CHEMICAL ENGINEERING, UNIVERSITY OF CALIFORNIA, BERKELEY

50 years

Fiftieth Anniversary of Chemical Engineering

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Tan Kah Kee Hall

Fifty Years of Chemical Engineering at Berkeley

by Harvey W. Blanch, Chair, and Charles R. Wilke, Professor Emeritus,
Department of Chemical Engineering

Faculty in the early years: Charles Tobias, Campbell Williams and Donald Hanson

The History of the Department

The academic year 1997-98 marks the 50th anniversary of the Chemical Engineering Department at the University of California, Berkeley. Although the profession can be considered to date back considerably further, Chemical Engineering emerged as an academic discipline in the United States at the turn of the century, with the development of programs at MIT, Michigan, Wisconsin and Penn. From 1898 to 1915, these programs emphasized industrial chemistry, with largely non-quantitative descriptions of processes used in industry. The concept of unit operations took hold in the following decade and became the central educational theme for many years. There was a slow development of the application of material and energy balances to chemical processes; these applications were augmented by applied thermodynamics and process control becoming important from 1935 to 1945. By the time the department at Berkeley was founded, applied chemical kinetics and process design had emerged with subsequent less emphasis on unit operations.

As Chemical Engineering moved slowly toward engineering science, Berkeley's young department rapidly rose to prominence. Berkeley took the lead in developing new areas of research, particularly electrochemical engineering, biochemical engineering, and semiconductor processing. The department has consistently ranked among the top three research and teaching programs in the country. It continues to be at the forefront in developing research and teaching programs in emerging areas of technology, in part because of its close ties with the Department of Chemistry and interactions with Lawrence Berkeley National Laboratory.

Edith Taylor, secretary for the chair's office and then the Department's manuscript editor, in a 1969 photo

Founding of the department and the early years

Appointment of the first Professor of Chemical Engineering on July 1, 1946 marked the administrative decision leading ultimately to the present chemical engineering program at Berkeley. Prior to that time the university offered very little in the field. In 1912, G. N. Lewis, Dean of the College of Chemistry, instituted a chemical technology major in the chemistry program. Handled principally by Professor Merle Randall, it emphasized industrial chemistry. In 1942, an interdepartmental group from the Colleges of Chemistry and Engineering was formed to offer an M.S. degree in Chemical Engineering. As the university began to recognize more fully the importance of chemical engineering—especially through its contributions to the war effort in the development of the atomic bomb and in the petroleum and chemical industries—the need for a full-fledged program became apparent. Considerable controversy developed initially as to whether the program should be in the College of Engineering or the College of

Prof. Charles Wilke

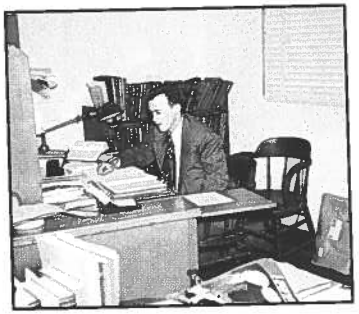
Chemistry, but in December 1945 Provost Deutch authorized the program to be placed in Chemistry.

Philip Schutz, a Berkeley Ph.D. graduate in chemistry and then Professor of Chemical Engineering at Columbia University, was selected to head up the fledgling program. To assist Schutz, Dean Wendell Latimer arranged the appointments of Charles Wilke, a Wisconsin Ph.D. graduate who was at the time an instructor in Chemical Engineering at Washington State College, and LeRoy Bromley, an Illinois Institute of Technology M.S. graduate, who was a chemistry graduate student at Berkeley. Their academic titles were "Instructor in Chemistry." The initial plan for the first year was for Schutz to teach the second half of unit operations and kinetics, for Bromley to teach the first half of unit operations and thermodynamics, and for Wilke to teach the stoichiometry course and develop a series of unit operations laboratory experiments, which were to be constructed in the north end of Gilman Hall by the students in the course.

Prof. Ted Vermeulen

The program got under way in September 1946 as planned, with a substantial upper division enrollment of returning students whose college work had been interrupted by the war. Sadly, in November Schutz became terminally ill with cancer and passed away soon after. To replace Schutz, Theodore Vermeulen, a UCLA Ph.D. graduate with industrial experience at Union Oil Co. and Shell Development, joined the group in February 1947 as Associate Professor of Chemical Engineering. In the fall of 1947, Donald Hanson, a Wisconsin Ph.D. then at Shell Development, and Charles Tobias, a Budapest Ph.D., joined the chemical engineering group as instructors. They were followed by F. Campbell Williams from Iowa State in the fall of 1948.

The initial faculty group remained in place without further additions until 1952. The years from 1946 through 1952 were a particularly important formative period for the program. The basic core of courses and facilities were developed, the undergraduate and graduate curricula were specified and the program came into its own administratively. The Ph.D. program was formally approved by the Graduate Division in 1947, followed by approval for the granting of B.S. degrees in chemical engineering in 1948. A student chapter of the American Institute of Chemical Engineers was formed in 1947, and the B.S. program was fully accredited by the Institute in 1949. Also in 1949, the name of the Chemistry Department was changed to the Department of Chemistry and Chemical Engineering, and the academic titles of the chemical engineering faculty were changed correspondingly. In December 1952 a formal Division of Chemical Engineering was established within the joint department with Vermeulen as Chairman, to be succeeded by Wilke in 1953.



Prof. LeRoy Bromley

As existence of the program became recognized in California and elsewhere, it rapidly gained momentum and grew in enrollment, degrees granted, faculty size and research activity. From inception through June 1953 the program had produced 261 B.S., 48 M.S. and 10 Ph.D. degrees. Kenneth Gordon from MIT joined the faculty in 1952, followed by Eugene Petersen from Penn State in 1953, Andreas Acrivos from Minnesota in 1954 and John Prausnitz from Princeton in 1955. Also, in 1955 Charles Oldershaw, an experienced process engineer at Dow Chemical Co., began a multi-year stint as a part-time instructor to teach the plant design course from an authoritative industrial viewpoint, to be joined similarly by E. Morse Blue from Chevron in 1959.

In 1957, Kenneth Pitzer, then Dean of the College of Chemistry, was successful in lobbying for promotion of the Division to a full Department of Chemical Engineering. Chancellor Clark Kerr approved the change, giving Chemical Engineer-

ing administrative status equivalent to that of the Department of Chemistry and other Departments of Engineering in the university.

In the early years there was relatively little financial support for research. Using limited college funds, many of the early experimental setups were constructed of laboratory glassware, pipe, angle iron and sheet metal. Graduate students were supported by GI bill stipends, a few fellowships and by employment as teaching assistants, including serving in Chemistry laboratory courses. The first governmental research grant was obtained by Tobias and Wilke from the Office of Naval Research in 1950, for studies of mass transfer effects in electrolysis.

The Chemical Engineering program was housed initially in Gilman Hall in space made available from Chemistry by the then recent completion of Lewis Hall. During the first few years office space and related amenities were very limited. Except for the chairman, the faculty shared offices and did not have telephones. Each office was equipped with a buzzer by which faculty could be summoned by the Dean's secretary to her office on the first floor to receive incoming calls or messages. Calculations were typically made by slide rule.

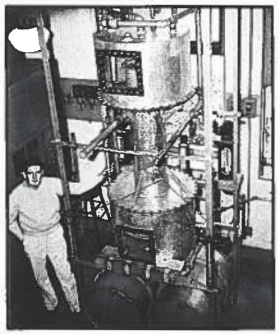
Current Faculty

The department has been exceedingly fortunate in attracting talented faculty members who have worked together congenially and have been responsible for the program's success in research and in gaining high academic recognition. The success of the department has also been facilitated by its association with a world-famous university, with a superb department of chemistry, with excellent departments in other areas of engineering and science, and by a capable staff and supportive administration within the College of Chemistry.

Alexis T. Bell	Heterogeneous catalysis
Harvey W. Blanch	Biochemical engineering
Elton J. Cairns	Electrochemical science and technology
Arup K. Chakraborty	Complex fluids, molecular theory, heterogeneous catalysis
Douglas S. Clark	Biochemical engineering
Morton M. Denn	Complex fluids and polymers: rheology
Simon L. Goren	Aerosols and particulate systems
David B. Graves	Electronic materials, plasmas
Enrique Iglesia	Heterogeneous catalysis, reaction engineering
Jay D. Keasling	Biochemical engineering, bioremediation
C. Judson King	Separations, process design
Roya Maboudian	Electronic materials
Susan J. Muller	Complex fluids: rheology
John Newman	Electrochemical science and technology
John M. Prausnitz	Applied thermodynamics, complex fluids, and biomacro molecules
Clayton J. Radke	Complex fluids, colloids
Jeffrey A. Reimer	NMR spectroscopy, catalysis, complex fluids, electronic materials
David Schaffer	Biochemical engineering, gene therapy

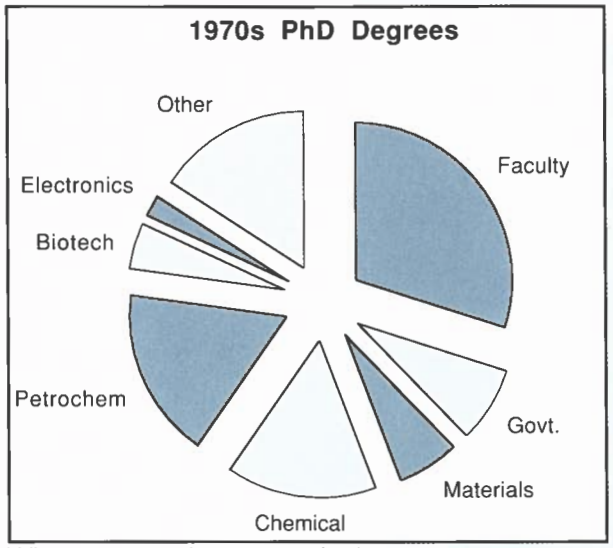
Growth and the Emergence of Engineering Science

In 1953 a major development occurred through the support of Professor Glenn Seaborg: he arranged a substantial, essentially unrestricted, block grant as well as space for chemical engineering research under the Nuclear Chemistry Division of the Radiation Laboratory. This support, renewed annually for many years, was a crucial factor in the development of the graduate program; it helped new faculty to become established in research, and it attracted outstanding students from other universities. In later years, as the faculty grew in numbers and stature, and as government research support became more widely available, the financing of research, although always a problem, has become somewhat less critical.



James Crawford, (M.S. '51) with a solvent extraction tower. His research under Wilke led to correlation of limiting flows in extraction towers, which is still the standard today.

During the early 1950s, Charles Tobias initiated a program in applied electrochemistry at the urging of Wendell Latimer. This was the genesis of modern electrochemical engineering, and Tobias made key contributions that allow the rational design of large-scale electrochemical processes. John Newman joined the faculty in 1963 and brought the tools of transport analysis to electrochemical systems. Elton Cairns, a Ph.D. student with John Prausnitz, returned to Berkeley in 1978 and developed a strong electrochemistry and battery program at LBNL. Faculty in electrochemical engineering nationwide can trace their origins to the program that was developed at Berkeley. Today, this area continues to flourish, with research on high-performance batteries, fuel cells, lithium-based electric vehicle batteries, transport, kinetics and thermodynamics in electrochemical processes.



Where our students went in the 1970s...

In 1963 Latimer Hall was completed for Chemistry, thus opening up additional space in Lewis Hall for Chemical Engineering, which nearly doubled in size by the end of the decade. Construction of Hildebrand Hall in 1966 and expansion of underground facilities peripheral to the Giauque Low Temperature Laboratory provided further space for the program. During this period, research flourished in the department. The number of doctoral degrees nearly tripled from 1960 to the late '70s, with a corresponding increase in M.S. degrees. The research activities were, to a large extent, driven by the opportunities and needs of the petrochemical industry.

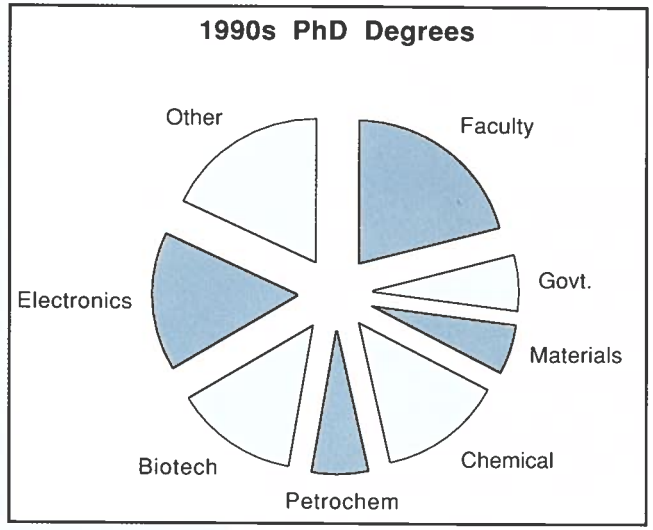
Berkeley developed a nationally recognized program in reaction engineering and catalysis during this period. Gene Petersen focused on reaction engineering, complemented by the catalysis research of Michel Boudart. Robert Merrill brought surface science to the department, and Alex Bell initiated studies on catalysis and surfaces using IR (infrared) spectroscopy. The program continued in more recent years at the molecular level, with Bell's work on zeolites and surface chemistry, and the reaction engineering component was strengthened with the arrival of Enrique Iglesia from Exxon in 1993. Today the program includes targeted synthesis of catalytic solids, their structural and chemical characterization, studies of surface reactions, and more recently, Monte Carlo simulations of the diffusion and adsorption properties of catalytic solids.

Prof. John Prausnitz

Part of the attraction that Berkeley held for John Prausnitz was the presence of Joel Hildebrand and Ken Pitzer in the Chemistry Department. Although Prausnitz arrived from Princeton in 1955 to work on packed bed chemical reactor design, he soon turned his attention to molecular interpretation of experimental data using Hildebrand's regular solution theory and Pitzer's corresponding states theory. A summer job at Chevron confirmed his conviction that a systematic rather than an empirical approach was needed to provide a means to

obtain activity coefficients and equation of state parameters that would be of value to the petrochemical industry. The approach Prausnitz pioneered in chemical engineering was based on a molecular viewpoint; physicochemical properties could be best correlated when they were based on a knowledge of pertinent intermolecular forces. His early research on vapor-liquid and liquid-liquid equilibria was extended to polymers, gels and hydrates, and later to wax and aspheltene precipitation. A collaboration with David Lyon opened the door to cryogenic systems, including liquid nitrogen, helium and hydrogen. At the same time that Donald Hanson was developing the first computer-based design strategies for separation processes such as distillation and extraction, Prausnitz's research provided the necessary thermodynamic correlations. The introduction of Hanson's computer algorithms, described in his text, and Prausnitz's thermodynamic properties models provided the petrochemical industry with computerized tools to design multicomponent separation processes.

Prof. David Lyon with Nobelist William Giauque, 1959.



...and where they are going today.

As polymers became an increasingly important product of the chemical industry, Prausnitz turned his attention to the properties of polymers and polymer blends. An important contribution was the translation of the approach of Flory, describing such systems, to chemical engineering practice. This was later extended to gels and polyelectrolytes. For the past ten years, a fruitful collaboration with Harvey Blanch has led to the application of molecular thermodynamics to biological systems.

The appointment of C. Judson King in 1963 expanded the program in separations. His research interests encompassed food processing and preservation, including freeze drying and spray drying. His research also emphasized chemical process design and synthesis, and he developed, with Scott Lynn, a strong focus in design. Jud King also had a flair for administration: he served as department chair from 1972 to 1981, as Dean of the College from 1981 to 1987, and as Berkeley's Provost for Professional Schools and Colleges from 1987 to 1994; he was appointed Provost for Research for the University of California system (1994) and then Senior Vice President in 1996.

Prof. C. Judson King

A very large fraction of the department's undergraduate and graduate students found employment in the petrochemical and chemical industries during the '60s and '70s. In the '70s, the growth of the electronics industry attracted an increasing number of B.S. graduates; it was not until the '80s and '90s, however, that large numbers of M.S. and Ph.D. students found employment in the electronics area. Today, the electronic-materials area is the largest employer of the department's undergraduate and graduate chemical engineers. The demand for doctoral engineers in the chemical and petrochemical industries has decreased, but the biotechnology/pharmaceutical industry has attracted large numbers of chemical engineers at all degree levels. Berkeley has continually produced a large number of doctoral students who pursue academic careers. Approximately 10 percent of the chemical engineering faculty in the United States are Berkeley graduates. The number in foreign institutions is equally impressive.

Textbooks Published at Berkeley

The College of Chemistry has been particularly influential in setting the direction of curricula in Chemistry and Chemical Engineering. Continuing the tradition Chemistry initiated with texts such as Lewis and Randall's book on thermodynamics, textbooks authored by Chemical Engineering faculty have been important in establishing new areas of research and technology. The text by Prausnitz on thermodynamic properties and their prediction, Hanson's book on computer-based design of separation processes, and Newman's electrochemical engineering text provide examples where new fields were established. Mort Denn, perhaps the most prolific textbook author in the department, has had a major impact on undergraduate education with his books on fluid mechanics and chemical engineering analysis.

Blanch/Clark	*Biochemical Engineering*
Denn	*Process Fluid Mechanics*
	Process Modeling
	Introduction to Chemical Engineering Analysis (with T.W.F. Russell)
	Stability of Reaction and Transport Processes
	Optimization by Variational Methods
King	*Separation Processes*
	Freeze Drying of Foods
Hanson	*Computation of Multistage Separation Processes*
Newman	*Electrochemical Systems*
Petersen	*Chemical Reaction Analysis*
Prausnitz	*Molecular Thermodynamics of Fluid Phase Equilibria* (with Lichtenthaler & de Azevedo)
	Properties of Gases and Liquids (with B. Poling & R. Reid)
	Regular and Related Solutions (with J.H. Hildebrand & R.L. Scott)
Reimer	*Chemical Engineering Design & Analysis* (with T. M. Duncan)
Sherwood, Pigford & Wilke	*Mass Transfer*

The Technical Writing Program

Chemical Engineering 185: Past and Present, or "Where are you now, Elvis?"

By Paul Plouffe

Chem E 185 could be such a great course if only...! A lament I heard every week or so back in 1984 from a disgruntled student. (Let's call him Elvis.) No doubt Elvis was frustrated at watching slip away what he saw as a chance to deal with "other important (presumably non-quantitative) stuff" as a vehicle for improving writing and speaking skills. Were Elvis to return to the Department today he might find less cause for frustration. Just as the Department has evolved in response to the demands of the profession—and of society as a whole—so has Chemical Engineering 185, Technical Communication for Chemical Engineers.

In the late 1970s, the faculty took a step that was, and remains, virtually unique among departments of chemical engineering: it established an in-house, technical communication course designed specifically for chemical engineering undergraduates, with oral communication as a major component.

Chem E 185 was created to improve students' communication skills with both engineering and non-technical audiences. Perhaps the most obvious difference that Elvis would find in Chem E 185 these days is its status within the curriculum. Begun as a two-unit, pass/non-pass course, Chem E 185 became a three-unit, graded course in 1988—a move that recognized both the importance and quantity of the work required of the students. Today, there are five major assignments in the class, each dealing with an important facet of communication that engineers will encounter in their careers.

The first written assignment involves an explanation of the physical principle(s) underlying a familiar phenomenon (e.g., the need for heat-resistant tiles on spacecraft) for an audience of non-scientifically trained adults. The second assignment is a written and oral explanation of a laboratory instrument or procedure to an audience of students re-entering college, who are on average thirty-two years of age and who have only high-school science in their background. Communicating technical information to non-technical audiences challenges both the student's creativity (for instance, in

coming up with helpful analogies from everyday life) and his/her actual understanding of the material.

The third assignment is the mid-semester Proto-154 report, which engages students in the analysis of experimental data and the presentation of results to an audience of chemical engineers, in preparation for Chem E 154, Unit Operations Laboratory.

Another sign of the evolution of Chem E 185 is its introduction of students to engineering ethics. Elvis' fourth assignment would be a case study culled from chemical engineering journals and textbooks in engineering ethics. He would be asked to analyze the fundamental issues involved, to identify possible solutions to the dilemma, and finally to make a recommendation supported by convincing arguments. Elvis would have to present all of this in both written and oral form. This presentation would be taped, as were the other two major oral presentations he would make, and he would have to submit a written critique of his performance.

The final weeks of the semester are devoted to the oral and written presentation of a literature-research project of the student's choice, with topics ranging from shape memory alloys, to fuzzy logic, to the formation of avalanches. This project encourages students to explore material that is outside (though often related to) the content of their courses, and to present their synthesis of the material to an audience of other (non-chemical) engineers.

Many of the people involved in starting Chem E 185 make up the core of today's faculty, while others such as David Lyon, Gene Petersen, Charles Wilke, Bill Benjamin, and Mike Williams have since retired. Patricia Whiting, the first instructor in Chem E 185 and one of its architects, moved on in the early 1980s. Over the years, other instructors, including Ralda Sullivan (from 1981 to 1994), have taught the course and contributed to both its continuity and change.

Whatever may have been the immediate motivation for establishing Chem E 185 in our Department, I believe that a single, fundamental truth justifies—or, rather, makes necessary—such courses in any university that claims to educate scientists and engineer-scientists: there can be no science without writing, speaking, sharing, and putting ideas to the test. In this connection, I often think of J. Robert Oppenheimer, a man whose courage I admire and reflect upon whenever I enter LeConte Hall. In his farewell address to his colleagues at Los Alamos in 1945, Oppenheimer said: "It is not good to be a scientist, and it is not possible, unless you think that it is of the highest value to share your knowledge." I find it fascinating—and remarkable—that after leading what was perhaps the most secret project in the history of science, Oppenheimer found himself coming back to the essential role of openness in science.

Perhaps to a greater extent than with any other human enterprise, science exists and advances only through communication. And whether we like it or not, the ability to communicate clearly, simply, and accurately is no longer a part of the general culture. It has gone the way of Elvis. So if we don't at least try to teach it, who will?

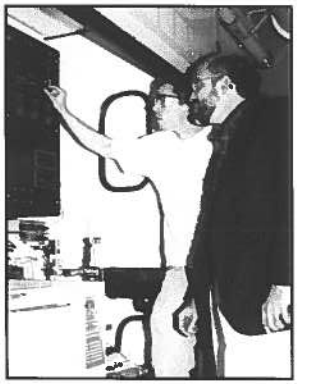
Prof. Susan Muller

Prof. Jay Keasling and students in their new Latimer labs.

Prof. Arup Chakraborty

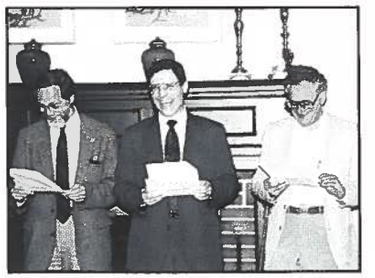
Most recent faculty additions (the past ten years)

Prof. Roya Maboudian



Prof. Enrique Iglesia reviewing a student's experiment.

Chronology of Events in Chemical Engineering at Berkeley



New chair Morton Denn, Dean Alex Bell, and future chair Simon Goren performing at a party commemorating Bell's 10-year tenure as chair in 1991.

1912 G. N. Lewis institutes a chemical technology major.

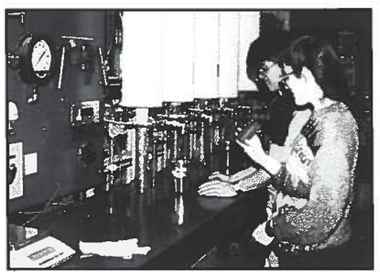
1942 An interdepartmental graduate group offers the M.S. degree in chemical engineering.

1945 Provost Monroe Deutsch authorizes the establishment of a Chemical Engineering program in the College of Chemistry.

1946 Initial faculty members are appointed to teach Chemical Engineering: Professors Philip Schutz (deceased, 1947), LeRoy Bromley (retired, 1972), Charles Wilke (chair 1953-63; retired, 1987). Undergraduate instruction begins.

1947 Professors Theodore Vermeulen (chair 1947-53; deceased, 1984), Donald Hanson (chair 1963-66; retired, 1989), Charles Tobias (chair 1966-71; retired, 1991; deceased, 1996) join the faculty. Ph.D. program is approved.

1948 B.S. degree program in Chemical Engineering is approved. Professor F. Campbell Williams joins the faculty (left, 1952, for Petrobas and University of Brazil).



Graduate Student Instructor (TA) helping an undergraduate student in the unit operations lab.

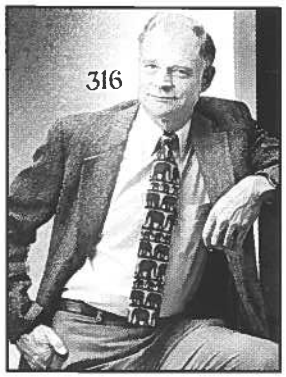
1949 The Chemistry Department is renamed the Department of Chemistry and Chemical Engineering. B.S. program is accredited by the AIChE.

1952 A Division of Chemical Engineering is created within the Department of Chemistry and Chemical Engineering. Professor Kenneth Gordon joins the faculty (left, 1954, for University of Michigan).

1953 Professor Eugene Petersen (retired, 1991) joins the faculty.

1954 Professor Andreas Acrivos joins the faculty (left, 1963, for Stanford).

Prof. Eugene Petersen



Prof. Scott Lynn

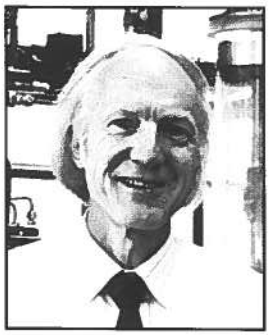
1955 Professor John Prausnitz joins the faculty.

1956 Professor Donald Olander joins the faculty (left, 1961, for UCB Nuclear Engineering Department).

1957 Chemical Engineering is established as a separate department.

1958 Professor David Lyon (retired, 1982) joins the faculty.

1961 Professors Alan Foss (retired, 1994) and Michel Boudart (left, 1965, for Stanford; appointed Adjunct Professor, 1994-97) join the faculty. Professors Simon Goren (chair 1994-97) and Richard Wallace (resigned, 1965) join the faculty.


Prof. Alan Foss

1963 Professors Edward Grens (retired, 1987), C. Judson King (chair 1972-81), John Newman, Richard Ayen (left, 1968, for Stauffer Chemical Co.) join the faculty.

1964 Professor Robert Merrill joins the faculty (left, 1977, for Cornell).

1965 Professor Michael Williams (retired, 1989) joins the faculty.

1966 Professor Robert Pigford joins the faculty (returned, 1975, to University of Delaware). Room 307 Gilman Hall designated a registered National Historic Landmark by the U. S. Department of the Interior as the location for the discovery of plutonium.

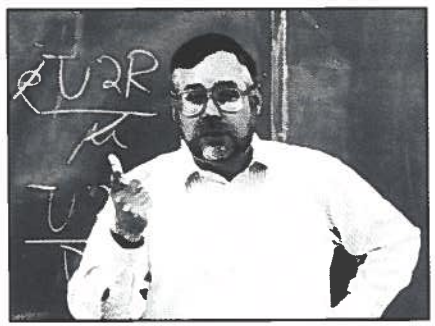

Prof. Michael WIlliams with two students.


Prof. John Newman

1967 Professors Scott Lynn (retired, 1994) and Alexis Bell (chair 1981-91) join the faculty.

1969 Professor Mitchell Shen joins the faculty (deceased, 1979).

1970 Professors Lee Donaghey (left, 1977, for Chevron) and Thomas Sherwood (deceased, 1976) join the faculty.


Prof. Clayton Radke

1975 Professor Clayton Radke joins the faculty.

1977 Professor Dennis Hess (left, 1991, for Lehigh University) joins the faculty.

1978 Professors Elton Cairns and Harvey Blanch (chair 1997-) join the faculty.

1979 Professors David Soane (Soong; left, 1994, for Soane Technologies; appointed Adjunct Professor, 1994) and Edward Reiff (left, 1982, for DuPont) join the faculty.


Prof. Elton Cairns

1981 Professor Morton Denn (chair 1991-94) joins the faculty.

1982 Professors Jeffrey Reimer and James Michaels (left, 1989, for Mobil) join the faculty.

1986 Professors Douglas Clark, David Graves, and Doros Theodorou (left, 1994, for University of Patras) join the faculty.

1988 Professor Arup Chakraborty joins the faculty.


Prof. Douglas Clark


Prof. Jeff Reimer

1991 Professor Susan Muller joins the faculty. Room 307 Gilman Hall designated a Nuclear Historic Landmark by the American Nuclear Society as the site of the first chemical identification of plutonium on February 23-24, 1941.

1992 Professor Jay Keasling joins the faculty.

1993 Professors Enrique Iglesia and Roya Maboudian join the faculty. Construction of Tan Hall begins.

1997 Gilman Hall designated as an ACS National Historic Chemical Landmark. Dedication of Tan Kah Kee Hall, April 12, 1997.

1999 Professor David Schaffer to join the faculty.

Chemical Engineering Faculty, 1982

Photo Credits: Greg Butera, Dan Krauss, Harry Schelber, Christopher Springmann