours beginning at 4 p.m., joint cocktail hours at 5:30 p.m. in the Athenaeum courtyard, followed by dinners in separate Athenaeum dining rooms at 6:30 p.m.

The Caltech Varsity Quartet hasn't actually traveled to the moon, as this picture before the mural in South Mudd might suggest. But the quartet will be visiting three southern states as part of a 10-day Glee Club tour this spring. Quartet members are, from left, John Bacon, Mark S. Bickford, James Brubaker, and William Dower. Appearing at colleges and prep schools in Georgia, Tennessee, and Louisiana, the Glee Club will give 10 scheduled performances and make several informal appearances on a tour that is partially funded by a challenge grant from the Coca-Cola Company. Members will appear in elegant new attire — traditional black concert garb.

Alumni Board nominates officers

The Board of Directors of the Alumni Association met as a nominating committee on January 27, 1976, in accordance with Section 5.01 of the bylaws. Six vacancies on the board, in addition to the positions of president, vice president, secretary, and treasurer, are to be filled, as is a vacancy for a chapter representative who will serve a one-year term. The current members of the board, with the years in which their terms expire, are as follows:

William J. Carroll, BS '48, MS '49—1976
Joseph A. Dobrowolski, BS '49—1978
G. Louis Fletcher, BS '56, MS '57—1976
Oliver H. Gardner, BS '51—1978
John D. Gee, BS '53—1976
Robert B. Grossman, BS '33—1976
Carole L. Hamilton, PhD '63—1977
Rolf C. Hastrup, BS '53, MS '54, Eng '58—1978
Raymond L. Heacock, BS '52, MS '53—1976
Richard A. Karp, BS '64—1976
Le Val Lund, Jr. BS '47—1977
William L. Martin III, BS '69, MS '70—1978
Raymond A. Saplis, BS '44—1977
Leon T. Silver, PhD '55—1976
Howell N. Tyson, Jr., BS '50—1978
Richard L. Van Kirk, BS '58—1977
Peter M. Wilzbach, BS '70—1978

The following individuals have been nominated for terms beginning at the close of the annual meeting in June 1976:

President: *John D. Gee,* BS '53—1 year
Vice President: *Richard L. Van Kirk,* BS '58—1 year
Secretary: *Joseph Dobrowolski,* BS '49—1 year
Treasurer: *William L. Martin III,* BS '69, MS '70—1 year

Directors:
Clarence R. Allen, MS '51, PhD '54—3 years
James R. Davis, BS '48, MS '49—3 years
Hiroshi Kamei, BS '51, MS '52—3 years
Harry J. Moore, Jr. BS '48—1 year
Carel Otte, MS '50, PhD '54—3 years
James W. Workman, BS '57, MS '58—3 years

Section 5.01 of the bylaws provides that the membership may make additional nominations for directors or officers by a petition signed by at least 50 regular members in good standing, provided the petition is received by the secretary no later than April 15. In accordance with section 5.02 of the bylaws, if no additional nominations are received by April 15, the secretary casts the unanimous vote of all regular members of the Association for the election of the candidates nominated by the board. Otherwise a letter ballot is required.

Below are the biographical summaries of those nominated for directors.

Clarence R. Allen, MS '51, PhD '54, has been a professor of geology and geophysics at Caltech since 1964, and a member of the faculty since 1955. Before coming to the Institute, he was on the faculty of the University of Minnesota.

Allen's primary research interests are the geophysical and structural studies of glaciers, physiography of active faults, relationships between seismicity and geologic structures, tectonics of regional fault systems, earthquake mechanisms and microearthquakes, and earthquake prediction.

He is a member of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, the American Association of Petroleum Geologists, the American Association of University Professors, and numerous other professional groups. He has been a member of many state, national, and local boards and commissions on earthquake analysis and prediction.

Clarence R. Allen

James R. Davis, BS '48, MS '49, is president of Converse Davis Dixon Associates, Geotechnical Consultants, Pasadena. A civil engineer specializing in soil and foundation engineering, he is a fellow of the American Consulting Engineers Council and the Institute for the Advancement of Engineering. He is also active in the American Society of Civil Engineers, Structural Engineers Association of California, Association of Soil and Foundation Engineers, and other professional groups.

Davis has served on the West Covina Planning Commission, Los Angeles County Engineering Geologists' Qualifications Board, Los Angeles City Mayor's Construction Coordinating Committee, and Orange County Board of Qualifications, in addition to other civic responsibilities. He has served on past Alumni Seminar Day Committees and is chairman of the Alumni Scholarship Committee.

James R. Davis

Hiroshi Kamei, BS '51, MS '52, has been a member of the technical staff of the Autonetics Division, Rockwell International Corporation, since June 1952. A registered mechanical engineer, he is the division's primary technical specialist on thermal design and analysis. He is active in Alumni Association fund drives and the Class of 1951 Reunion Committee.

Hiroshi Kamei

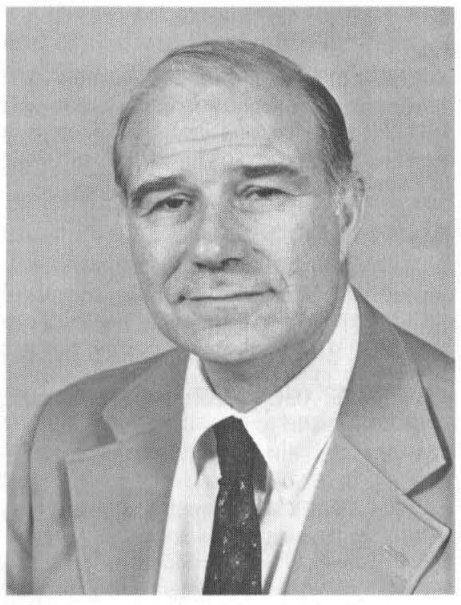
Harry J. Moore, BS '48, is director of manufacturing services on the IBM Corporation corporate staff and is a fellow of the American Management Association. He is former president and current secretary-treasurer of the New York Chapter of alumni, and is the Westchester, New York, Area chairman for the 1975-76 Alumni Fund.

Harry J. Moore

Carel Otte, MS '50, PhD '54, vice president and manager of the Geothermal Division of the Union Oil Company, was educated in The Netherlands and received a bachelor's degree in geology from the University of Amsterdam in 1943. He served as liaison officer with the Royal Air Force in the Mediterranean and Near East from 1944 to 1947.

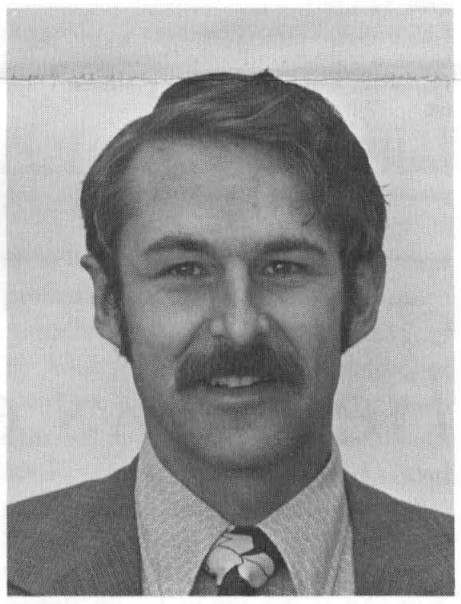
Since 1963, Otte has directed the geothermal activities of the Union Oil Company. Previously he was employed by the Pure Oil Company until its merger with Union Oil, and by the Shell Oil Company.

He is a fellow of the Geological Society of America and a member of the American Association of Petroleum Geologists. Otte is the author of several technical publications, and coeditor of a book on geothermal energy, recently published by the Stanford University Press.



Carel Otte

James W. Workman, BS '57, MS '58, is a member of the technical staff at Agbabian Associates, an engineering consulting firm located in El Segundo, California. After graduating from Caltech with degrees in mechanical engineering, he obtained his doctorate in engineering science from Columbia University. Before joining Agbabian Associates in 1967, he spent five years with the Rand Corporation. He is a member of Sigma Xi. He served on the Program Committee for the 1973 Alumni Seminar Day.



James W. Workman

Alumni Directory Supplement

The supplement to the 1975 Alumni Directory is now ready for distribution. It lists the names and addresses of those who received degrees in June 1975. Copies will be sent automatically to Association members who received degrees in 1975. Other Association members may receive a copy by filling in the form below and sending it to the Alumni Office, 106 Dabney—mail code 106-40, the California Institute of Technology, Pasadena, California 91125.

Please send the 1976 supplement to the 1975 Alumni Directory to:

Name _____

Address _____

City _____ State ____ Zip _

PERSONALS

1921
ARTHUR N. MALE retired from the Pacific Telephone and Telegraph Company on June 1, 1963. He and his wife celebrated their 50th wedding anniversary, on January 7, with a trip to Carmel, California.

1930
S. STEWART WEST, MS '32, PhD '34, retired on May 31, 1974, as chief of research and statistics with Alaska's department of health. Since June 1974, West has been conducting contract research in epidemiology for the division of public health, Alaska department of health and social services, in Juneau.

1931
RAY F. LABORY was named "Engineer of the Month" in January by the Society of Automotive Engineers. He is president of L/R Associates, transportation engineering consultants.

1933
PAUL F. HAWLEY, MS, PhD '37, has retired as patent director of the Pan American Petroleum Corporation of Tulsa, Oklahoma.

1934
W.S. (BILL) EVERETT, founder and former owner of Pulsation Controls Corporation of Santa Paula, California, has formed a new consulting engineering firm, Everett Associates, in Ventura, California. The company specializes in industrial noise control, community engineering acoustics, water hammer solutions for large and long pipelines, and vibration and pulsation control.

1939
JOSIAH E. SMITH, BS '40, Eng '48, was married on January 10. He and his wife reside in Vienna, Virginia.

1940
GEORGE R. BROWN has been transferred to Lagos as manager of Texaco Overseas (Nigeria) Petroleum Company, which produces crude oil.

JAMES V. CRAWFORD, MS '41, has become president of Universal Oil Products, a conglomerate owned by Signal Oil Company. Its headquarters are in Des Plaines, Illinois, where the Crawfords will live. Crawford had been executive vice president of the Garrett Corporation.

KIYO TOMIYASU was one of seven employees in the space division of General Electric Company to become a member of the One-in-a-Thousand Club in November 1975. The award is the highest honor the space division can bestow. Tomiyasu is a consulting engineer in microwave techniques.

1949
WARREN E. DANIELSON, MS '50, PhD '52, was transferred from Bell Laboratories in New Jersey to the Chicago area, where he is executive director, electronic switching, in Naperville.

ARTHUR O. SPAULDING, MS '58, has become vice president and general manager of the Western Oil and Gas Association, based in Los Angeles. Spaulding previously was regional manager of the Rocky Mountain Oil and Gas Association. He was president of the Alumni Association in 1972-73.

1952
DEANE K. SMITH, JR., was elected secretary of the American Crystallographic Association for 1976-78.

1953
BRUCE N. AMES, PhD, professor of biochemistry at UC Berkeley, is the first recipient of the Federation of American Societies for Experimental Biology Award for Research in the Life Sciences. The award, sponsored by the 3M Company, was established to honor scientists whose research contributes significantly to the health and welfare of mankind. The award will be presented at the annual meeting of the Federation, April 11-16.

DONALD K. NORRIS, PhD, of the Institute of Sedimentary and Petroleum Geology in Calgary, received the 1975 Medal of Merit from the Canadian Society of Petroleum Geologists in January. The medal was awarded for a paper on structural geometry and the geological history of the northern Canadian Cordillera.

1959
YOUNG C. KIM, MS, professor of civil engineering at Cal State Los Angeles, recently spent two months in Holland on a NATO Senior Fellowship in Science award. He was involved in coastal engineering research at the Delft University of Technology, Delft Hydraulics Laboratory, and Rijkswaterstaat.

1960
THOMAS E. BOWMAN, MS '61, was promoted to professor of mechanical engineering at the Florida Institute of Technology in April 1975.

1961
PETER R. VOGT writes, "After working seven years as marine geophysicist with the U.S. Naval Oceanographic Office in Suitland, Maryland, I resigned in December to accept a similar position with the Naval Research Laboratory in Washington, D.C."

1962
DONALD C. SHREFFLER, PhD, former professor of human genetics at the University of Michigan Medical School, has been named acting head of the department of genetics at the Washington University School of Medicine.

1964
GEORGE N. REEKE, JR., was awarded an Alfred P. Sloan research fellowship for 1975-77.

1965
STEPHEN H. GARRISON, MS '66, resigned as executive vice president of California Growth Real Estate, Inc., in Century City, to form a real estate development company in the City of Industry. The firm, Garrison Investment and Development Company, specializes in the development, management, and brokerage of neighborhood and convenience shopping centers.

1968
CHARLES A. WOLFE obtained a PhD degree in electrical engineering from UC Irvine, and is employed as a systems analyst for the ORINCON Corporation in San Diego, California.

1971
KIRK A. MATHEWS has been promoted to the rank of lieutenant in the U.S. Navy.

PIERRE SUNDBORG is a program administrator in planning at IBM's field engineering division in White Plains, New York, where he is responsible for nationwide staffing requirements.

WILLIAM H. WAGGY is an environmental engineer for the consulting firm of Hydrocomp, Inc., where he is in charge of water quality management studies. Last year he passed the California professional engineers' examination in civil engineering.

1972
STEVEN A. GRANDI received his PhD degree in astronomy from the University of Arizona in December 1975, and is now doing postgraduate work at the Lick Observatory at UC Santa Cruz.

OBITUARIES

1924
REINHARDT SCHUHMANN, SR., PhD, in October 1968. He was professor of chemistry, emeritus, at Western State College of Colorado. Schuhmann is survived by his wife, Alice, and three children.

HARRY L. WARREN on December 18, 1975, following major surgery. He was retired.

1933
WENDAL A. MORGAN on January 24, of cancer. He had retired from the Bechtel Corporation in September 1975. Surviving are his wife, Elizabeth, two children, and five grandchildren.

1941
DELMAR L. CROWSON, MS, retired general in the U.S. Air Force, on November 18, 1975.

1954
SHELTON B. BILES, JR., MS, in Germany on February 12, 1974. Biles was a Lieutenant Colonel in the U.S. Army Corps of Engineers.

Carroll Chatham

He grows emeralds in his labs

An explosive beginning ushered in the career of Carroll F. Chatham, BS '38. In an attempt to create a synthetic diamond at the age of 15, he almost blew up his dad's basement by putting a white-hot crucible of iron carbide into liquid nitrogen.

But his unique career recovered from that rocky beginning, and today he markets his Chatham Created Gems to buyers throughout the world. His fame as the first and only U.S. geochemist to create emeralds in the laboratory at commercially attractive prices has brought him publicity in the *Saturday Evening Post, True, Science Illustrated, Readers Digest,* and *Fortune,* plus a featured appearance on the television show, "You Asked for It."

This extensive publicity has spawned exotic but unfounded rumors about his work — such as one story to the effect that his gems had found their way into Egypt's crown jewel collection. The publicity has also attracted mail from all over the world from people who want to swap rare minerals with Chatham, become his business partner, or sell him an exclusive process for creating still other gems in the laboratory.

"I keep these letters in what I call my 'crazy file,' " Chatham said. "I could write a book based on the crazy letters I've received."

One strange incident involved a letter from Singapore that had his picture clipped from *True* magazine pasted on the envelope and the words: "He looks like this, General Delivery, San Francisco." It was delivered.

Chatham, who majored in chemistry at Caltech, says that at the age of 15 he became obsessed with the possibility of developing emerald crystals in the laboratory — a feat that had not yet been accomplished. He spent 20 years in evolving a commercially feasible process for growing them around a tiny low-grade emerald seed under extremely high temperatures and pressures. This process is not patented but is a carefully guarded trade secret, and no one has been able to duplicate his results.

Chatham began to produce his gemstones commercially in 1946, after conducting chemical research for Del Monte Foods for several years. Since that time he has grown and marketed several million carats of emeralds and rubies. His stones are marketed through his corporation, Chatham Created Gems, Inc.

"I operate like a mine," he explained. "I sell to manufacturers and distributors who sell to retail jewelers."

In the early phases of his career, Chatham marketed only rough stones to gem cutters, mostly outside the United States. Now he also sells faceted stones on the wholesale level.

A top-quality, one-carat cut emerald, grown in Chatham's laboratory during a one-year period, sells through a retail outlet for about $300 — approximately one-tenth the price of a natural emerald of the same size and quality. And only an expert can tell, after extensive tests and because of its lack of impurities, that the stone is the creation of man rather than nature.

The largest Chatham-created gem, a 1,400-carat rough emerald worth $30,000, weighs more than half a pound, and is in the Harvard Museum. A runner-up in size and value is an emerald crystal the size of a large lemon, weighing more than 1,000 carats. This gem is housed in the Smithsonian Institution and is valued at about $20,000.

In addition to his emeralds and rubies, Chatham has also produced some sapphires, and he's experimenting with the creation of alexandrites. He's been working for many years to develop a commercially profitable process for creating diamonds. But emeralds continue to be his favorite stones.

Carroll F. Chatham

Chatham gives his Caltech education substantial credit for his success in an unusual endeavor.

"My Caltech education taught me how to think and how to conduct a research project effectively and with a minimum of time," he said. "There's no better institution."

Of the many stones that he's created, one particular gem continues to be his favorite — his first, a one-carat emerald that he produced in 1938. It's in his wife's wedding ring.

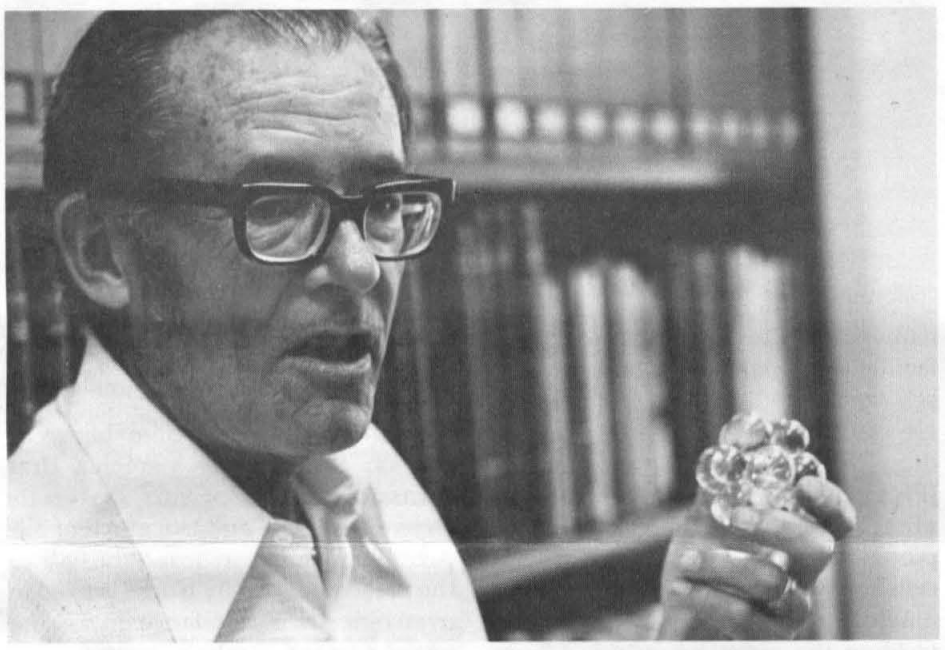
James Bonner

An explorer for the modern age

by Winifred Veronda

James F. Bonner, professor of biology, recently celebrated his 65th birthday at a dinner in the Athenaeum attended by 300 of his colleagues and his former students. There his guests honored Bonner for a distinguished career in which he has built an international reputation as a research scientist, an educator, and a communicator to laymen of the scientific perspective.

Most recently, Bonner has been known for his work on the control of gene activity in higher organisms — that is, what biochemical signals turn cells on and off, or what starts cells growing and what stops them. Knowing what is involved in this process of cell regulation is important in understanding why cancerous cells don't respond to the signals that should limit and control their growth. Earlier in his career, he was involved in the discovery of plant hormones and in developing ways to increase the yield of rubber trees.



Bonner is interested in genetic engineering, population problems, and food supplies in developing countries, and has spoken and written frequently on these subjects. As an educator, he has long been interested in improving educational processes in order to make better use of students' own creative drives. The author or co-author of seven books, he is a member of the National Academy of Sciences and other professional organizations. An active member of several skiing and alpine organizations, he has climbed in many parts of the world, including the Himalayas in Nepal. Here he discusses creativity in the scientific process, and in his own career.

What inspired your interest in science?
I was the first child of parents who were both chemists. Until I started school, I thought that everybody in the world was a chemist. I'd watch people going off to work and say, "Look, they're all going to their labs." Our family called sugar, sucrose, water, H_2O, and salt, sodium chloride. My six brothers and sisters and I all took first degrees in chemistry, and I planned to become a physical chemist.

But when I arrived at Caltech in 1929, exciting work in fruit-fly genetics was being done under Thomas Hunt Morgan, and I decided that biology was a real subject. Subsequently I concluded that my knowledge of chemistry particularly fitted me to be a biochemist.

Is there a field other than science in which you could have been happy?
Not in this generation. But if I'd lived 150 years ago, I could have been happy as an explorer. I just *love* exploration. I'd love to climb mountains without maps, as the early explorers did.

What part of the world would you have liked to explore?
Western North America would have been ideal. The country is beautiful and the climate excellent . . . much preferable to exploring Africa and dying of malaria or dysentery. But most of all, I'd have liked to explore Central Asia. Ever since I read the writings of Sven Hedin, the noted Swedish explorer, when I was 12, I've been obsessed with the idea of exploring that area, and I've partially satisfied this gigantic obsession. I've been to Soviet Central Asia twice and although I haven't been to Chinese Central Asia, I once flew over it in a Soviet airplane. So you see, I could be happy as an explorer, but today every place in the world has been explored. And so I've been involved in exploration of another kind.

How do you like to spend your leisure time?
I lead a dual life. I'm a professor at Caltech and I enjoy my work, but I also like to ski. For the past 28 winters I've been a ski patrolman at Mount Waterman by the Angeles Crest Highway. I keep my identity as a scientist a secret. Most of the ski patrolmen are firemen and electricians and plumbers, and if they learn I'm a scientist, they tend to be awed. I've learned that almost everyone is afraid of a professor. So to them, I'm just Jim Bonner.

What if they learn that you are a professor?
Oh, it doesn't spoil our relationship. They josh me about it, and then they expect me to produce magic solutions to difficult problems.

What stereotypes do they hold of scientists?
They expect my work to be incomprehensible to them, and to be complex, specialized, and probably not practical.

Do you believe that in the minds of many in our society, scientists have replaced the high priests of earlier centuries as beings whose work is so mysterious that no mortal can really fathom it?
Yes, to a considerable extent this is quite true.

How does it feel to be viewed in this way?
In the abstract, you must ignore the attitude. And in specific situations, you must talk with people in language they can understand, and show them, step by step, the value of scientific advances and how these advances are genuinely beneficial to them personally and to society as a whole.

What was the most exciting moment in your career in terms of a discovery?
This moment came in 1962, when my colleague R.C. Huang and I gained the first basic insight into the control of gene expression. We learned that the genes that are not expressed are those complexed with histones. This insight opened up whole new areas related to the structure and functioning of the genetic apparatus — areas with applications for cancer research, aging, and medical genetics. A whole new field has grown from that insight, and it's been just as exciting as anything to see it all unfold.

That evening, how did you celebrate?
Dr. Huang went home and took care of her two children and I went home and talked with my son about his research with butterflies. You don't celebrate something like that.

Except inwardly.
Oh, yes! Lord, you feel so happy.

Writing about creativity in science, one writer said that "the stubborn powers of habit are the antithesis of creativity and originality." How does a creative scientist overcome the drag of those powers of habit?
To be creative in science, you must be a little schizophrenic . . . schizophrenic enough to let go and think wild, unconventional thoughts about a problem; schizophrenic enough to see how many different, silly ways you can find of looking at it. And then you must get unschizophrenic and ask yourself, "How can I test this wild idea and find out if it's any damn good?"

I've known scientists with two kinds of failings. Some scientists — most, in fact — are unable to become schizophrenic enough to have a creative thought. And the others are unable to discriminate between their genuinely creative ideas and their nutty ones. I once had a colleague who would invest so much of himself in his ideas that he could never let his bad ones go. I've seen him hang onto bad ideas for 30 years.

The same writer contended that "corporate orthodoxy is the curse of genius," and he wrote that the scientific establishment resists ideas that are too radically new. What's your opinion of this theory?
I wouldn't regard it as a theory, but rather as an established fact. As a scientist, you can present ideas that make the orthodox body of thought more beautiful and streamlined, and these will meet with ready acceptance. But if you present an idea that's too new and different, it won't be accepted unless you have extremely compelling and understandable evidence to link it to orthodoxy. If your idea lies beyond orthodoxy, then you'll become an outcast or be considered a genius, depending on how convincing you can make your insights.

Have many creative ideas been passed over because they were too far ahead of their time?
Lots and lots. It's a sad fact for the initial discoverer that what he discovers today can be rediscovered in the future. So if his discovery is ignored because it's too far ahead of its time, someone else will rediscover it when its time has come.

One noted scientific pioneer said of himself, "I am by temperament a conquistador with the curiosity, the boldness, and the tenacity that belongs to that type of person." Are these qualities inherent in the creative scientist?
Yes, boldness, curiosity, and tenacity — and above all, hard work. A number of years ago, a psychologist was commissioned by the National Institutes of Health to find out the difference between successful and unsuccessful scientists. She learned that what really characterized the successful ones was that they worked extraordinarily diligently and really persisted with ideas that they believed in.

How can you distinguish the graduate students who are going to be the truly productive scientists?
You can distinguish the creative ones within a few months. They generate new ideas of their own, they don't simply feed back what's been put into them. They have lots of energy, and they move fast. If you see a student slouching slowly along the hall, you can be pretty sure he's not going to succeed as a scientist. Of course, a survey of gifted children at Stanford showed that intelligence, good health, and a high level of physical activity come in the same package.

How do you account for the fact that discoveries are often made by more than one person at the same time?
These discoveries are logical extrapolations of what we already know. They occur when the body of knowledge has moved to a point where certain conclusions are beginning to be obvious. And since more scientists are at work today than ever before in history, these simultaneous discoveries are becoming more common.

Do you believe creativity is the product of heredity or environment?
I'm sure that creativity is genetically determined, but it can't find expression without a suitable environment. Let me give you an example. An English artist who was painting watercolors in the Australian desert met an aborigine who had never seen a painting before and who asked to try his hand. This aborigine proved to be a gifted painter; he became Australia's most noted artist. And, further, it developed that the little tribe to which he belonged was full of people with this talent — a talent that had had no opportunity for expression before the artist arrived.

I was fortunate because creativity, or at least unconventional thought, was encouraged in my family. Caltech is successful in generating this kind of environment; many schools are not. At the Institute, an undergraduate has as much right as any faculty member to question the ideas of his peers and the professor for whom he works, and to propose ideas of his own.

When do your own creative insights come to you?
Often as I'm going to sleep. I always think about my work then, and at this time the conscious controls are relaxed — the controls that have been insisting that an idea was too unorthodox to consider. And I can remember these ideas in the morning.

Discussion with other people in my field often generates new insights. When I first came to Caltech as an undergraduate, Dr. Noyes enforced a sacred rule that on Tuesdays and Thursdays at 10 a.m., all the chemistry undergraduates, graduates, postdocs, and professors would meet together. We would discuss the entire field of chemistry in gruesome detail, and every once in a while someone would produce an exciting idea. I've tried the same procedure within my group. When we're confronted with a difficult problem, we discuss every aspect of it and we generally generate lots of ideas that lead toward solutions.

If you could give one bit of advice to a graduate student about his career, what would it be?
I'd give two bits of advice. Work, and work incredibly hard.

But unless one genuinely enjoys his work, he simply becomes a drudge.
Sure. Work incredibly hard, and enjoy it.

The Engineering Division

To the forefront in energy research

Outstanding graduates to help provide the country's future technological leadership are the division's most important contribution. This was the view of Robert H. Cannon, Jr., chairman of the Division of Engineering and Applied Science, in a talk at the Alumni Leadership Conference.

"The leadership role of our graduates is all out of proportion to the size of this institution," Cannon told the alumni. And he added that their leadership increasingly involves not only technology but policy decisions of a far-reaching nature.

Cannon described energy research in the division, and he termed this field "an exciting and compelling one where Caltech must be in the forefront."

In order to continue its national leadership, Cannon said the division has evolved a threefold philosophy: It will stay at the frontier of fundamental research, it will be increasingly a division of engineering as well as applied science, and it will build on Caltech's special strengths — its excellent faculty and students, and its proximity to "the finest science in the world."

This proximity, he said, gives it the opportunity to know intimately about the newest in fundamental scientific research, and how new technology can be built upon it.

In stressing the quality of Caltech's faculty, Cannon pointed to the 25 percent who are members of the National Academy of Engineering: 15 percent more than the percentage from any other institution.

The excellence of its students is equally impressive and must continue to be so, Cannon said. "To continue to attract the best students," he said, "we must provide them with the strongest possible base of fundamentals and expose them to challenging areas that draw on the newest that is known."

As he described the division's work in energy, Cannon noted that we live in an era in which impending shortages of materials and of energy, and commitment to full protection of the environment have become central concerns. And technological advances must be achieved commensurate with the importance of these concerns, he pointed out.

As an example of bringing fundamental understanding to bear on mainstream engineering problems, Cannon cited the research of Francis Clauser, Clark Blanchard Millikan Professor of Engineering, and his group, who are probing a mystery surrounding the internal combustion engine. This mystery concerns the hydrocarbons that appear in engine exhausts, and how they are created, for theoretically the internal combustion process itself should produce only a hundredth to a thousandth of the hydrocarbons that are actually exhausted.

"If we can lick this problem, then we can use a leaner fuel-air ratio in the internal combustion engine, and thus make real strides in reducing nitrous oxide and carbon monoxide in exhaust emissions," Cannon said.

Clauser suspects that the excess hydrocarbons are caused at ignition by the presence of residual material from the previous cylinder stroke. He believes that the flame may be quenched much more by this inert exhaust-gas layer than by the cooled wall itself.

Meanwhile, our basic understanding of mixing in the combustion process is aided by a new tool being used in the division — a laser doppler velocimeter, Cannon told alumni. This device directs two laser beams into a pattern of turbulence to produce very high resolution information about the velocity patterns within a fluid. Techniques for using the new velocimeter, developed by Paul E. Dimotakis, assistant professor of aeronautics and applied physics, make it possible to follow particles through a turbulent pattern and study their motion in precise detail.

Dimotakis has also developed computer techniques for recording these measurements. By using a computer to process the data, the researchers can collect a wealth of information that is much more precise than if it had been gathered through other means.

In another area of fundamental research, faculty in electrical engineering and applied physics are hard at work on technologies fundamental to solar energy. Professors James W. Mayer, James O. McCaldin, Thomas C. McGill, Carver A. Mead, and Marc-A. Nicolet are addressing problems that underlie the development of solar cells that would economically convert the sun's radiation directly into electricity.

Robert H. Cannon, Jr.

"Solar-cell work here is very fundamental," Cannon stressed. "Our faculty are looking at the basic processes by which sunlight disarranges electrons so that electric energy can be drawn out of the affected material. JPL's expertise is of help to us in this area, because the laboratory pioneered in the development of solar cells for use in space systems."

While some engineers have been tackling the question of how to use power from the sun, others have been hard at work on protecting the ecology of the ocean. Norman H. Brooks, professor of environmental science and civil engineering, and E. John List, associate professor of environmental engineering science, have been dealing with the problem of how ocean water used for cooling power plants can be returned to the ocean without thermal disturbance to that environment. Brooks recently designed an ocean thermal discharge system for the San Onofre Nuclear Generation Station. The system more than meets state requirements — requirements which specify that water returning to the ocean via a thermal outfall system can't be more than 2.2 degrees centigrade warmer than the natural ocean temperature.

Meanwhile, List has reviewed ocean temperature records of Pacific coastal waters, taken over several decades, to learn about natural variations in ocean temperatures. He has discovered that the natural differences between two temperature-recording stations are often greater than that allowed by state law, even when there has been no thermal discharge at all. He has also learned that, at certain places off the southern California coast, the ocean is warmer in winter than in summer.

One area of research that may help meet man's need for nonpolluting energy centers around man's old friend, the windmill. Ernest E. Sechler and Homer J. Stewart, professors of aeronautics, want to learn whether modern windmills, far larger than those that once provided power for family farms, could make substantial contributions to the electrical needs of particular areas, Cannon said. Sechler is addressing questions about the size and diameter of the windmills needed to produce large quantities of power, and how much wind can be tapped to run them.

"New technologies and new materials are giving us better answers to these questions than ever before," Cannon said.

Cannon then turned to highway trucks, the boxlike vehicles that transport much of our materials cross-country — and use much of our petroleum doing it. Roughly half of the fuel consumed by trucks is used to overcome their resistance to air, he noted. Anatol Roshko, professor of aeronautics, and his colleagues are designing more efficient truck shapes, and creating devices that can decrease the drag of existing trucks by a substantial percentage, Cannon told alumni. He said the Caltech wind tunnels are being used for tests to determine the effectiveness of these designs.

Cannon noted some additional areas where research relating to energy is under way:

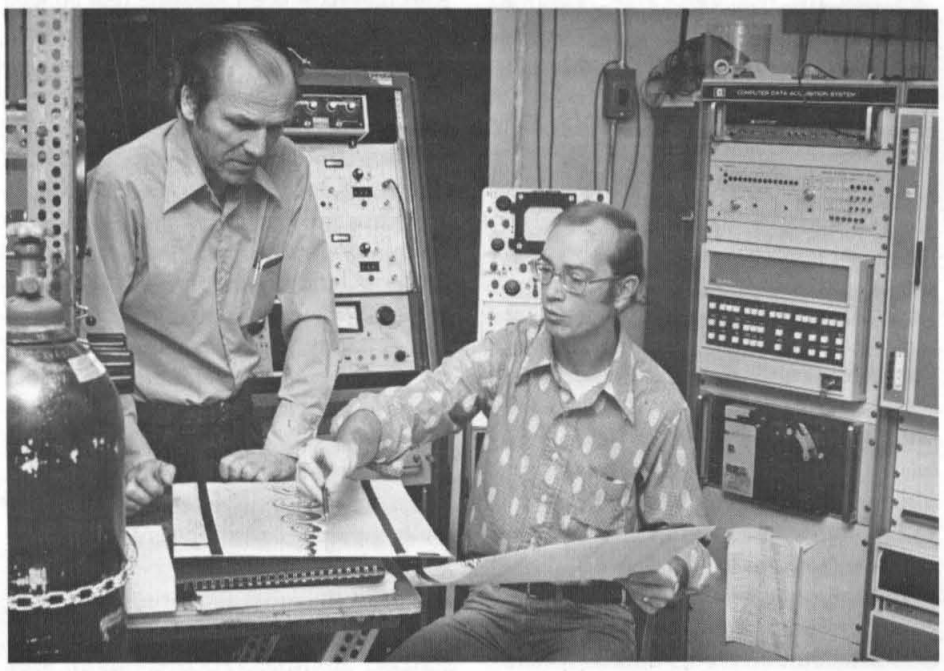
The fluid mechanics faculty is working on the problem of designing nuclear power plants so that accidental loss of coolant could have no serious consequences.

The earthquake engineering group is determining how to make sure nuclear power plants are earthquake proof.

Roy W. Gould, professor of applied physics, is studying the basic behavior of plasmas — an essential step in harnessing nuclear fusion.

Thad Vreeland, Jr., and David S. Wood, professors of materials science, are conducting research on radiation damage to materials.

Cannon stressed the importance of the Alumni Fund and its contributions to the Institute in its continuing excellence. "Gift money is the most precious because it allows us to pursue exciting initiatives we otherwise could not: for example adding new, young people to our faculty," he explained. "This place is a pacesetter for the whole country because it is private and independent and an example of what people can do on their own volition," he concluded. "And your gifts help to keep it that way."



A better understanding of the way two fluid streams mix in the turbulent region where they interact is important in the development of more efficient jet propulsion and internal combustion engines, and many other devices. Here, Anatol Roshko and graduate student John Conrad study a picture of a row of turbulent eddies in the shear layer created when two fluids — flowing the same direction but at different velocities — were mixed. Roshko wants to learn more about eddy structures such as this one, because he believes they control the mixing process.