CHEMICAL SCIENCE AND ENGINEERING

Newsletter of the College of Chemistry, University of California, Berkeley
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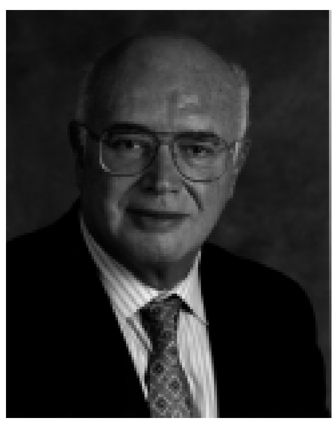
Somorjai Wins Wolf Prize

First Major International Award for Surface Chemistry

by Greg Butera and Robert Sanders

Chemistry Professor Gabor A. Somorjai, a pioneer and world leader in the field of surface chemistry, has been awarded the annual Wolf Prize in Chemistry from the Israel-based Wolf Foundation. Somorjai, 62, shares the $100,000 award with Gerhard Ertl, 61, of the Fritz-Haber Institute of the Max-Planck Gessellschaft in Berlin. The two independently laid the foundation for the present understanding of chemical reactions at the surface of materials. The field is of great importance in industry today, in areas ranging from pollution control by catalytic converters to the creation of thin films on computer hard drives.



Professor Gabor A. Somorjai

The prize is given to researchers working on the intellectual frontiers of chemistry. It is the first major international recognition for condensed phase chemistry, reflecting the increased importance of the field. "This award really calls attention to the study of surface chemistry," said Somorjai. "I am very gratified that they perceive me as one of the leaders in this field, and to be recognized for my life accomplishments."

The study of surfaces in general—their electrical, magnetic and optical as well as chemical properties—has been pushed greatly by the race to make electronic circuits smaller and smaller, cramming millions of transistors into a dime-sized area. Surfaces are surprisingly important in our lives, Somorjai said, whether it's the surface of our skin or the rubber soles of our shoes. Surfaces may even have been important in the primordial evolution of organic

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Celebrating 50 Years of Chemical Engineering in the College of Chemistry

This special issue of our newsletter celebrates the 50th Anniversary of the Department of Chemical Engineering. A story highlighting the tradition of collaboration between chemistry and chemical engineering will be in a future publication.

*More information about the Department of Chemical Engineering will be published in a booklet that will be made available at the **50th Anniversary reception, open to all College alumni**, on **April 22, 1998**, at **5:30 p.m.** in **The Great Hall of The Faculty Club** following the second Berkeley Lecture in Chemical Engineering. Please join us.*

A History of Chemical Engineering at Berkeley

Beginning as a small program in the College of Chemistry some 50 years ago, chemical engineering at Berkeley today is ranked among the top three departments in the country at both the undergraduate and graduate levels (*U. S. News & World Report* and National Research Council surveys). The location of chemical engineering within the College of Chemistry—the subject of considerable controversy in the early years—has significantly shaped the development of the department and its curriculum, and has encouraged unique opportunities for informal collaboration as well as joint research.

Although the first professor of chemical engineering was not appointed at Berkeley until 1946, research and teaching in the field had gone on since the beginning of the century. Chemistry had been linked with the needs of the mining, agricultural and pharmaceutical industries since the College's founding in 1872, and G. N. Lewis, dean of the College, formally instituted a chemical technology major

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within the chemistry program as early as 1912.

Chemical engineering as a formal discipline began at MIT in the 1920s and spread to Wisconsin, Michigan, Yale and other eastern and midwestern schools. Berkeley became one of the first universities on the west coast to offer a substantial program in the field. After World War I, chemical processing increased in importance in American industry. At this time, the College's courses in "chemical technology" were really just chemical engineering with another name.

Until the mid-fifties, Berkeley's College of Engineering and the College of Chemistry competed for control of the field. Joel Hildebrand, chair of chemistry and dean of the College from 1949-51, said in an oral history given to the Bancroft Library at UC Berkeley, "In the early '20s, we tried to call it 'chemical engineering,' but the engineering school jealously guarded the term. Engineering had to be in their school. So we (continued to) call it 'chemical technology.'"

Prof. Emeritus Donald Hanson

However, an interdepartmental group from the two colleges was formed in 1942 to offer an M.S. in chemical engineering. In 1945, the university determined that courses in chemical engineering would be taught in Chemistry, and the Engineering school would teach "process engineering," in many ways duplicating the curriculum. For several years, both programs were accredited by the American Institute of Chemical Engineers. Robert Connick, emeritus professor of chemistry, credits Dean Wendell Latimer and Joel Hildebrand for the development and placement of chemical engineering. Connick was on the committee on education policy which looked at the issue. "Both groups had committed themselves by hiring faculty. Latimer and Hildebrand were prime movers on campus, and they effectively persuaded key decision-makers. Chemistry was a highly developed scientific field, emphasizing research," said Connick. "Before World War II, engineering's focus was not on research. The real future of chemical engineering lay in research, so it made more sense to locate it in Chemistry."

Prof. Emeritus Charles Wilke

Prof. Theodore Vermeulen

Philip Schutz, who had received his Ph.D. in chemistry from Berkeley in 1933, was brought to Berkeley from Columbia University in 1946 to head the program, but he became terminally ill a few months after he arrived. Theodore Vermeulen was brought from Shell Development Company to replace Schutz in February 1947. Charles Wilke and LeRoy Bromley were hired with Schutz as instructors to staff the small program, with Donald Hanson and Charles Tobias added in 1947. The program grew quickly in the ensuing years as the faculty established a reputation and as large numbers of military veterans returned to the university.

Prof. Charles Tobias

Professor John Prausnitz, who came to Berkeley in 1955, attributes the success of the department to these early faculty members. "There were fewer students in the program in Engineering," said Prausnitz, in part because the program in chemistry was titled 'Chemical Engineering,' "but more importantly because the intellectual reputation established by G. N. Lewis (in the College of Chemistry) was highly regarded."

A Ph.D. program in chemical engineering was formally approved in 1947, and in 1948 the B.S. degree in chemical engineering was established. The department name was changed to the Department of Chemistry and Chemical Engineering in 1949, and in 1951, the Division of Chemical Engineering was formed. Dean Kenneth S. Pitzer, ever the statesman, continued the diplomacy begun

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The *NEWSLETTER OF THE COLLEGE OF CHEMISTRY* at Berkeley is published three times each year to support the College's mission of providing excellent teaching, research, and public service in the fields of Chemistry and Chemical Engineering.

Editor: Greg Butera, (510) 642-6867, greg@cchem.berkeley.edu, 420 Latimer Hall, UC Berkeley, Berkeley, CA 94720-1460.

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Wolf Prize

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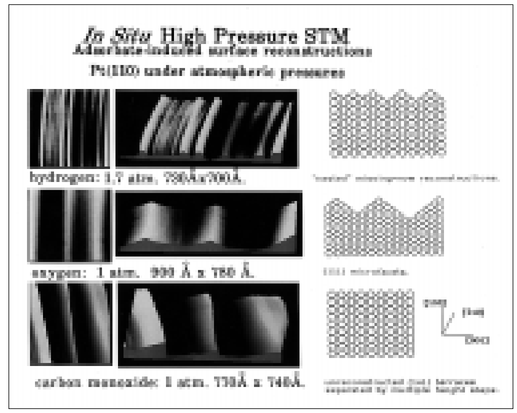
molecules such as DNA and proteins essential to life on Earth. More practically, the surfaces of metals have long been used to catalyze chemical reactions, such as the use of platinum surfaces to make gasoline during oil refining, and more recently the conversion of unburned combustion products from automobile engines into nonpolluting gases by catalytic converters.

Despite their ubiquity, surfaces were studied little when Somorjai completed his Ph.D. at UC Berkeley in 1960. His novel idea was to work with simple surfaces—surfaces of a single, uniform crystal of metal—to discover how chemical reactions occur there. The findings could then be extrapolated to more complex surfaces like those used in industrial reactions. "We developed a large number of techniques to study reactions at the molecular level on single crystal surfaces," he said.

What he found is that the atomic cracks, kinks, steps and terraces on the surface are what hold the chemicals as they rearrange. Defects encourage or catalyze reactions on the surface. Recognizing this, he has looked at the selective adsorption of chemicals on surfaces and how a single surface can catalyze many different reactions. "Surfaces can do a lot of chemistry, and they are flexible—the same surface can catalyze different reactions when you put in different chemicals," he said.

Somorjai credits his success to close collaboration with fellow scientists. "The Chemistry Department and LBNL have been good to me through my long career at Berkeley. Without this environment that fosters interdisciplinary science it would have been much more difficult to succeed in such a field as surface chemistry," says Somorjai. "I had strong collaboration over the years with Dr. Michel Van Hove of LBNL, a theorist in the field of low energy electron diffraction; with Dr. Miguel Salmeron of LBNL, an expert in scanning tunneling microscopy and atomic force microscopy; and with Professor Ron Shen of the Physics Department in the field of laser spectroscopy. Professor Alex Bell from Chemical Engineering and I shared several graduate students who came from both chemistry and chemical engineering. The superb graduate students in chemistry here and the postdoctoral fellows who come here make productive and high quality research possible."

During his nearly 40-year career he has supervised more than 90 Ph.D. students, half of whom are in industry and the other half in academia. Another 110 postdoctoral researchers have worked in his laboratory. These colleagues and Somorjai have taken the study of surface reactions down to the atomic scale, using scanning tunneling microscopy and atomic force microscopy. "To a large extent the advent of surface technologies has led to the ability to manipulate, control and characterize materials on an ever smaller scale," Somorjai said.



Somorjai, using high pressure Scanning Tunneling Microscopy, discovered surfaces have different molecular structures in the presence of different gases.

Somorjai and his laboratory colleagues now use seven scanning tunneling microscopes to study surfaces' reactions, and they are developing new laser techniques that can take snapshots of chemical reactions as they occur, in order to look at the short-lived intermediates. A new area of study involves polymers such as polyethylene. He is interested in how catalysts produce the long polymeric chain and what the arrangement is of the long chain molecules on the polymer's surface.

Somorjai continues to follow his curiosity into new areas, most recently the area of friction or tribology. As devices are made increasingly smaller, friction becomes a significant problem. And despite centuries of scientific study, the basics are still poorly understood. "I still don't understand how we can walk," Somorjai said.

Born in Budapest, Hungary, in 1935, he was in his fourth year as a chemical engineering student at the Technical University in Budapest when the Hungarian Revolution broke out in 1956. In November 1956, three weeks after the Russians invaded, he fled to the United States. By February of 1957 he had enrolled in graduate school at UC Berkeley, one of some 50 students from Hungary whom Berkeley admitted that year. After completing his Ph.D. work in chemistry in 1960, he joined the research staff at

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IBM in New York, where he worked until returning to UC Berkeley as an assistant professor of chemistry in 1964. He obtained his U.S. citizenship in 1962.

The author of more than 700 scientific papers and three textbooks, he is a member of the National Academy of Sciences, a fellow of the American Association for the Advancement of Science and the American Physical Society, and a member of the American Academy of Arts and Sciences. He has received many awards for his work, including the Von Hippel Award of the Materials Research Society, the Peter Debye Award in Physical Chemistry from the American Chemical Society and the Chemical Pioneer Award of the American Institute of Chemists. He holds three honorary degrees, including one from his alma mater, the Technical University of Budapest.

The Wolf prize has a long and distinguished history. The Wolf Foundation was established by the late Dr. Ricardo Wolf, inventor, diplomat and philanthropist, "to promote science and art for the benefit of mankind." Annual awards of $100,000 each are made in the areas of chemistry, physics, medicine, agriculture, mathematics and the arts. This is the 20th year the prize has been awarded. Roughly half of the Wolf Prizes in Chemistry have been followed with Nobel awards. Past winners of the Wolf award in the Chemistry Department are the late George C. Pimentel, Alex Pines, and Peter Schultz.

Somorjai's Wolf Prize will be presented May 10 at the Knesset (parliament) building in Jerusalem by Israeli President Ezer Weizman. In addition to the award ceremonies, an anniversary symposium on the future of science is planned.

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by Latimer and Hildebrand and solidified the program's standing in the College of Chemistry. In 1957, President Clark Kerr acceded to Pitzer's request, splitting off the Department of Chemistry and promoting the Division to the Department of Chemical Engineering. This gave it status and administrative staff equivalent to other Departments of Engineering, while keeping it closely associated with Chemistry.

In the early years, research money was tight. Early experiments were constructed of laboratory glassware, pipe, angle iron and sheet metal. Students were supported by G. I. Bill stipends, a few fellowships and by employment as teaching assistants. An important milestone was the very substantial research grant from Chemistry Professor Glenn Seaborg in 1953. The grant, under the Nuclear Chemistry Division of the Radiation Laboratory, provided support and space for chemical engineering research and was a crucial factor in the development of the graduate program.

Charles R. Wilke was chairman of chemical engineering during the critical years from 1953 to 1963. Prausnitz said, "He deserves credit for setting the tone of the department. A note of cooperation was sent around that presented an air of teamwork rather than competitiveness. Chemical engineering faculty help each other at Berkeley instead of developing rivalries. We have a cooperative spirit because of Wilke."

Berkeley has consistently demonstrated its place on the frontiers of research in chemical engineering. Strong programs in electrochemistry, thermodynamics, separations and transport were later complemented by biochemical engineering and research in semiconductors, often ahead of most other U. S. institutions. Other strong areas of research are in the understanding of polymers at the molecular level and polymer processing, and in catalysis and its strong interactions with surface science.

Berkeley was one of the first chemical engineering departments to offer courses in electronic materials. "In the 1970s the questions about how to make electronic materials were just becoming important," said Prausnitz. "Andy Grove got his Ph.D. here in 1963. He, along with two others (Gordon Moore, B.S. '50 in chemistry, and Robert Noyce) started the Intel Corporation. He was one of the first chemical engineering graduates to move into electronic components, and he became a role model to us." In 1970, Lee Donahey taught the first courses in electronic materials. These courses were significantly developed by Dennis Hess. Today Jeff Reimer, David Graves and Roya Maboudian carry the torch.

Prausnitz continued, "In the early years, it was also rare that other schools paid attention to electrochemical engineering. You might argue that Tobias started the field. The program here remains one of the most distinguished in the world." He also credited Wilke with the development of

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biochemical engineering at Berkeley in the ’60s, and for recruiting Harvey Blanch, now chair of the department. Wilke noted another area pioneered at Berkeley: “David Lyon’s research in cryogenic engineering was made possible by the facilities in the Giauque Low Temperature Laboratory. He was one of the few engineering scientists in the United States to work in this area.”

Notable appointments in the 1960s were C. Judson King (separations technology) and Alexis T. Bell (heterogeneous catalysis), who each went on to chair the department for ten years and then to serve as Dean of the College.

Several books published by chemical engineering faculty at Berkeley are widely used in the field and in academia. Texts by Hanson on computerization of separations, and by Prausnitz on thermodynamic properties, are used worldwide for design of industrial separation operations. King’s book on separation processes, Robert Pigford’s, William Sharwood’s and Wilke’s text on mass transfer, and John Newman’s electrochemistry text have also been quite influential, says Wilke. The more recent book by Blanch and Clark on biochemical engineering has also become an internationally accepted text.

The chemical engineering program was initially housed in Gilman Hall, as chemistry moved into the newly completed Lewis Hall following World War II. Eventually, all of Gilman Hall was dedicated to chemical engineering. Latimer Hall was completed in 1963, opening more space in Lewis Hall. The completion of Hildebrand in 1966 and expansion of the underground Giauque Low Temperature Laboratory provided further space for the program.

Until the completion of Tan Hall in 1997, however, the chemical engineering department did not have any modern space of its own. Tan Hall was the result of more than 15 years of fundraising begun under King, now UC Provost and Senior Vice President. Current Chair Harvey Blanch said, “King was a significant force. He spearheaded the earliest efforts to get the Chemical Engineering department new laboratory space in a new building. When Bell took over as chair, he and (former) Dean Brad Moore were also very influential in fundraising.” Final private funding was secured in a major push three years ago, allowing nine groups of chemical engineers and three of chemists to move in last spring. Bell, now Dean of the College, highlights Tan Hall’s significance as “the first new space conceived and designed specifically for the modern needs of today’s chemical engineering faculty.”

Blanch agrees that modern space was crucial. “There are stronger ties to chemistry and electrical engineering (semiconductors), and as a result, the nature of research facilities and equipment has changed,” says Blanch. “In the past 20 years there has been a shift from unit operations, where research was performed at the macroscopic level, looking at flow, transport and other issues, to an increasing emphasis on the microscopic level. Now much of chemical engineering is focused on the molecular understanding of phenomena.”

Characteristic of the changing nature of the field is Berkeley’s first faculty member with a dual appointment. Arup Chakraborty joined the chemical engineering faculty in 1988, and last year was appointed to chemistry as well, demonstrating the increasing interdependence between the two fields. Also significant were the arrivals of Susan Muller in 1991 and Roya Maboudian in 1993, the first female faculty members in the chemical engineering department, reflecting a lowering of traditional gender barriers.

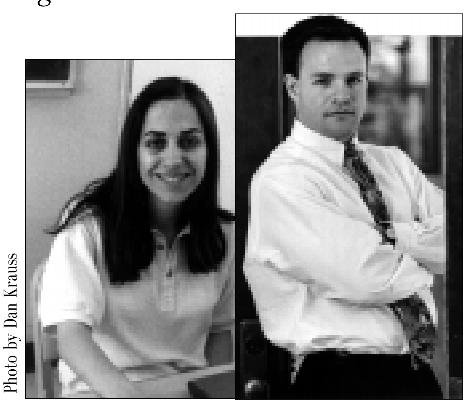

Photo by Dan Krauss

Jay Keasling, (biochemical engineering and environmental remediation) and Roya Maboudian (silicon surface engineering) are the department’s newest tenured faculty, as of July 1, 1998, demonstrating the trends in chemical engineering research.

Former Chair and Professor Emeritus Wilke credits the success of the chemical engineering program at Berkeley to its development in the high quality research atmosphere of the renowned chemistry department, good fortune in attracting world-class researchers, and the overall prestige of the university. He points out that the linkages with chemistry strengthen the program at Berkeley. “The student perspective is influenced by faculty, who are heavily influenced by chemistry because of the microscopic level of today’s research,” says

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Wilke. "Where chemical engineering is located in engineering schools, there may be strong ties with electrical, sanitary and mechanical engineering. But the atmosphere in this department permeates to students reflecting more interest in chemistry."

Dean Bell agrees, saying, "Our courses and research in chemical engineering have a higher content of chemistry. The undergraduate courses surpass the minimum chemistry requirements established by the American Board of Engineering Training, which certifies our program."

Bell adds that students here are enriched with the different language, tools and perspective of the other department. "Chemists have a different perspective than engineers do. They are problem-oriented, they understand phenomena and make interesting molecules and properties. But they do not do this from the need of application in industry. Engineers look at the process for chemical transformation, and knowledge of chemistry is often more important than engineering aspects."

Prausnitz says that "chemical engineering is one of a few areas which has not succumbed to extreme specialization. A wide variety of concepts and ideas are taught; students need to know more than just chemistry. It's not enough to know chemical reactions, but also diffusion rates, transport, fluid flow and other areas." Students also are exposed to electrical, mechanical, and civil engineering, physics, math and economics. "They are ready for almost any technical work. Our alumni go into varied careers," said Prausnitz.

Another unusual feature of Berkeley's chemical engineering program is its class, created in the '70s, to improve students' communication skills. The class is taken in the junior or senior year. Focusing on communicating applied science to a variety of audiences, students write and make oral presentations, learning how to take complicated concepts and make them available to an audience that is not experienced in the subject. Now under the direction of Dr. Paul Plouffe, the class also helps students to learn the technical material better.

Chair Blanch notes that "within the UC system, we produce 40 percent of all the B.S. and Ph.D. degrees awarded in chemical engineering among the nine campuses. And we do that with only 17 percent of the total UC Chemical Engineering faculty."

The future of chemical engineering will include many challenges, according to Blanch. "We still need to teach students classic chemical engineering, process design and synthesis. But their research needs to be more directed at fundamental phenomena, designing products as well as processes." That is where the collaboration with chemistry makes Berkeley a strong presence in the chemical engineering field.

This story is based in part on Wilke's "Brief History of Chemical Engineering at Berkeley."

Commencement 1998

Sunday, May 24
2:00 p.m.
Chemistry Plaza.

Darleane C. Hoffman, Chemistry Professor Emeritus and winner of the National Medal of Science in 1997 for her contributions to nuclear chemistry, will deliver the commencement address.