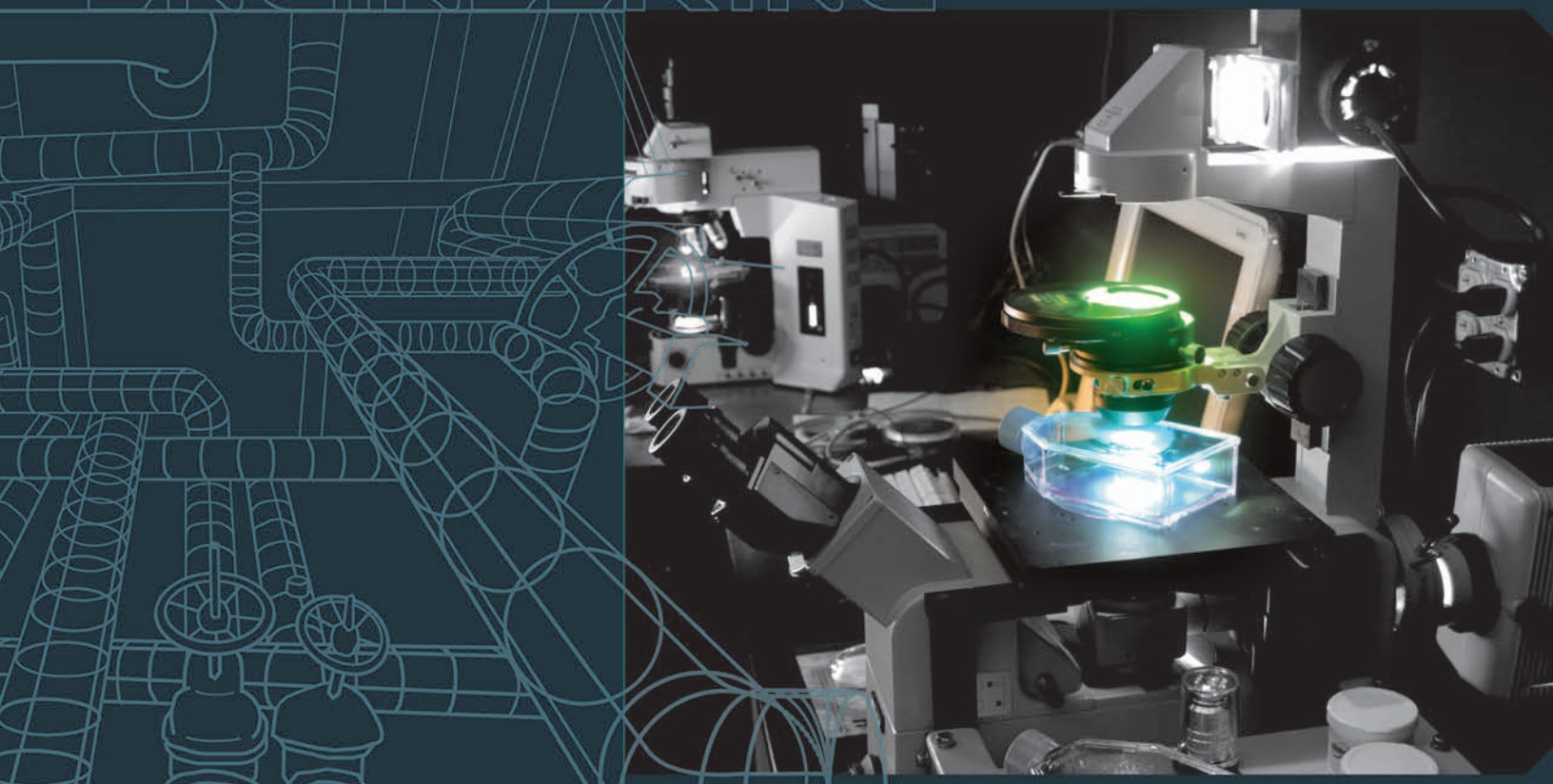
UNIVERSITY *of* HOUSTON

DEPARTMENT OF CHEMICAL ENGINEERING



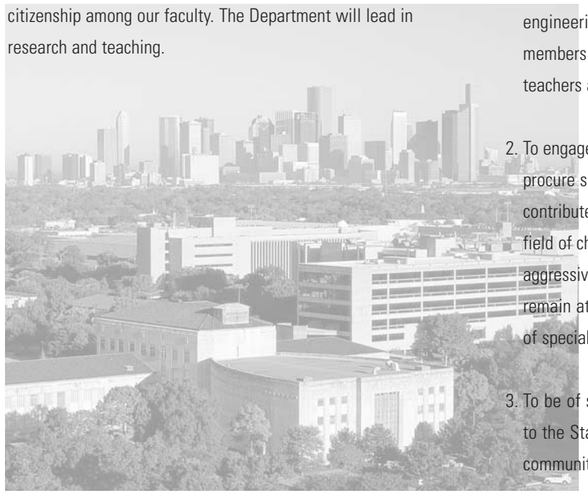
2002-2003 ANNUAL REPORT

INTRODUCTION

This Annual Report describes the activities and accomplishments of the Chemical Engineering Department at the University of Houston during the 2002–2003 academic year. Information is provided regarding Departmental activities spanning education and research.

VISION STATEMENT

The Department will regain international prominence within five years, through leadership in three core research areas and our graduating students becoming leaders in the field. The Department will create the highest level of enthusiasm, collegiality, and citizenship among our faculty. The Department will lead in research and teaching.



MISSION STATEMENT

1. To provide a high-quality education for undergraduate and graduate Chemical Engineering students through a comprehensive curriculum that emphasizes basic science, mathematics, engineering science, and engineering design. UH ChE faculty members are expected to maintain their reputations as superior teachers and to provide a stimulating educational environment.

2. To engage in research programs that train graduate students, procure support for this research on a continuous basis, and contribute to the development of fundamental knowledge in the field of chemical engineering. Our Department's varied and aggressively pursued research ensures that our faculty members remain at the technological forefront of their respective areas of specialization.

3. To be of service to the community at large and, in particular, to the State of Texas, and to provide the local engineering community opportunities for advanced and continuing education.

A special thanks to Mr. Toban Dvoretzky for compilation of this Report, as he has done in stellar fashion on a regular basis since he conceived and produced the inaugural issue in 1992.

Prepared by the University of Houston Department of Chemical Engineering, Toban Dvoretzky

Produced by the UH Cullen College of Engineering Office of Communications, Chelsea Windlinger, Harriet Yim

UNIVERSITY OF HOUSTON
CULLEN COLLEGE OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING

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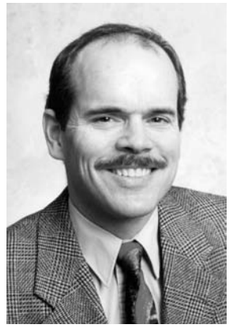
CHAIRMAN'S SUMMARY



This report provides an update of the accomplishments, initiatives, and directions of the Department of Chemical Engineering at the University of Houston.

The Department is doing very well during the continued transitional period of the chemical engineering field. Our undergraduate program has sustained enrollments with a larger fraction of our students gaining employment in nontraditional areas. Our graduate program is very healthy due to the strong surge in support of research projects spanning upstream energy, environmental reaction engineering, biomaterials, polymers, and electronic materials.

During this period, we have continued to expand as a faculty, with particular growth emphasis on the biological and materials areas. Our most recent hires, Drs. Peter Vekilov, Vince Donnelly, and Adam Capitano, typify the new directions of the field with their research of crystallization of biomolecules, nanoscale plasma deposition, and cell printing. Several UH faculty have become affiliated and adjunct members of our Department, including Dr. Veronique Tran, UH undergraduate alumna, who is the first hire in the new Biomedical Engineering Program; and Dr. Akhil Bidani (M.D.), UH PhD alumnus, who is Professor of Pulmonary Medicine at the University of Texas Health Science Center.

For our alumni: I encourage you to contact us and to share with us your accomplishments. We would like to enhance our interactions with our alumni, many of whom reside in the greater-Houston area.

I hope that you find the report informative. I invite you to peruse the report and to give any feedback or suggestions. I also invite you to visit our web site (http://www.chee.uh.edu/) where we provide news items connected with accomplishments of our students, faculty, and alumni.

Sincerely,

Mike Harold
Department Chair

STRATEGIC PLAN
DEPARTMENT OF CHEMICAL ENGINEERING

Long-Range Goals

Overall Program

» Sustain top ranking among Chemical Engineering Departments.
» Grow the Chemical Engineering Department to at least 20 full-time, research-active faculty with improved diversity (women and minorities).
» Establish stronger industrial interactions, especially with companies in the greater-Houston area.
» Improve infrastructure and facilities to promote scholarly research.

Graduate Program

» Increase scholarly output and recognition in terms of doctoral students, publications, invited lectures, and awards.
» Improve the quality of incoming graduate students.
» Establish three research centers of excellence that involve at least three Chemical Engineering faculty members in each. These centers should attract major funding from industrial and governmental sources. The centers are key to enhancing the external visibility and reputation of the Department.
» Increase the number and percentage of domestic graduate students.
» Through research partnerships and programs, take full advantage of the unique geographical location that the Department enjoys as a result of its proximity to the chemical, energy, and medical industries.

Undergraduate Program

» Recruit more and better full-time undergraduate students, focusing on both academic ability and leadership potential.
» Create an undergraduate curriculum that is responsive to changes in the Chemical Engineering field and which prepares students for a breadth of employment opportunities. The curriculum should include training that prepares students for employment, including communication skills, ethics, and financial engineering.
» Sustain high ranking of undergraduate program.

Outreach

» Conduct research that will directly benefit the State of Texas, particularly the greater-Houston area.
» Enhance the interactions with Chemical Engineering alumni, particularly those who reside in the local area.
» Provide educational opportunities for the community through specialized courses and short courses.

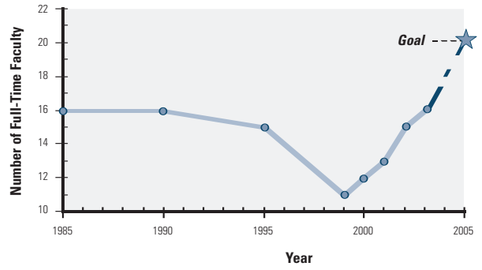


Figure 1. **Faculty Size**

Short-Term Objectives

1. **Overall Program**
a. Grow the department by at least four full-time faculty members, with at least one hire in materials and two in bioengineering.
b. Implement new Departmental name and undergraduate curriculum.
c. Improve research infrastructure.
d. In partnership with the College of Engineering, initiate new B.S. option in Biomedical Engineering.
e. Raise funds for endowed chair in Chemical and Biological Engineering.

2. **Graduate Program**
a. Increase research expenditures from approximately $150K to $200K per FTE (or a 33% increase).
b. Continually improve the quality of graduate students.
c. Increase the number of incoming domestic graduate students to at least 40% of the incoming full-time students (or a 100% increase). Establish scholarships and industrial intern program to attract students.
d. Establish a critical size in at least two core research areas that are central to the future of the Chemical Engineering profession. The research should span the fundamentals and applications in order to attract financial support from government and industry sources. The research should also involve collaboration between faculty in the Department and with other Engineering and Science faculty.
e. Establish two research centers of excellence in the Department, funded either by major government programs (e.g., NSF center) or industrial consortia members; center examples include
» Environmental reaction engineering
» Molecular bioengineering
» Thin-film electronic and polymeric materials
f. Improve the Master of Chemical Engineering program.
g. Reduce teaching loads for full-time, research-active faculty from average of 2.5–3 to 2–2.5 courses per academic year.

3. **Undergraduate Program**
a. Enhance size and quality of the undergraduate student body.
b. Continually upgrade undergraduate curriculum by (i) being more flexible for student interns, (ii) being responsive to the emerging materials and biotechnology trends in the field, and (iii) delivering excellent and up-to-date courses to our students.
c. Implement new information technology into at least three undergraduate courses, including but not limited to visualization tools, computational examples using fluid dynamics and finite-element codes, and web-based instruction.
d. Continue to adhere to Year-2000 ABET guidelines and criteria.
e. Modernize the undergraduate lab by investing in new experiments and upgrading existing experiments.

4. **Income-Producing Programs**
Establish and run at least three income-producing educational or research programs, including
» Petroleum Engineering MS in Mexico
» Chemical Engineering MS in Mexico
» Licensing of "Toluene Methylation Technology"

5. **Outreach and Communication**
a. Establish semiannual Departmental Newsletter, Annual Report, and continually upgraded Departmental web site and Graduate Brochure.
b. Increase contributions from industry for undergraduate and graduate scholarships, facilities, and equipment by 100%.
c. Establish improved relations with alumni through activities and alumni involvement in departmental initiatives. Seek to increase alumni contributions by 100%.

As of Fall 2004, the Department of Chemical Engineering will comprise 10 full professors, four associate professors, one assistant professor, two professors emeriti, three affiliated faculty, three adjunct associate professors, and 22 lecturers.

// Faculty Research Interests //

PROFESSORS

AMUNDSON, NEAL R. (PhD Mathematics, Minnesota, 1945). Cullen Professor & Professor of Mathematics. Atmospheric aerosols and particulates; reaction and diffusion; air-quality modeling.

BALAKOTAIAH, VEMURI (PhD ChE, Houston, 1982). John and Rebecca Moores Professor. Chemical reaction engineering—modeling and analysis of catalytic monoliths; numerical computation and bifurcation analysis of homogeneous and wall-catalyzed reacting flows; spatiotemporal patterns in catalytic reactions and reactors. Multiphase flow—studies on wavy films in gas-liquid two-phase flows; studies on gas-liquid two-phase flows in normal and microgravity conditions. Biomedical Engineering—modeling of oxygen transport in tissues and tumors; pulmonary gas-exchange modeling.

DONNELLY, VINCENT M. (PhD Phys. Chem., Pittsburgh, 1977). Plasma diagnostic techniques, plasma-processing chemistry and physics, plasma etching for microelectronics and nanotechnology applications, plasma/surface interactions, applications for plasma-treated surfaces.

ECONOMIDES, MICHAEL J. (PhD Petr. E., Stanford, 1984). University Professor. Petroleum-production engineering; reservoir stimulation (fracturing and acidizing); advanced reservoir-exploitation strategies; next-generation high-intensity design.

ECONOMOU, DEMETRE J. (PhD ChE, Illinois, 1986). John and Rebecca Moores Professor; Associate Department Chairman; Director of Undergraduate Studies. Plasma reactor modeling and simulation; plasma diagnostics; processing with energetic neutral beams; etching and deposition of thin solid films for microelectronic-device fabrication; environmental remediation; surface modification of materials.

EHLIG-ECONOMIDES, CHRISTINE (PhD PetrE, Stanford, 1978). Director, Petroleum Engineering Program. Reservoir appraisal and development; data interpretation; analytical models for well-test analysis, drilling, production enhancement, oil recovery.

FLUMERFELT, RAYMOND W. (PhD ChE, Northwestern, 1965). Dean of Engineering. Processing of cellular materials; environmentally benign blowing agents; nucleation in low-surface-energy materials; rheological behavior of base polymers; viscoelastic-film drainage and stability; biodegradable products for consumer applications.

HAROLD, MICHAEL P. (PhD ChE, Houston, 1985). Dow Chair Professor & Department Chairman. Multifunctional chemical reactor synthesis and analysis; high-purity hydrogen generation for fuel cells; integrated catalytic filtration devices for diesel-exhaust abatement; multiphase selective oxidation of hydrocarbons.

LUSS, DAN (PhD ChE, Minnesota, 1966). Cullen Professor. Chemical reaction engineering; dynamics of chemically reacting systems; hot-spot formation in packed-bed reactors; production of synthesis gas in membrane reactors; electrical and magnetic-field formation during high-temperature solid reactions.

MOHANTY, KISHORE K. (PhD ChE, Minnesota, 1981). Transport in microstructured media; improved oil-recovery; colloids and complex fluids; functional biomaterials.

RICHARDSON, JAMES T. (PhD Physics/Chemistry, Rice, 1955). Heterogeneous catalysis; catalytic processes; reactor engineering; solar energy; catalytic destruction of hazardous wastes; gas-to-liquid conversion processes; high-temperature superconductivity; solid-oxide fuel cells; ceramic membrane reactors; combinatorial catalysis.

ASSOCIATE PROFESSORS

KRISHNAMOORTI, RAMANAN (PhD ChE, Princeton, 1994). Director of Graduate Admissions. Structure/processing/property relations for multiphase polymers; polymer crystallinity in bulk and thin films; thermodynamics and viscoelasticity of polymer blends and copolymers; nanocomposite structure and viscoelasticity.

NIKOLAOU, MICHAEL (PhD ChE, UCLA, 1989). Process simulation, control, optimization; computer-aided process engineering.

VEKILOV, PETER G. (PhD Chemistry, Russian Academy of Sciences, 1991). Protein crystallization, intermolecular interactions, phase diagrams; thermodynamics, nucleation, phase transitions in protein solutions; physico-chemical aspects of sickle-cell anemia; structural biology; crystal growth.

WILLSON, RICHARD C. (PhD ChE, MIT, 1988). Joint Associate Professor, Biochemical & Biophysical Sciences. Biochemical separations; molecular recognition and diagnostics.

ASSISTANT PROFESSOR

CAPITANO, ADAM T. (PhD Chemistry, Michigan, 1999). Tissue-based biosensors for defense of water systems; development of fluorescent assays for differentiated cell function; two-photon microscopic characterization of three-dimensional cultures; tissue engineering of heart valves; adaptation of three-dimensional printing technology for tissue engineering.

PROFESSORS EMERITI

HENLEY, ERNEST J. (DSc ChE, Columbia, 1953).

TILLER, FRANK M. (PhD ChE, Cincinnati, 1946).

AFFILIATED FACULTY

ANNAPRAGADA, ANANTH V. (PhD ChE, Michigan, 1989). Associate Professor, UT Health Sciences Center at Houston. Novel drug-delivery systems; MEMS technology applied to drug-delivery; engineered porous particles for aerosol drug-delivery, simulation of particle flow in pulmonary airways, targeted drug-delivery for cancer, early cancer detection by novel contrast agents.

BIDANI, AKHIL (PhD ChE, Houston, 1975; MD, UT-Galveston, 1981). Professor of Medicine, UT Health Sciences Center at Houston. Characterizations and strategies pertaining to pulmonary medicine, respiratory physiology, gas exchange, capillary blood flow.

BRIGGS, JAMES M. (PhD Chemistry, Purdue, 1990). Assistant Professor, Biochemical & Biophysical Sciences. Computer simulation of biomolecules; HIV-1 integrase inhibitor design; re-engineering of enzyme substrate specificity.

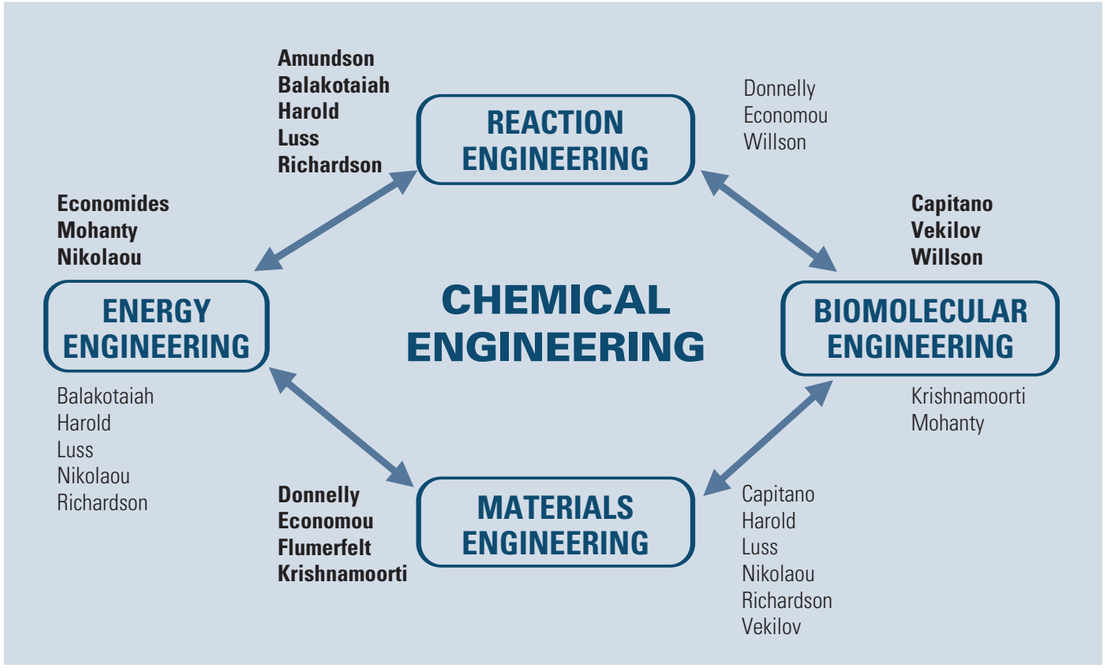


Figure 2. **Research Classification of the Faculty**

FOX, GEORGE E. (PhD Chemistry, Syracuse, 1974). Professor of Biology & Biophysical Sciences. Artificial RNA technology; microbial monitoring; RNA design.

LEE, T. RANDALL "RANDY" (PhD Chemistry, Harvard, 1991). Professor of Chemistry. Preparation and characterization of nanoscale materials, with focus on carbon nanotubes, polymers, organic thin films, nanoparticles. Synthesis (organic, inorganic, organometallic, solid-state to prepare new materials for emerging technologies.

PERRY, SCOTT S. (PhD Chemistry, U. Texas at Austin, 1991). Professor of Chemistry. Physical/materials chemistry, surface science, scanning-probe microscopy, tribology, metal carbides/oxides, organic thin films, educational technology.

TRAN, VERONIQUE V. (PhD Biomedical E., UT Southwestern Medical Center, 2002). Joint Assistant Professor of Biomedical Engineering & Chemical Engineering. Cellular engineering; bioactive surfaces; drug-delivery systems.

ADJUNCT PROFESSORS

FLEISCHER, MIGUEL T. "MICKY" (PhD ChE, Houston, 1978).

ROOKS, CHARLES W. "MICKEY" (PhD ChE, Oklahoma, 1973). Director, Undergraduate Practices Laboratory.

ADJUNCT ASSOCIATE PROFESSOR

MARPLE, STANLEY JR. (PhD ChE, MIT, 1943).

LECTURERS

ChE.:
Dr. Ahmed Alim, Dr. Fouad Khoury, Dr. Herbert C. McKee, Dr. Angelo Montagna, Dr. Ravindra Saxena, Albert Swarts

Petr. E.:
Dr. Jeffrey F. App, Dr. Jon Burger, Dr. Amiel David, Dr. Birol Dindoruk, Robert O. Hubbell, Ross Kastor, David Murphy, Dr. Fred Ng, Dean C. Rietz, Dr. Grant E. Robertson, Dr. G.S. Robello Samuel, Dr. Luigi Saputelli, Dr. John Thuren, Dr. Donald van Nieuwenhuise, Dr. Jeffrey Yarus

// Departmental Research Activities //

Prof. **VEMURI BALAKOTAIAH**'s research involves the mathematical modeling and analysis of the interactions between the transport processes and chemical reactions in various systems of engineering interest. The objective of the research is to gain a fundamental understanding of the complex behavior of these systems and use this understanding to practical advantage. His group's current research projects include modeling and analysis of catalytic monoliths (for pollution-reduction in automobiles, oxidation of VOCs, power generation, and removal of NOx from exhaust gases); numerical computation and bifurcation analysis of homogeneous and wall-catalyzed reacting flows; spatiotemporal patterns in catalytic reactions and reactors; studies on wavy films in gas-liquid two-phase flows; and studies on gas-liquid two-phase flows through packed beds under normal and microgravity conditions.

The research performed by Prof. **JIM BRIGGS** focuses on computational studies of protein structure and function, inhibitor design, investigations of possible inhibitor-resistance pathways, and development of methods for the above work. Targets for these studies include those important in the treatment of AIDS, cancer, tuberculosis, and other disease states.

Prof. **ADAM CAPITANO** focuses on the use of engineered biological tissues to solve real-world problems. Improvements in cell-culture technology and increased understanding of cellular biochemistry have allowed the complex interplay of cells to be harnessed to form more-complicated structures. Tissue cultures can be designed for purposes ranging from the sensing of chemical-warfare agents to organ repair. One research thrust involves using liver-tissue culture to detect dangerous chemical compounds, including aflatoxin B1 and microcystin-LR. Another focus involves adaptation of 3-D fabrication technologies to construct tissues, with one important application being the tissue-engineering of heart valves.

Prof. **VINCE DONNELLY**'s research interests are mainly in materials processing, and particularly plasma processing. He extends current knowledge about plasma physics and chemistry to even smaller nanoscale features. His current and future interests in experimental plasma diagnostics include development of optical diagnostic techniques for plasma processing, measurement of electron temperatures and energy distributions, and studies of plasma-surface interactions during etching of silicon and other microelectronic materials.

Prof. **MICHAEL ECONOMIDES**' research involves the optimization of the overall hydrocarbon-production system from the reservoir and the wellbore to the market. He is currently conducting industry efforts for developing deep offshore technology, world energy scenario forecasts, and natural-gas development. His group's current research projects include petroleum production engineering (improving reservoir deliverability through fracturing, acidizing, and lift performance); complex well architecture in petroleum production; reservoir stimulation; advanced reservoir-exploitation strategies; and next-generation high-intensity design.

The research of Prof. **DEMETRE ECONOMOU** includes: [a.] Plasma etching and deposition: large-scale numerical simulations of plasma flow and chemistry in complex multi-dimensional geometries; fluid and direct-simulation Monte Carlo (DSMC) approaches; plasma diagnostics, involving laser-induced fluorescence, mass spectrometry, *in situ* real-time multichannel laser interferometry, and ion-energy and angular-distribution detectors. [b.] Plasma physics, including electron velocity distribution functions; plasma heating; and new plasma sources and chemistries for advanced integrated-circuit manufacturing. [c.] Chemical vapor deposition, specifically metallorganic chemical vapor deposition (MOCVD) of thin films. [d.] Atomic-layer processing, involving nanofabrication, and experimental realization of atomic-layer etching and molecular-dynamics simulation of the interaction of energetic beams with crystal surfaces.

The laboratory of Prof. **GEORGE FOX** conducts ongoing basic research efforts to understand the structure, function, and evolution of RNA. These studies utilize tools of bioinformatics and molecular biology. When needed, atomic-resolution RNA structures are determined by high-resolution structure studies by NMR. Of special interest are the ribosomal RNAs of the protein-synthesis machinery whose sequences and structures are providing insight into the early evolution of life. Applied research derives from the core RNA research and focuses on the use of RNA in various applications. These include the development of monitoring methods for the rapid detection and identification of bacteria in Space and Biodefense applications; the development, production, and use of artificial RNAs; and the monitoring of bacteria during bioremediation.

The research interests of Prof. **MIKE HAROLD** are in the area of chemical reaction engineering. His groups carry out fundamental experiments complemented by mathematical modeling in order to understand reaction-transport interactions in chemical reactors, and to develop customized reactors for specialized applications. Areas of particular interest include reaction-separation devices and materials, environmental reaction engineering, and multiphase transport and reaction. Ongoing projects include multifunctional chemical reactor synthesis and analysis (consolidating heat-exchange and separation into single, multifunctional devices); high-purity hydrogen generation for fuel cells (converting methanol into high-purity hydrogen for on-demand supply to a proton-exchange membrane fuel cell); integrated catalytic filtration devices for diesel-exhaust abatement (reducing particulates and NOx in the net-oxidizing exhaust of lean-burn gasoline and diesel vehicles); and multiphase selective oxidation of hydrocarbons (elucidating the interactions of chemistry and transport phenomena, and developing operating schemes to optimize the contacting of hydrocarbon and oxygen).

Prof. **RAMANAN KRISHNAMOORTI** and his groups undertake research that aims to understand the structure-processing-property relations in nano- and microstructured multiphase polymer materials, building on strong collaborations with industry, national laboratories, and academia. The foremost and unique aspect of the research program has been the capability to synthesize well-defined and controlled materials (polymers and inorganic materials) and combine this with well-established measurement techniques to examine fundamental molecular and macroscopic properties that determine and characterize the final properties of multiphase polymer systems. Five specific current projects are: effect of pressure on the phase behavior of polyolefin blends; polymer crystallinity in bulk and thin films; phase transitions in block copolymers and block-copolymer-based balanced microemulsions; structure and viscoelasticity of macro- and nanocomposites; and structure and transport in biopolymers.

Prof. **RANDY LEE** and his group focus on organic and materials research chemistry. The six general areas include selectively fluorinated organic thin films; complex organic interfaces with controlled local composition, structure, and function; biologically active interfaces; nanoparticle growth and manipulation; biopolymers and conducting polymers; and polymerization catalyst development. The common thread tying all of these research areas together is synthesis, whether organic, inorganic, organometallic, or solid-state, with the goal of preparing new materials for technological applications.

Several projects of Prof. **DAN LUSS**' research groups are associated with the dynamic features of chemically reacting systems, such as reverse-flow reactors, hot-spot formation in packed-bed reactors, and the temperature-rise during polyolefin polymerization via metallocene catalysts. Dr. Luss' groups also conduct research on the use of membrane reactors to produce synthesis gas, the destruction of nitrogen oxides in reverse-flow reactors, and the formation of electrical and magnetic fields during high-temperature solid reactions. Specific projects include: dynamics of chemically reacting systems (using bifurcation theory to classify the dynamic features of various chemical reactors, with application to the destruction of NOx); hot-spot formation in packed-bed reactors; production of synthesis gas in membrane reactors (optimizing the operation of a novel membrane reactor); and electrical and magnetic-field formation during high-temperature solid reactions (during the combustion of various metals).

Prof. **KISHORE MOHANTY**'s research focuses on transport of simple and complex fluids in complex microstructured materials for applications in energy, environment, and biotechnology. This research is aimed at imaging structures, understanding the physics of transport, relating the microstructures to transport coefficients, and developing new materials for enhanced targeted transport. Current research includes: transport in microstructured media (using microscopy, microtomography, CT-scanning, and NMR to image microporous materials and the transport within); improved oil recovery (studying oil extraction by miscible flooding, and probing the interaction between flow and phase behavior); colloids and complex fluids (fluids containing surfactants and polymers are

developed for stable foams, low-tension micellar solutions, and micelle-enhanced separation processes, with kinetics of hydrate dissociation being studied for potential production of natural gas from subsea hydrates); and functional biomaterials for controlled and targeted drug-delivery (probing the relations between the molecular interaction, material nanostructure, and transport/interfacial properties).

Prof. **MIKE NIKOLAOU**'s research interests are in computer-aided systems engineering. His work emphasizes the interplay between theory and applications in a number of industries, including chemicals, energy and petroleum, microelectronics, and food processing. Prof. Nikolaou's group develops new approaches for broad classes of problems, screens candidate technologies for specific applications, and develops proofs of concept or working prototypes, frequently in collaboration with industrial sponsors. Recent topics of interest with general applicability include model predictive control, nonlinear control, system identification and adaptive control, and performance-monitoring. Areas of application include petrochemical processes, oil and gas reservoir drilling and production systems, and plasma etching of semiconductors.

Prof. **SCOTT PERRY** employs scanning-probe microscopy and ultra-high-vacuum surface-analytical techniques to study the structure, chemical reactivity, and tribological properties of several different classes of material surfaces. These include metal oxides, carbides, and nitrides; ultra-thin polymer films; and organic self-assembled monolayers. The use of an array of experimental techniques is needed to develop a complete picture of these materials' surfaces. Current projects include studies of surface-chemical reactivity and functionalities of titanium carbide and vanadium; the correlation of molecular structure and the physical interfacial properties of molecularly thin coatings, with focus on wetting, adhesion, and friction; and size-dependent chemical and catalytic properties of nanometer-scale metal particles.

Prof. **JIM RICHARDSON**'s research involves experimental heterogeneous catalysis as related to industrial processes. Topics include heterogeneous catalysis and catalytic processes, reactor engineering, and catalyst preparation, characterization, and design; solar energy, solar-receiver design, and solar-related chemical processes; gas-to-liquid conversion processes; high-temperature superconductivity and processing of ceramic superconductors; solid-oxide fuel cells; ceramic membrane reactors; and combinatorial catalysis.

Prof. **VERONIQUE TRAN**'s research integrates strategies in cellular engineering, bioactive surfaces, and drug-delivery systems in order to influence cell function in the body. *In vitro* cell-culture models are used to test various aspects of the strategies. A major project in the lab is development of a local immune-privilege site for protection of an artificial pancreas for treatment of Type I (Juvenile) Diabetes. Other application areas include improving biocompatibility of cardiovascular devices and treatment of inflammatory diseases.

Prof. **PETER VEKILOV** carries out pioneering research in biomolecular engineering, with a focus on phase transitions occurring in solutions of biological macromolecules. Application areas include protein-condensation diseases, structural biology, and bio-based nanotechnology. His current research interests include: protein crystallization; physico-chemical aspects of sickle-cell anemia; crystallization tools for structural genomics; nucleation and phase transitions in protein solutions; protein intermolecular interactions and phase diagrams; criteria for the impact of reduced gravity on protein-crystal perfection; and kinetics and stability of crystal growth.

The major research interests of Prof. **RICHARD WILLSON** lie at the interface between the life sciences and engineering, and range from fairly basic investigations of fundamental phenomena to development of novel technologies. Specific areas: molecular recognition and adsorption, including separations of proteins and nucleic acids for purification and analysis, antibody and aptamer affinity and selectivity, and biophysical and structure/function characterization of driving forces and kinetics of interactions involving biological macromolecules; and environmental biotechnology, including microbial and enzymatic degradation of wastes, DNA probe technology, ribosomal RNA technology, and combinatorial methods.

// Current Research Projects & Grants //

Awards granted to the Department of Chemical Engineering

BALAKOTAIAH, VEMURI

$ 3,800,000 **City of Houston**
"Diesel Exhaust Abatement: Modeling and Experimental Studies" (2003–2007)
** jointly with Mike Harold, C.W. Rooks*

$ 405,000 **NASA Lewis Research Center**
"Fundamental Studies on Gas-Liquid Two-Phase Flows through Packed Beds in Microgravity" (2002–2006)
** jointly with M.J. McCready (Notre Dame)*

$ 155,000 **Dow Chemical Company, Freeport, TX**
"Bifurcation Analysis of Catalytic Reactors" (2003–2004)

$ 150,000 **Robert A. Welch Foundation**
"Modeling and Analysis of Spatiotemporal Patterns in Catalytic Reactions and Reactors" (2001–2004)

$ 150,000 **Texas Advanced Technology Program** & **Engelhard Corp.**
"Design and Optimization of a NOx Trap Reactor"
** jointly with Mike Harold*

$ 147,000 **Texas Advanced Technology Program**
"Novel Catalyst and Reactor Designs for Ultra-Low Vehicular Emissions" (2002–2003)

$ pending **NASA - Fluid Physics Program**
"Determination of Gravity Independence of Two-Phase Flows"
** jointly with Mark McCready (Notre Dame)*

CAPITANO, ADAM T.

$ 4,000 **UH Internal Educational Development**
"Development of Interactive Web-based Biomaterials Module" (2003)

DONNELLY, VINCENT M.

$ 1,000,000 **National Science Foundation**
"Nanopantography" (2003–2007)
** jointly with D. Economou, P. Ruchhoeft, S. Jin*

$ 470,000 **Department of Energy**
"Space-Resolved Studies of Microdischarges" (2003–2006)
** jointly with D. Economou*

$ 252,880 **Semiconductor Research Corporation**
"Etching of High-K Dielectric Materials" (2003–2006)

$ 250,000 **Semiconductor Research Corporation**
"Energetic Neutral Beams for Damage-Free Processing of Porous Ultra-Low-k Stacks" (2004–2006)
** jointly with D. Economou*

$ 180,000 **Texas Advanced Research Program**
"A Novel Method for Forming Any Complex Nano-Wire Pattern Over Large Areas" (2004–2005)
** jointly with D. Economou*

$ 160,000 **Texas Advanced Technology Program**
"Energetic (100's of eV) Neutral Beams for Advanced Microelectronics Manufacturing" (2004–2005)
** jointly with D. Economou*

$ 150,000 **Robert A. Welch Foundation**
"Chemical Mechanisms in Plasma-enhanced Chemical Vapor Deposition of Carbon Nanotubes" (2004–2006)

$ 80,000 **American Chemical Society Petroleum Research Fund**
"Heterogeneous Radical Recombination on Dynamic Surfaces in Reactive Environments" (2003–2006)

$ 40,000 **Semiconductor Research Corporation**
"A New Method for Massively Parallel Fabrication of Three-dimensional Nanostructures" (2004)

$ 25,500 **Seagate Corporation**
"Novel RIE Chemistries for the Patterning of Materials of Interest in Magnetic Storage Read/Write Head Structures" (2003–2004)

$ 21,700 **GEAR (University of Houston)**
"Etching of High-K Dielectric Materials" (2003–2004)

ECONOMIDES, MICHAEL J.

$ 153,000 **RPSEA**

ECONOMOU, DEMETRE J.

$ 1,000,000 **National Science Founation**
"NIRT-Nanopantography" (2003–2007)
** jointly wih V. Donnelly, P. Ruchhoeft, S. Jin*

$ 470,000 **Department of Energy/National Science Foundation**
"Spatially Resolved Diagnostics and Modeling of Microhollow Discharges" (2003–2006)
** jointly with V. Donnelly*

$ 354,907 **National Science Foundation**
"Non-Local Transport in Inductively Coupled Plasmas" (2000–2004)

$ 333,386 **National Science Foundation**
"Adaptive Design of Experiments for Optimum Uniformity in Semiconductor Manufacturing" (2002–2005)
** jointly with M. Nikolaou*

$ 160,000 **Texas Advanced Technology Program**
"Energetic (100s of eV) Directional Neutral Beams for Advanced Microelectronics Manufacturing" (2003–2004)
** jointly with V. Donnelly*

$ 75,000 **National Institute of Standards and Technology**
"Sheath Structure, and Flux, Energy and Angular Distributions of Ions over Topgraphical Feautures in Plasma Processing" (2002–2003)

$ 25,000 **International SEMATECH**
"Resist Cleaning Using Neutral Beams for Advanced Low-k Dielectrics" (2004)

$ 18,000 **GEAR (University of Houston)**
"A New Paradigm in Microelectronics Manufacturing Using Energetic Neutral Beams" (2003–2004)

(continued on page 10)

HAROLD, MICHAEL P.

$ 3,800,000 **City of Houston**
"Evaluation and Testing of Emission Control Devices for Diesel Exhaust Abatement" (2002–2007)
** jointly with C.W. Rooks, V. Balakotaiah*

$ 300,000 **Texas Advanced Technology Program & Engelhard Corp.**
"Design and Optimization of the NOx Trap Reactor" (2004–2005)
** jointly with V. Balakotaiah*

$ 199,300 **Texas Advanced Technology Program**
"Integrated Catalytic Filtration Devices for Diesel Exhaust Abatement of NOx and Particulates" (2003–2004)

$ 60,000 **American Chemical Society — Petroleum Research Fund**
"Shape-selective Pneumatic Membrane Reactors for Enhanced Conversion and Yield in Equilibrium-Limited Sequential-Parallel Reaction Systems" (2001–2003)

$ 11,500 **Environmental Institute of Houston**
"Development of a Sulfur-tolerant Catalytic Adsorbent for NOx Reduction in Diesel Exhaust" (2003)

$ 11,500 **Environmental Institute of Houston**
"Scouting Studies of Simultaneous Soot Oxidation and NOx Reduction in Diesel Engine Exhaust" (2004)

KRISHNAMOORTI, RAMANAN

$ 1,600,000 **National Science Foundation**
"Nanotube-based Polymer Networks" (4 years)
** jointly with Jim Tour (Rice), Tony Mikos (Rice)*

$ 375,000 **NASA**
URETI (5 years)

$ 374,195 **National Science Foundation: CAREER**
"Understanding the Role of Process Variables on Properties of Multiphase Polymeric Materials" (1998–2003)

$ 349,000 **ExxonMobil Chemical Company**
"High-Performance Polymeric Materials" (2001–2006)

$ 300,000 **DARPA**
"Microwave/Nanotube Interactions in Blends and Composites" (3 years)
** jointly with Jim Tour (Rice)*

$ 285,000 **National Science Foundation**
"Block Copolymer - Layered Silicate Nanocomposites: Fundamental Study of Structure - Processing - Property Relationships" (3 years)
** jointly with Devon Shipp (Clarkson)*

$ 145,000 **Robert A. Welch Foundation**
"Tailoring Crystallinity in Thin Polymer Films" (2000–2003)

$ 60,000 **Carbon Nanotechnologies Inc.**
"Carbon-nanotube-based Polymer Composites" (1 year)

$ 60,000 **Carbon Nanotechnologies Inc.**
"Single-walled Carbon-nanotube-based Polymer Nanocomposites: Dispersion and Tailoring of Properties" (1 year)

$ 50,000 **Texas ARP-ATP; TD&T**
"Molecular Interactions between Phosphatidylcholine and NSAIDs: From Bench to Bedside" (2 years)
** jointly with Len Lichtenberger, V. Jayaraman (UTH); Rob Raphael (Rice); G. Anand (Baylor)*

$ 30,000 **Halliburton**
"Micellar Structure Determination" (1 year)

$ 26,000 **NIST**
"Combinatorial Screening of Nanocomposites: Mechanical & Vapor-Barrier Properties" (2000–2001)

LUSS, DAN

$ 291,948 **National Science Foundation**
"Electromagnetic Fields Produced by Self-Propagating High-Temperature Synthesis (SHS)" (2001–2004)

$ 246,773 **National Science Foundation**
"Formation and Motion of Transversal Hot Zones in Packed-bed reactors" (2002–2004)

$ 150,000 **Robert A. Welch Foundation**
"Temperature-Patterns Formation and Dynamics in Shallow Packed-bed Reactors" (2002–2004)

$ 80,000 **American Chemical Society — Petroleum Research Fund**
"Novel membrane reactor for synthesis-gas production" (2002–2003)

MOHANTY, KISHORE K.

$ 3,000,000 **U.S. Department of Energy**
"Exploitation & Optimization of Reservoir Performance in Hunton Formation, OK" (2000–2004)
** jointly with M. Kelkar (U of Tulsa)*

$ 744,250 **U.S. Department of Energy**
"Development of Shallow Viscous Oil Reserves in North Slope" (2001–2004)

$ 741,782 **U.S. Department of Energy**
"Relative Permeability Estimation from Imaging and Compositional Analysis" (2003–2006)

$ 622,661 **U.S. Department of Energy**
"Dilute Surfactant Methods for Carbonate Formations" (2002–2005)

$ 107,100 **Texas Advanced Technology Program**
"Microtomographic Study of Carbonate Petrophysics" (2002–2003)

$ 87,200 **Texas Advanced Technology Program**
"Degradable Nanoporous Microparticles for Tunable Pulmonary Drug Delivery" (2004–2005)
** jointly with A. Annapragada*

$ 96,000 **Texas Hazardous Waste Research**
"VOC Emission Control at Oil-loading Terminals" (2000–2003)

$ 50,030 **GCHSRC**
"Nanoscale Fe-Biosurfactant Colloidal Solution for Rapid *in situ* Treatment of Contaminated Sites" (2003–2004)
** jointly with C. Vipulanandan*

$ 44,601 annually **GCHSRC**
"Biosurfactant Produced from Used Vegetable Oil for Removal of Metals from Wastewaters and Soils" (2000–2003)
** jointly with C. Vipulanandan*

NIKOLAOU, MICHAEL

$ 340,000 **National Science Foundation**
"Adaptive Design of Experiments for Optimal Uniformity in Semiconductor Manufacturing" (starting 2003)
** jointly with Prof. D.J. Economou*

$ 80,000 **American Chemical Society — Petroleum Research Fund**
"A New Approach to High-Performance Drilling of Hydrocarbon Wells" (starting 2004)

$ 30,000 **American Chemical Society — Petroleum Research Fund**
KBR

$ 25,000 **Lam Research**
Gift

$ 20,000 **Shell Global Solutions**
Gift

RICHARDSON, JAMES T.

$ 185,800 **Texas Higher Education Coordinating Board (ATP)**
"More-Efficient Ceramic Membrane Reactors" (2000–2003)

$ 165,000 **Gulf Coast Hazardous Substances Research Center**
"Improved Halogen Resistance of Catalytic Oxidation through Efficient Catalyst-Testing" (2001–2003)
** jointly with R. C. Willson*

$ 155,000 **Texas Higher Education Coordinating Board (ATP)**
"Improved Catalytic Combustion System" (2003–2004)

$ 50,000 **U.S. EPA Gulf Coast Hazardous Substances Research Center**
"Improved Combustion Catalyst for NOx Emission Reduction" (2003–2004)

$ 15,000 **Houston Environmental Institute**
"Improved Catalysts for Catalytic Combustion" (2003–2004)

VEKILOV, PETER G.

$ 1,134,062 **NASA**
"Effects of Convective Transport of Solute & Impurities on Defect-Causing Kinetics Instabilities" (1999–2004)

$ 791,000 **NASA**
"Physico-chemical Tools for Rational Optimization of the Growth Conditions of Biological Crystals" (2001–2004)

$ 80,000 **American Chemical Society — Petroleum Research Fund**
"Dynamics and Structures of Liquid-Liquid Phase Separation in Protein Solutions" (2002–2004)

$ 10,000 **DuPont Chemicals**
"Dynamics of the Liquid-Liquid Phase Separation in Protein Solutions" (2002–2004)

WILLSON, RICHARD C.

$ 4,996,946 **NSF — CREST Center for Nanomagnetic System**
(2004–2009)
** jointly with J. Wolfe & five others*

$ 1,532,428 **NASA — National Space Biomedical Research Institue**
"Microorganisms in the Spacecraft Environment" (2004–2008)
** jointly with G. Fox*

$ 594,000 **NIH — NIAID**
"Ultraspecific Probes Detecting CDC Category A & B Agents" (2004–2006)
** jointly with Y. Fofanov, G. Fox*

$ 399,260 **DOD/ Army Res. Ofc.**
"Ultraspecific Host-Blind Probes and Primers for Pathogen Detection" (2004–2007)
** jointly with G. Fox, Y. Fofanov*

$ 350,000 annually **NASA — National Space Biomedical Research Institute**
(2000–2003)
** jointly with G. Fox*

$ 320,000 **National Science Foundation**
"Landmark Proteins for Improved 2-dimensional Electrophoresis"
** jointly with Y. Fofanov*

$ 300,000+ annually **NASA — Planetary Protection Program**
"Quantitative Polymerase Chain Reaction (Q-PCR) Technology to Measure Molecular Contamination and Validate Subsystem Cleaning" (2004–2006)
** jointly with A. Driks*
+ $60,000 annually to Willson lab

$ 270,000 **National Science Foundation**
"Competitive Ion-Exchange Adsorption of Proteins" (2001–2004)

$ 225,000 **Texas Learning and Computation Center**
"Genomic N-mer Arrays for Organism Identification" (2001–2004)
** jointly with Y. Fofanov, G. Fox*

$ 165,000 **U.S. EPA Gulf Coast Hazardous Substances Research Center**
"Improved Halogen Resistance of Catalytic Oxidation through Efficient Catalyst-Testing" (2001–2003)
** jointly with J.T. Richardson*

$ 153,000 **Robert A. Welch Foundation**
"Biophysical Chemistry of Molecular Recognition" (2002–2005)

$ 115,000 **Institute of Space Systems Operations**
"The Effect of Simulated Microgravity on Microbial Gene Expression" (1999–2004)
** jointly with G. Fox*

$ 111,000 **U.S. EPA Gulf Coast Hazardous Substances Research Center**
"Enzymatic Detoxification of Cyanide Wastes" (2000–2003)
** jointly with M. Benedik*

// Faculty News & Activities //

EHLIG-ECONOMIDES HIRED: Prof. Christine A. Ehlig-Economides was hired as Full Professor, effective Fall 2003. She served the Department as Adjunct Professor for three years as a lecturer and as Director of the Petroleum Engineering Program while retaining her industrial position as Global Account Manager for Schlumberger.

Prof. Ehlig-Economides earned a B.A. in Math-Science at Rice University (1971), the M.A.T. degree in Math Education at the University of Kansas (1974), an MS in Chemical Engineering from Kansas (1976), and her PhD in Petroleum Engineering from Stanford University (1979). Her articulation and demonstration of the benefits of integrating geosciences and engineering perspectives in the context of underlying geological implications has opened opportunities to work with geoscientists in the industry in a leadership capacity. At the same time, she continues to exhibit technical prominence in core competencies relating to well-testing, well-productivity, and classical reservoir engineering.

She has received many honors from the Society of Petroleum Engineers and was elected to the National Academy of Engineering in 2003.

TRAN HIRED: Veronique V. Tran joined the newly formed Biomedical Engineering Program as an Assistant Professor in Spring 2004, with a joint position in the Department of Chemical Engineering. Prof. Tran is an alumna of the UH Chemical Engineering undergraduate program, having received her B.S. degree in 1991. She previously worked for Shell Western Exploration and Production, Inc. (a subsidiary of Shell Oil) for four years. She returned to graduate school in 1995 and received her PhD in Biomedical Engineering from the Joint Program in BME at the University of Texas Southwestern Medical Center in Dallas and the University of Texas at Arlington. From 2002–2003, she served as a postdoctoral associate at Yale University in Prof. W. Mark Saltzman's Laboratory for Drug-Delivery and Tissue Engineering.

In Summer 2004, Prof. Tran received The Whitaker Foundation's Teaching Materials Award in support of the textbook that she is co-authoring with W. Mark Saltzman of Yale University. The introductory biomedical engineering textbook, **Biomedical Engineering: Bridging Medicine and Technology**, is to be published by Cambridge University Press in 2005.

PROF. RICHARD WILLSON delivered seven invited seminars during the year. He and his group members presented 10 papers and posters at conferences. Prof. Willson's involvement in technical meetings included service on the Programming Committee of the ACS Division of Biochemical Technology; as poster co-chair at the 11th International Conference on Recovery of Biological Products; on the Scientific Committee and as session chair at the 15th International Symposium on Affinity Technology and Biorecognition; and on the Scientific Committee of the 13th International Symposium on Analysis and Separation of Proteins, Peptides, and Polynucleotides. He serves on five editorial advisory boards and participates in three national review panels.

PROF. PETER VEKILOV served as a member of the Program Committee and as session organizer for the 15th American Conference on Crystal Growth and Epitaxy. He participates on an NSF review panel. He is a topic editor for *Crystal Growth & Design*. He and his group gave six invited research presentations and contributed to three more. Prof. Vekilov delivered 13 invited seminars during the year, including six internationally. He is the Director of the interdisciplinary Graduate Program in Biomedical Engineering at the University of Houston. His research group's work was featured on the cover of *Science* (vol. 299, 14 February 2003).

PROF. FRANK M. TILLER is an honorary professor at five Latin American universities, and he holds two honorary doctorates.

PROF. JAMES T. RICHARDSON presented two invited seminars during 2003. He participated in the *In-situ* Resource Utilization Program panel (NASA) and in the DOE's "Go/No-Go Panel on Fuel Processing for Fuel Cells." He continues as co-lecturer (with Prof. D. Luss) of the five-day short course "Applications of Heterogeneous Catalysis," presented semiannually by the Department. He has been involved in the development of seven patents.

PROF. MICHAEL NIKOLAOU coauthored paper SPE 71647, which won the Halliburton Energy Services Award. He co-chaired a session at the AIChE Annual Meeting and a workshop at the University of Houston. Amidst presenting five invited technical papers and two invited seminars, he remained exceptionally active on University, College of Engineering, and Departmental committees.

PROF. KISHORE MOHANTY received *Chemical Weekly's* Padmashri Dr. G.P. Kane Chemcon Distinguished Speaker award (Indian Institute of Chemical Engineers) in 2003. His two-year term as Executive Editor of the *SPE Journal* ended this year; he continues as an associate editor of *Vadose Zone Journal*. He served on an NSF review panel, chaired a session at the AIChE Annual Meeting, and participated on the SPE Gas Condensate ATW Organizing Committee. He serves on the UH Radiation Safety Committee and as the Department's Director of Graduate Studies (effective Fall 2003). His research group's work was presented on seven occasions during 2003.

PROF. DAN LUSS delivered two invited seminars in Germany during 2003 and presented a paper at the VIIth International Congress on SHS in Krakow, Poland. For not the first time, he won the Best Applied Paper award from the South Texas Section of the AIChE. He served as President of the ISCRE USA Board and as a member of the Technical Program Committee of ISCRE 18. He continues as editor of *Reviews in Chemical Engineering* and as editor of Plenum's *Chemical Engineering Series*, both for 20+ years.

PROF. RAMANAN KRISHNAMOORTI delivered seven invited seminars and presented five invited papers. He organized the Filled Polymer symposium session at the MRS meeting in Boston and served on an AIChE Programming Committee. He served on the editorial board for the *Journal of Polymer Science: Polymer Physics* and as editor of the special edition on Polymer Nanocomposites for that publication.

The second edition of the 1998 book "Separation Process Principles," coauthored by **PROF. ERNEST HENLEY** and J.D. Seader, now in its fifth printing, is due to be released by J. Wiley & Sons in Fall 2005.

PROF. MICHAEL HAROLD learned of his selection as a 2004 guest editor for *Catalysis Today* and as a member of the NSF's Career Award panel for Process & Reaction Engineering. During 2003, he and his group presented six papers, and he delivered that same number of invited seminars. He continues as Vice-Chair of the AIChE's Publications Committee, and, of course, as chairman of the UH Department of Chemical Engineering. With Profs. V. Balakotaiah, J.T. Richardson, and C.W. Rooks, he procured a multimillion-dollar grant from the City of Houston to reduce NO_x emissions in diesel vehicles.

During 2003, **PROF. DEMETRE ECONOMOU** was elected as a Fellow of the American Vacuum Society, and he earned a Teaching Excellence award from the UH Cullen College of Engineering. He served on the International Editorial Board of *Materials Science in Semiconductor Processing* and as guest co-editor of the special issue of "Plasma Science" for *IEEE Trans.* He served on four NSF panels, delivered two invited seminars, and with his group gave seven research presentations. In addition to continuing as Associate Chairman of the Chemical Engineering Department, he serves on two University committees, six College committees, and six Departmental committees.

PROF. MICHAEL ECONOMIDES participated in 15 continuing-education and short courses during 2003. He was published in daily newspapers eight times on energy and petroleum issues. He continued his annual schedule of delivering dozens of invited seminars around the U.S. and the world.

PROF. VINCENT DONNELLY delivered the featured invited talk at the 51st Annual American Vacuum Society Symposium:

"Plasma Processing Diagnostic Methods & Studies: A Historical Perspective." Prof. Donnelly also won the 5th Annual PSTD Prize for Science & Technology, presented by the Plasma Science & Technology Division of the American Vacuum Society.

PROF. ADAM CAPITANO presented an invited paper at the BMES Annual Meeting in Nashville during 2003. He serves on four committees within the University, College of Engineering, and Department.

PROF. VEMURI BALAKOTAIAH published 14 articles in refereed journals during 2003. He and his group presented six papers at conferences, and he delivered an invited seminar in Germany. Prof. Balakotaiah was instrumental in helping procure a multimillion-dollar grant for the Department from the City of Houston for reduction of NO_x emissions in diesel vehicles. He also won the prestigious UH Research & Scholarship Award in 2003.

PROF. NEAL R. AMUNDSON is a member of the National Academy of Engineering, the National Academy of Sciences, and the American Academy of Arts & Sciences. He was the first recipient of the Neal R. Amundson Prize, awarded at each ISCRE meeting to a recognized leader in the field of chemical reaction engineering. He also holds four honorary doctorates. The Chemical Engineering Building at the University of Minnesota is named in his honor.

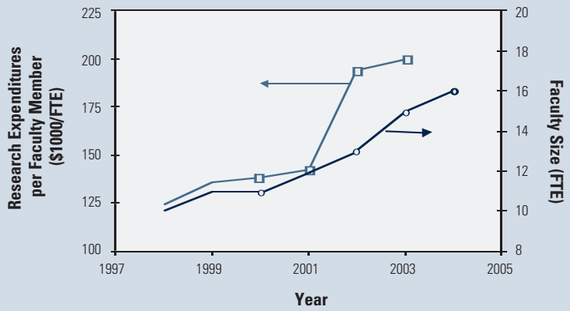


Figure 3. **Trends in Research Expenditures**

($1000's)	1997–98	1998–99	1999–00	2000–01	2001–02	2002–03
Federal	528	865	745	1084	1736	1749
Private	145	172	170	218	321	333
Industrial	531	376	459	432	318	479
State (Research)	308	269	373	192	306	371
State (HEAF)	43	40	67	113	399	151
City (Research)	0	0	0	0	0	300
Endowments/Fees	383	366	306	393	258	334
Univ. (personnel)	1458	1371	1644	1776	2238	2547
TOTAL	3396	3459	3766	4209	5577	6263
Research Expend.	*1246*	*1494*	*1518*	*1710*	*2521*	*2992*
FTE	*10*	*11*	*11*	*12*	*13*	*15*
RE/RTE ($1000/FTE)	**125**	**136**	**138**	**143**	**194**	**199**
RE/(Univ.+HEAF)	**0.83**	**1.06**	**0.89**	**0.91**	**0.96**	**1.11**

Figure 4. **Department Expenditures**

// Institute for Improved Oil Recovery (IIOR) //

in the University of Houston Department of Chemical Engineering

Contact:

Prof. Kishore K. Mohanty, Director

University of Houston

Department of Chemical Engineering

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Houston, TX 77204-4004

713-743-4331

713-743-4323 fax

The mission of the Institute for Improved Oil Recovery (IIOR) is to improve recovery of crude oil and natural gas under present-day economics, apply improved oil-recovery technology to the in situ *clean-up of hazardous wastes, and transfer technology to industry and national laboratories. The scope of the program encompasses R&D and field demonstration, testing, and evaluation.*

The Institute for Improved Oil Recovery (IIOR) conducts its university research via a research consortium that is funded by major oil and gas producers, service companies, the U.S. Department of Energy, and the state of Texas. After research has been conducted through cooperative university and industrial projects, results are presented in conferences and workshops around the United States.

Research areas include:

- Advanced computing technology applied to reservoir engineering
- Three-dimensional imaging of flow through porous media
- Gas-flooding methods (CO_2, hydrocarbon, N_2)
- Displacement mechanisms
- Foams
- Fractured reservoirs
- Formation evaluation
- Environmental engineering/containment technologies
- Particle transport, surface chemistry, wettability.

THE SIGNIFICANCE OF IMPROVED OIL-RECOVERY TECHNOLOGY:

The U.S. Department of Energy and other entities have estimated that less than one-third of the original oil in place can be produced with existing technologies. Hence, recovery of the remaining two-thirds constitutes the target for development of improved technologies. Approximately 341 billion barrels of mobile and immobile oil will remain bypassed or trapped in known U.S. reservoirs at the conclusion of conventional production. Of this remaining oil, it is estimated that an additional 76 billion barrels are recoverable by currently identified technologies with the application of well-designed R&D and technology-transfer strategies. This would sustain current levels of U.S. production for several decades, which is necessary for an orderly transition to alternative transportation fuels. Improved technology allows producers to work more efficiently and to extract more oil than otherwise.

The natural-gas supply from conventional resources is estimated to be approximately 800 trillion cubic feet (Tcf), of which 160 Tcf are proven reserves and 640 Tcf are inferred or undiscovered reserves. Half the conventional undiscovered gas is considered economical to produce, with improved recovery methods being necessary to convert this gas to reserves. The remaining 50% is also expected to require improved drilling, completion, and gathering technology. A reduction in imported oil could be one near-term payoff when new reserves are developed via improved exploration and extraction techniques. Fuel-switching in stationary markets could enable the replacement of two million barrels/day of oil (25% of imports) with 4 Tcf/year of gas. Technology can make a difference.

DEPARTMENTAL FUNDING, SUPPORT, RANKINGS, & TRENDS

DEPARTMENTAL SUPPORT & GRADUATE FELLOWSHIPS

As of September 2003, the UH ChE research program comprised 80 full- and part-time graduate students, 8 postdoctoral fellows, 46 Petroleum Engineering students, and 21 part-time Master of Chemical Engineering students (the industrially employed professionals who are attracted to our non-thesis terminal-degree option). The program is supported by the following sources:

State Budget		
Departmental	$	2,547,308.03
Research	$	482,461.32
HEAF	$	147,329.94
	$	**3,177,099.29**
Federal		
NASA	$	829,796.59
NSF	$	535,352.48
DOE/EPA	$	330,362.72
IDC	$	98,425.00
NIST	$	89,897.93
RPSEA	$	31,301.01
US-Foriegn Support	$	16,732.00
	$	**1,931,867.73**
University Funds		
Endowments & Fees	$	334,149.91
	$	**334,149.91**
Private Grants		
City of Houston	$	299,995.01
Welch Foundation	$	142,547.98
ACS-PRF	$	99,566.06
URA	$	47,613.97
	$	**589,723.02**
Industrial Funds		
Local Industrial Funds	$	302,623.70
ExxonMobil/Shell/Dow	$	175,242.51
	$	**477,866.21**
GRAND TOTAL	**$**	**6,510,706.16**

OUTSTANDING ALUMNI

These graduates of the UH Chemical Engineering program have received the UH Engineering Alumni Association's "Distinguished Alumnus" Award:

Robert Baldwin	BS, 1949
William Brookshire	BS, 1957
Robert M. Zoch, Jr.	BS, 1968
J.C.M. "Jimmy" Lee	PhD, 1970
Ravi Singhania	graduate work toward PhD

DONOR ORGANIZATIONS

The Department of Chemical Engineering is most grateful for the support contributed by these industrial, educational, and nonprofit organizations:

American Institute of Chemical Engineers
BASF Corporation
BP/Amoco
CAChE Corp.
Chevron U.S.A. Inc.
Council for Chemical Research
The Dow Chemical Company Foundation
The Dow Chemical Company
E.I. DuPont de Nemours & Company
ExxonMobil
Fluor Corp.
Halliburton Foundation, Inc.
The Lubrizol Foundation
Marathon Oil Company
Rohm and Haas Company
Shell Oil Company Foundation

INDUSTRIAL ADVISORY BOARD

The Chemical Engineering Department has an Industrial Advisory Board (IAB). The IAB provides the Chemical Engineering chairman and faculty an industrial perspective on important strategic and operational issues. With input and advice, the IAB addresses such salient topics as faculty hiring, student recruitment, curriculum content, and graduate research programs. The IAB members also provide a network through which fundraising efforts, student recruiting and internships, and engagement of alumni are enhanced.

Members of the IAB are:

ABB Lummus Global — Lummus Process Technologies (Houston, TX)
Dr. Dennis W. McCullough, Vice-President,
Strategic Business Development

Air Products & Chemicals, Inc. (Houston, TX)
Steve Pastore, Area Manager

Aspen Technology, Inc. (Houston, TX)
Rob Hawkins, Director, Product Marketing

Atofina Petrochemicals, Inc. (Deer Park, TX)
Dr. Michel Daumerie, Vice-President of Research & Technology
Dr. José Sosa, Research Scientist

BASF Corporation (Freeport, TX)
James P. Saccomanno, Operations Director

Bayer Corporation (Baytown, TX)
Dr. Thomas Daszkowski, Manager, Process Technology

Bechtel Corporation (Houston, TX)
Lance Murray, Principal Vice-President,
Manager of Refining Center of Excellence

BP North America, Inc. (Texas City, TX)
Gabriel W. Cuadra, General Manager, Strategy & Integration

ConocoPhillips Inc. (Houston, TX)
Jerry Feierabend, Manager, Upstream Process Engineering

Cutler Johnston Corporation (Barksdale, TX)
Dr. Charles R. Cutler, President

Dixie Chemical Company (Houston, TX)
John D. Super, Vice-President of Engineering & Commercial Development

The Dow Chemical Company (Freeport, TX)
Craig W. Snook, Director of Process Analytical, Texas Operations

Ethyl Corporation (Pasadena, TX)
Azfar Choudhury, Plant Manager

ExxonMobil Chemical (Baytown, TX)
Joseph E. Carey, Manager, Polypropylene Technology

Fluor (Sugar Land, TX)
Armando G. Almaguer, Executive Director, Process Engineering

Haldor Topsoe, Inc. (Houston, TX)
Niels Sorensen, Executive Vice-President & General Manager

Kellogg Brown & Root (Houston, TX)
Tim Challand, Vice-President, Worldwide Engineering, Onshore Operations

Lyondell (Houston, TX)
William H. McDowell, Distinguished Engineering Advisor

M.A. Ervin & Associates (Austin, TX)
Dr. Michael A. Ervin, President

Marathon Ashland (Texas City, TX)
Michael S. Armbrester, Division Manager

OxyVinyls, L.P. — Houston Operations (Deer Park, TX)
Kenneth J. Carlson, Technical Steward Manager

Rohm and Haas Texas Incorporated (Deer Park, TX)
Robert W. Brinly, President/Plant Manager

SAIC Consulting (Houston, TX)
M. Bernadette Cullinane, Assistant Vice-President

SABIC Americas, Inc. (Sugar Land, TX)
Dr. Scott Mitchell, Research Scientist/Team Leader

Schlumberger — Well Services (Sugar Land, TX)
Bruno Lecerf, Solutions Engineer

Shell Chemical L.P. (Houston, TX)
Dr. Carlos E. Garcia, Technology Manager, PDO/PTT

The Department was saddened by the untimely death of Robert J. Mitchell, Refining Process Engineering Manager, ConocoPhillips Inc. (Sweeny, TX) in Fall 2003. He was 49 years old.

// Graduate Ranking: National Research Council //

Besides featuring the top-ranked doctoral program in the University of Houston, the Chemical Engineering Department ranked in the top 20 nationally out of 93 ChE doctoral programs rated by the National Research Council (1995):

RELATIVE RANKINGS FOR RESEARCH-DOCTORATE PROGRAMS IN CHEMICAL ENGINEERING

OVERALL RANKING	INSTITUTION	NRC SCORE
1	University of Minnesota	4.86
2	Massachusetts Institute of Technology	4.73
3	University of California, Berkeley	4.63
4	University of Wisconsin (Madison)	4.62
5	University of Illinois (Urbana-Champaign)	4.42
6	California Institute of Technology	4.41
7	Stanford University	4.35
8	University of Delaware	4.34
9	Princeton University	4.14
10	University of Texas at Austin	4.08
11	University of Pennsylvania	3.97
12	Carnegie Mellon University	3.87
13	Cornell University	3.86
14	University of California, Santa Barbara	3.82
15	Northwestern University	3.75
16	Purdue University	3.67
17	**UNIVERSITY OF HOUSTON**	**3.66**
18	University of Michigan	3.52
19	City University of New York	3.46
20	University of Washington	3.44
T21	University of Massachusetts at Amherst	3.35
T21	Rice University	3.35
23	Pennsylvania State University	3.34
24	University of Notre Dame	3.30
25	North Carolina State University	3.20
26	University of Colorado	3.18
27	Lehigh University	3.13
28	University of California, Davis	3.11
29	State University of New York at Buffalo	3.08
T30	University of Virginia	3.01
T30	Georgia Institute of Technology	3.01

Source: NRC report, "Research-Doctorate Programs in the United States: Continuity and Change" (1995). The NRC produces these reports once every 10 years.

// Enrollment Trends & Degrees Conferred //

Enrollment figures are as of the start of the Fall semesters in the years indicated.
Degree figures are totals of those conferred at the ends of the Spring semesters in the years indicated.

UNDERGRADUATE ENROLLMENT & DEGREES CONFERRED:

YEAR:	1996	1997	1998	1999	2000	2001	2002	2003
Fall Enrollment:	460	383	373	317	295	291	327	315
BS Degrees:	43	40	36	40	29	31	40	38

GRADUATE ENROLLMENT & DEGREES CONFERRED:

YEAR:	1996	1997	1998	1999	2000	2001	2002	2003
Fall Enrollment:	113	98	95	103	94	99	99	113
MS Degrees in ChemE:	12	9	16	14	9	11	10	7
MS Degrees PetroleumE:	16	7	8	6	7	8	9	31
PhD Degrees:	16	7	12	7	6	10	7	13
MChE Degrees:	6	6	7	6	8	4	6	2

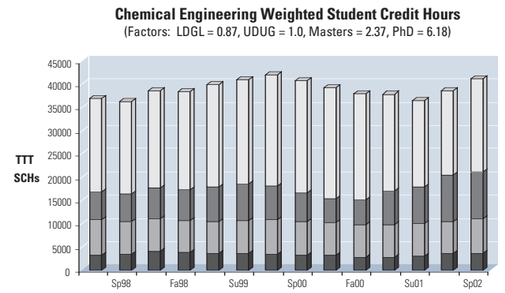

Figure 5. **Weighted Student Credit Hours**
A trendline of the weighted student credit hours shows a modest growth.

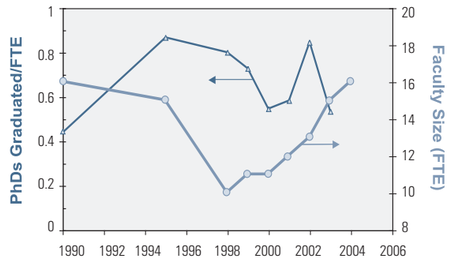

Figure 6. **PhD Productivity Trend**

YEAR:	1985	1990	1995	2000	2001	2002	2003
Faculty:	16	16	15	12	13	15	16
Enrollment							
» Undergraduate:	229	313	445	295	291	330	315
» Graduate:	66 *	126	135	112	99	102	110
Student/Faculty							
» Undergraduate:	14	20	28	25	22	22	20
» Graduate:	4.1*	7.9	9.0	9.3	7.6	7.9	7.3

**Excludes MChE students*

Figure 7. **Faculty and Student-Body Trends**

// Students Receiving Degrees //

** NOTE: Some students have filed Privacy Requests and are thus not listed here.*

2002–2003 BS CHE GRADUATES WITH HONORS AND/OR MEMBERSHIP IN THE HONORS COLLEGE

Michael J. Aguirre *(cum laude)*
Kerem Aydogan *(cum laude)*
Gregory M. Barnes *(honors)*
Lisa M. Bergeron *(magna cum laude, honors)*
Hanskarl H. Borck *(cum laude, honors)*
Brooke L. Butts *(summa cum laude)*
Kristina M. Carr *(cum laude, honors)*
H. Jeannie Flippen *(magna cum laude)*
Thomas S. Hitchcock *(honors)*
Aunberin N. Khan *(honors)*
Mei Yee Khoo *(summa cum laude)*
Greg G. LoTurco *(magna cum laude)*
Shane A. Mansur *(cum laude)*
Jason P. Manthey *(magna cum laude, honors)*
Kristina Martinez *(honors)*
Ashwin G. Menon *(cum laude)*
Alay A. Patel *(cum laude)*
Matt D. Peel *(magna cum laude)*
Joel Roberts *(cum laude)*
Yanez A. Singh *(magna cum laude, honors)*
Weng Soong Soo *(cum laude)*
Cong T. Trinh *(summa cum laude)*

Cong Trinh was named the "Departmental Outstanding Senior."

Lisa Bergeron was graduated with University Honors and Honors in Major, the latter for her thesis *Entropy and Hydrophobicity in Crystallization of Insulin* (Prof. P. Vekilov, advisor).

RECIPIENTS *(since Summer 2002)*

M.S. in Chemical Engineering
Luis F. Filobelo
Maria Gennata
Dimitra K. Georgiou
Nikhil B. Joshi
Nitika Kalia
Berkan Kaya
Deepti Machiraju
Balamurali K. Nair
Narender R. Nanchary
Aysu Ozturk
Erwin Rusli
Anita Seethepalli
Emre Serpen
Keyur S. Shah

M.S. in Petroleum Engineering
Neal J. Adams
Kerati Charnvit
Apostolos Chomatas
Asim A. Deshpande
Oluyinka A. Jimoh
Madhu A. Kulkarni
Lina M. Marin
Kiran M. Mehendale
Richard M. Parma
John C. Rasmus
David E. Rios-Aleman
Jacouba Traore
Jacob T. Wilkie

Master of Chemical Engineering
Robert M. Dannels
David J. Grattan II
Andrzej C. Nowakowski

2002–2003 RECIPIENTS, PHD IN CHEMICAL ENGINEERING

Saikat Chakraborty, Averaging Theory and Low-dimensional Models for Homogeneous and Catalytic Reactors *(V. Balakotaiah, advisor)*

Jinxia Deng, Structure-based Drug Design on HIV-1 Integrase and Brownian Dynamics Studies of the Phosphate Receptor from M. tuberculosis *(J. Briggs, advisor)*

Pankaj S. Gautam, Multiphase Transport through Complex Composite Media *(K. Mohanty, advisor)*

Keesu Jeon, Crystallization Behavior in Thin Polymer Films *(R. Krishnamoorti, advisor)*

Bharat M. Marwaha, Dynamics of Transverse Hot Zones in Shallow Packed-bed Reactors *(D. Luss, advisor)*

Pratik Misra, Studies on Identification and Nonlinearity Assessment of Multivariable Control Systems *(M. Nikolaou, advisor)*

Kanaka R.M. Panga, Modeling and Analysis of Multiscale Reaction and Transport Problems *(V. Balakotaiah, advisor)*

Dimitrios Sagias, Control of Nonlinear Processes at Various Steady States: Controller-Performance Monitoring and Controller Adaptation *(M. Nikolaou, advisor)*

Sathish Sankaran, Development of Process Models from Operation Data: Studies in Hydraulic Fracturing and Predictive Control *(M. Nikolaou, advisor)*

Luigi A. Saputelli, Self-learning Reservoir Management: Adaptive Control of Three-phase Fluid Migration in Multilayer Oil Reservoirs *(M. Economides, advisor)*

FACULTY PUBLICATIONS

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Saul, J.M., A. Annapragada, J.V. Natarajan and R.V. Bellamkonda, "Controlled Targeting of Liposomal Doxorubicin via the Folate Receptor in vitro," *J. Cont. Rel.* **92I**, 49-67 (2003).

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Balakotaiah, V. and S. Chakraborty, "Averaging Theory and Low-Dimensional Models for Chemical Reactors and Reacting Flows," *Chem. Eng. Sci.* **58**, 4769-4786 (2003).

Panga, M. and V. Balakotaiah, "Low-Dimensional Models for Vertically Falling Viscous Films," *Phys. Rev. Lett.* **90**, #15, 154501-1 to 154501-4 (April 2003).

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Bhattacharya, M., M.P. Harold and V. Balakotaiah, "Mass Transfer Coefficients in Washcoated Monoliths," *AIChE J.* (accepted for publication, 2004).

DONNELLY, VINCENT M.

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ECONOMIDES, MICHAEL J.

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EHLIG-ECONOMIDES, CHRISTINE A.

Nonrefereed publications:

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HAROLD, MICHAEL P.

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LEE, T. RANDALL

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Lee, T.-C., D.J. Hounihan, R. Colorado Jr., J.-S. Park and T.R. Lee, "Stability of Aliphatic Dithiocarboxylic Acid Self-Assembled Monolayers on Gold," *J. Phys. Chem. B* **108**, 2648-2653 (2004).

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Saputelli, L. and M. Nikolaou, "Multiphase Fluid Migration In Layered Oil Reservoirs with Field-Wide Control and Optimization," paper 437g, AIChE Annual Meeting, San Francisco (2003).

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Saputelli, L., M. Economides, M. Nikolaou and A. Demarchos, "Real-Time Decision-Making for Value Creation while Drilling and Well Intervention," paper AADE-03-NTCE-12, 2003 National Technology Conference "Practical Solutions for Drilling Challenges," Houston, Texas (1-3 April 2003).

PERRY, SCOTT S.

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Lin, H., S.-T. Yau and P.G. Vekilov, "Dissipating Step Bunches during Crystallization under Transport Control," *Phys. Rev. E* **67**, 0031606 (2003).

Petsev, D.N., X. Wu, O. Galkin and P.G. Vekilov, "Thermodynamic Functions of Concentrated Protein Solutions from Phase Equilibria," *J. Phys. Chem. B* **107**, 3921-3926 (2003).

Gliko, O., I. Reviakine and P.G. Vekilov, "Stable Equidistant Step Trains during Crystallization of Insulin," *Phys. Rev. Lett.* **90**, 225503 (2003). Featured in *Physics News Update* **636** #2, May 7, 2003.

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Vekilov, P.G., *Solvent Entropy Effects in the Formation of Protein Solid Phases*, in **Methods in Enzymology**, Volume 368: "Macromolecular Crystallography, Part C" edited by C.W. Carter, Jr. and R.M. Sweet, (Academic Press, San Diego, 2003), pp. 84-105.

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Vekilov, P.G., "Microscopic, Mesoscopic, and Macroscopic Lengthscales in the Kinetics of Phase Transformations with Proteins," in *From Fluid-Solid Interfaces to Nanostructural Engineering*, edited by J.J. De Yoreo and X.Y. Lui (Kluwer Press, New York) (accepted for publication, 2004).

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WILLSON, RICHARD C.

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Murphy, J.C., G.E. Fox and R.C. Willson, "Enhancement of Anion-Exchange Chromatography of DNA Using Compaction Agents," *J. Chromatogr. A* **984**, 215-21 (2003).

Mourich, D.V., M.W. Munks, J.C. Murphy, R.C. Willson and A.B. Hill, "Spermine Compaction is an Efficient and Economical Method of Producing Vaccination-Grade DNA," *J. Immunol. Methods* **274**, 257-264 (2003).

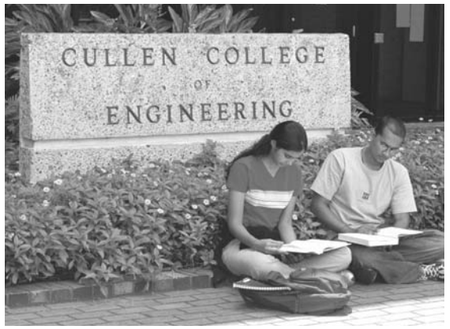
Nonrefereed Publications:

Guest Editor, Special Issue on Nucleic Acid Technology, *Biotechnology Progress* (in press, 2004).

THE UNDERGRADUATE PROGRAM

The UNDERGRADUATE CHEMICAL ENGINEERING PROGRAM of the UNIVERSITY OF HOUSTON is consistently rated among the top programs in the country (10th in the Gourman Report).

// ChE UNDERGRADUATE ADMISSION //



Students seeking admission as freshmen to the Cullen College of Engineering should refer to: **www.uh.edu/enroll/admis/freshman_req.html** for the current and complete requirements.

Students aspiring toward undergraduate Chemical Engineering study at the University of Houston may request applications from:

Undergraduate Admissions Office
University of Houston
122 E. Cullen Bldg.
Houston, TX 77204-2023, U.S.A.

ENROLLMENT TRENDS:

YEAR*	ENROLLMENT
1975	237
1980	356
1981	423
1982	470
1983	596
1984	322
1985	229
1986	167
1987	205
1988	200
1989	260
1990	313
1991	385
1992	479
1993	545
1994	480
1995	445
1996	460
1997	383
1998	373
1999	317
2000	295
2001	291
2002	327
2003	315

** at the beginning of the academic period.*

Figures since 1991 include students registering as Postbaccalaureates. Enrollment figures have followed national trends.

The success of our program is due to the soundness of our undergraduate curriculum, the commitment of our faculty (all of whom teach undergraduate courses), and the support of local petroleum and petrochemical industries. We look forward to continued growth in the future and to the changes in chemical engineering education demanded by the 21st century.

Transfer applicants who have earned fewer than 15 semester hours of college credit must meet the engineering requirements for high-school graduates. Applicants who have earned between 15 and 29 semester hours of college credit must meet all of these requirements:

1. A grade-point average (GPA) of 2.50 or higher for all college-level work attempted.
2. A GPA of 2.50 or higher for all college-level mathematics courses attempted.
3. A GPA of 2.50 or higher for all college-level chemistry and physics courses attempted.
4. A GPA of 2.50 or higher for all college-level English courses attempted; international students must have a TOEFL score of 550.
5. A GPA of 2.50 or higher for all college-level engineering courses attempted.
6. Must have attempted at least one college-level mathematics course and at least one college-level physics or chemistry course.

Applicants with special questions about the undergraduate Chemical Engineering program may contact:

Mrs. Sharon Gates
Undergraduate Assistant Advisor
University of Houston
Chemical Engineering
S222 Engineering Bldg. 1
Houston, TX 77204-4004, U.S.A.
Phone: 713-743-4325
E-mail: SMGates@uh.edu

UH Chemical Engineering Undergraduate Enrollment

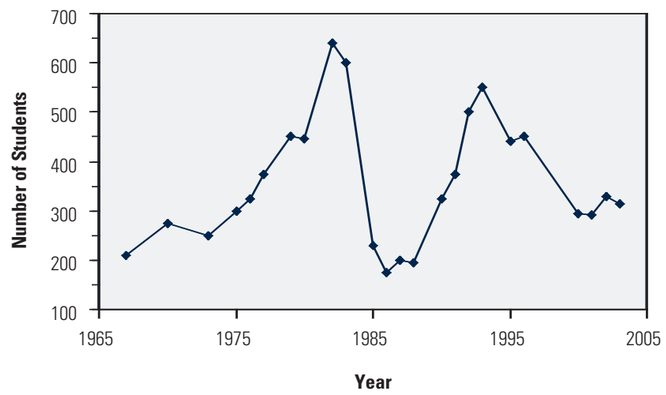


Figure 8. **Undergraduate Enrollment Trends**

// Undergraduate Courses: Chemical Engineering (CHEE) //

1131: Challenge of Chemical Engineering Cr. 1 (1-0). *Prerequisites:* Science or Engineering major. The Chemical Engineering professions. Strongholds and frontiers of Chemical Engineering. Career opportunities for chemical engineers. Communication skills; engineering ethics.

1331: Computing for Engineers (also CIVE 1331, INDE 1331) Cr. 3 (2-2). *Prerequisite:* MATH 1431. Credit cannot be received for more than one of CHEE 1331, CIVE 1331, or INDE 1331. Introduction to the computing environment, matrix arithmetic, programming essentials, spreadsheets, symbolic algebra tools, solution of typical engineering problems using computer tools.

2331: Chemical Processes Cr. 3 (3-0). *Prerequisites:* CHEE or CIVE 1331, MATH 1432, PHYS 1321, and credit for or concurrent enrollment in MATH 2433 and CHEM 1332. Introduction to chemical engineering, calculations, unit equations, process stoichiometry, material and energy balances, states of matter, case studies.

2332: Chemical Engineering Thermodynamics I Cr. 3 (3-0). *Prerequisites:* CHEM 1332, MATH 2433, PHYS 1321, CHEE 2331. Fundamental concepts of thermodynamic systems, heat and work, properties of pure substances, first and second laws.

3300: Materials Science & Engineering I Cr. 3 (3-0). *Prerequisite:* CHEE 2331, CHEM 1332, PHYS 1321, and credit for or concurrent enrollment in MATH 3321. Properties of materials, with emphasis on metals, ceramics, polymers, and electronic materials.

3333: Chemical Engineering Thermodynamics II Cr. 3 (3-0). *Prerequisite:* CHEE 2332. Multicomponent systems, phase equilibria, and prediction of thermodynamic properties.

3334: Statistical & Numerical Techniques for Chemical Engineers Cr. 3 (3-0). *Prerequisites:* CHEE or CIVE 1331, CHEE 2332, MATH 3321 or equivalent, and credit for or concurrent enrollment in ENGI or CHEE 3363. Statistics for chemical engineers, curve-fitting, numerical methods in linear algebra, nonlinear algebraic equations, ordinary and partial differential equations, optimization. Special emphasis on problems appearing in chemical engineering applications.

3363: Fluid Mechanics for Chemical Engineers (formerly ENGI 3363) Cr. 3 (3-0). *Prerequisites:* CHEE 2332, MATH 3321 or equivalent, MECE 3400, PHYS 1321, and credit for or concurrent enrollment in CHEE 3334. Foundations of fluid mechanics, fluid statics, kinematics, laminar and turbulent flow; macroscopic balances; dimensional analysis and flow correlations.

3367: Process-Modeling & Control Cr. 3 (3-0). *Prerequisites:* CHEE 3334, CHEE or ENGI 3363, MATH 3321, and PHYS 1322. Modeling techniques of chemical engineering problems, with emphasis on process control.

3369: Chemical Engineering Transport Processes Cr. 3 (3-0). *Prerequisite:* CHEE or ENGI 3363. Mass transfer in single- and multiphase systems and combined heat- and mass-transfer. Selected topics in heat and mass transfer, and in heat and momentum transfer.

3399-4399: Senior Honors Thesis Cr. 3 per semester. *Prerequisites:* senior standing; 3.00 cumulative grade-point average in chemical engineering and overall.

3462: Unit Operations Cr. 4 (3-1 [1-2]). *Prerequisites:* CHEE 3333, CHEE or ENGI 3363, and credit for or concurrent enrollment in CHEE 3369. Unit operations, with emphasis on distillation, absorption, extraction, and fluid-solid systems.

3466: Biological & Physical Chemistry Cr. 4 (4-0). *Prerequisite:* CHEE 3333, CHEM 3332. Introduction to biochemistry, and physical-chemical topics including chemical kinetics and adsorption.

4198:4298:4398:4498: Special Problems Cr. 1-4 per semester, or more by concurrent enrollment. *Prerequisite:* approval of the Chairman.

4300: Materials Science & Engineering II Cr. 3 (3-0). *Prerequisites:* CHEE 3300, 3333, 3363. Advanced topics in the selection and design of materials. Topics covered will include phase diagrams, corrosion and degradation, property selection and control, and four topical case studies.

4321:4322: Chemical Engineering Design Cr. 3 per semester (3-0). *Prerequisites:* CHEE 3333, 3462, 3369, and credit for or concurrent enrollment in CHEE 4367. Computer-aided design of chemical processes, with emphasis on process economics, profitability analysis, and optimal operating conditions.

4361: Chemical Engineering Practices Cr. 3 (1 1/2-5). *Prerequisites:* CHEE 3462, 3467, 3369, and credit for or concurrent enrollment in CHEE 4367. Design and execution of experiments, with emphasis on heat and mass transport, unit operations, process control, and reactors. Written reports.

4366: Biochemical Engineering Cr. 3 (3-0). *Prerequisites:* CHEE 3466 and credit for or concurrent enrollment in CHEE 4367. Analysis and design fundamentals for biochemical process, reactor design, transport phenomena; applications of enzymes and microbial populations.

4367: Chemical Reaction Engineering Cr. 3 (3-0). *Prerequisites:* CHEE 3366 and 3369. Chemical-reaction kinetics, mechanisms, and reactor design in static and flow systems; introduction to heterogeneous catalytic reactions in flow systems.

5360: Biochemical Engineering Fundamentals Cr. 3 (3-0). *Prerequisite:* credit for or concurrent enrollment in CHEE 4367. Analysis and design fundamentals for biochemical process, reactor design, transport phenomena; applications of enzymes and microbial populations.

5367: Advanced Process Control Cr. 3 (3-0). *Prerequisite:* CHEE 3367 or consent of instructor. Application of the use of high-speed computers in the control of chemical processes, reactors, and units.

5371: Pollution-Control Engineering Cr. 3 (3-0). *Prerequisites:* credit for or concurrent enrollment in CHEE 4321 and CHEE 4367. Pollution problems and remedies with the Earth as an environmentally closed system. Limitations of absorption and self-cleaning for terrasphere, hydrosphere and atmosphere, and their interrelationship.

5373: Environmental Remediation Cr. 3 (3-0). *Prerequisites:* ENGI 3363, CHEE 3462, and credit for or concurrent enrollment in CHEE 4367. In situ and ex situ methods of remediation or restoration of contaminated environmental sites. Emphasis is on hydrocarbon contaminants in soil, surface water, and groundwater.

5374: Reaction Kinetics for Industrial Processes Cr. 3 (3-0). *Prerequisite:* Credit for or concurrent enrollment in CHEE 4367. Methods for predicting product distribution in practical chemical reactors. Determination of thermochemical and kinetic constants from statistical mechanics and transition-state theory. Applications from vapor-phase processes to catalysis.

5375: Chemical Processing in Microelectronics Cr. 3 (3-0). *Prerequisite:* CHEE 4367 or consent of instructor. Chemical engineering principles applied to microelectronic-device fabrication and processing.

5376: Solid/Liquid Separation—Environmental Processes Cr. 3 (3-0). *Prerequisite:* CHEE or ENGI 3363. introduction to solid/fluid separation and processing. Particle characteristics, porous media; interfacial phenomena; flow through compactible and granular beds; sedimentation, clarification, filtration, centrifugation, expression, washing.

5377: Introduction to Polymer Science Cr. 3 (3-0). *Prerequisite:* CHEE 3363, and either 3366 or 3466 or consent of instructor. Synthesis, characterization, physical properties and processing of polymeric materials. Methods to measure and characterize the correlations among structure-processing properties of polymeric materials.

5379: Safety & Reliability Cr. 3 (3.0). *Prerequisites:* CHEE 3363, 3369, 3367. An overview of risk, safeguards, and hazards associated with chemical process engineering. Layers of protection, hazard identification, source-term models, toxic release and dispersion models, fires and explosions, probabilistic analysis, fault-tree analysis, designs to prevent accidents, safety-instrumented systems, and safety-related standards and regulations.

5380: Biochemical Separations Cr. 3 (3-0). *Prerequisite:* senior standing in Chemical Engineering, or consent of instructor. Producing cloned proteins in useful amounts; use of recombinant DNA methodologies to produce proteins; characterization methods.

5383: Advanced Unit Operations Cr. 3 (3-0). *Prerequisite:* senior standing in Chemical Engineering, or consent of instructor. Property prediction of multicomponent fluids. Advanced principles of heat-exchanger design, multicomponent fractionation, absorption, stripping, and extraction.

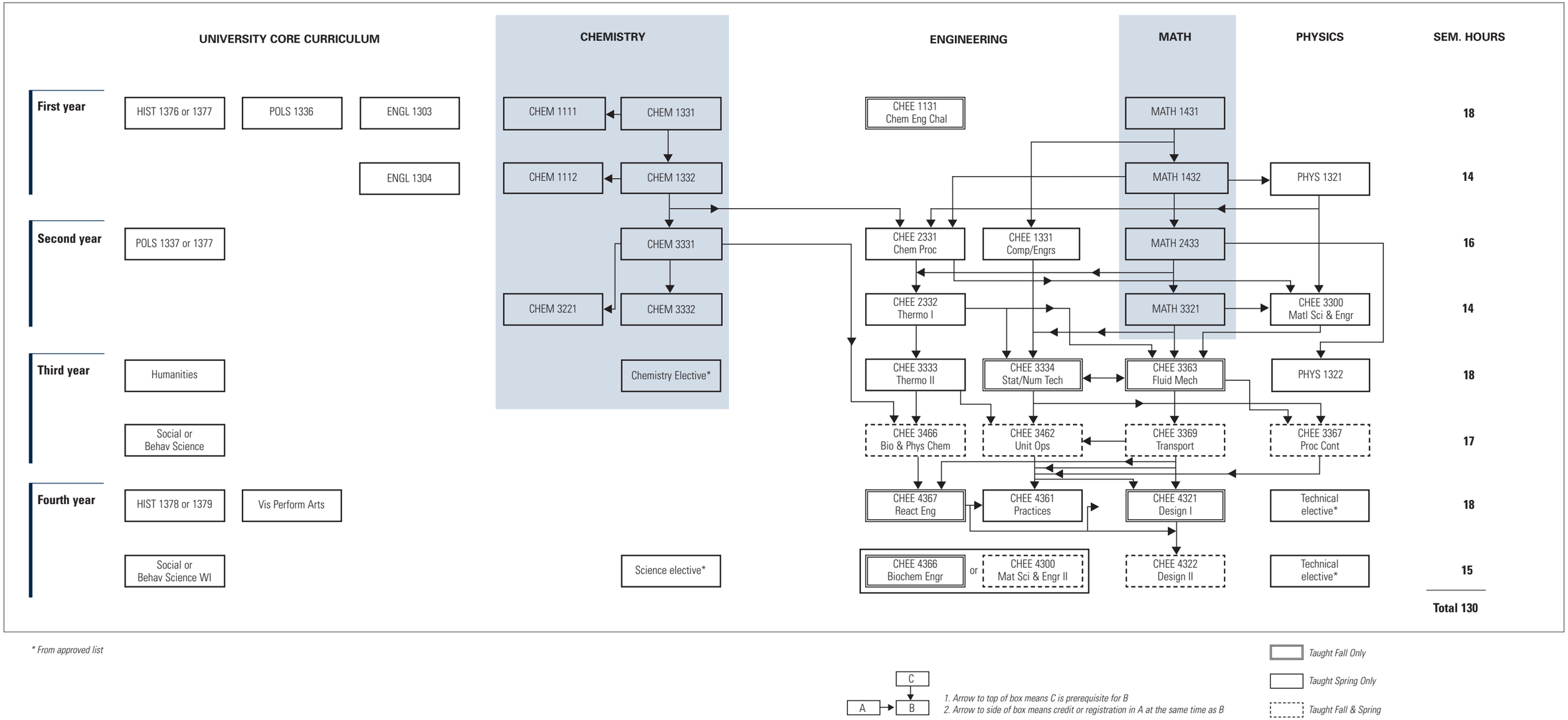
5384: Petrochemical Processes Cr. 3 (3-0). *Prerequisite:* consent of instructor. Description of the petrochemical industry in terms of products, feedstocks, companies, and future trends. Markets, technology, and economics are provided for each of the major building blocks and derivatives to the end products.

5386: Air-Pollution Problems & Control Cr. 3 (3-0). *Prerequisite:* consent of instructor. Air-pollutant identification and control technology; estimation of pollutant transport, dispersion, and conversion; computer application for design of control units.

5387: Plasma Processing: Principles & Applications Cr. 3 (3-0). *Prerequisites:* senior standing in Engineering or Natural Sciences, or consent of instructor. Principles of low-pressure glow-discharge plasmas; plasma generation and maintenance, plasma chemistry, plasma diagnostics. Applications with emphasis on semiconductor manufacturing.

5388: Catalytic Processes Cr. 3 (3-0). *Prerequisites:* credit for or concurrent enrollment in CHEE 4321 and 4367. Process-oriented survey of catalytic technology; catalyst selection and design; catalytic processes, engineering and economics in the petroleum, chemical, and pollution-control industries.

// Undergraduate Chemical Engineering Curriculum //



** From approved list*

1. Arrow to top of box means C is prerequisite for B
2. Arrow to side of box means credit or registration in A at the same time as B

Taught Fall Only
Taught Spring Only
Taught Fall & Spring

// Undergraduate Degree Plan //

Effective Fall 2002.

FIRST YEAR

FALL SEMESTER

Course #	Course	Hrs.
CHEE 1131	Chem. Engng. Challenges	1
CHEM 1111	Fund. of Chemistry Lab	1
CHEM 1331	Fundam. of Chemistry	3
ENGL 1303	English Composition I	3
HIST 1376/7	U.S. History to 1877	3
MATH 1431	Calculus I	4
POLS 1336	U.S. & Texas Politics	3
		18

SPRING SEMESTER

Course #	Course	Hrs.
CHEM 1112	Fund. of Chemistry Lab	1
CHEM 1332	Fundam. of Chemistry	3
ENGL 1304	English Composition II	3
MATH 1432	Calculus II	4
PHYS 1321	Engineering Physics I	3
		14

SECOND YEAR

FALL SEMESTER

Course #	Course	Hrs.
CHEE 1331	Computing for Engineers	3
CHEE 2331	Chemical Processes	3
CHEM 3331	Fund. of Organic Chem. I	3
MATH 2433	Calculus III	4
POLS 1337	U.S. Government	3
		16

SPRING SEMESTER

Course #	Course	Hrs.
CHEE 2332	Chem. Eng. Thermo. I	3
CHEE 3300	Mat'l Science & Engr.	3
CHEM 3221	Fund. of Org. Chem. Lab	2
CHEM 3332	Fund. of Organic Chem. II	3
MATH 3321	Engineering Mathematics	3
		14

THIRD YEAR

FALL SEMESTER

Course #	Course	Hrs.
CHEE 3333	ChE Thermo. II	3
CHEE 3334	Anal./Numer. Techn.	3
CHEE 3363	Fluid Mech. for ChE	3
PHYS 1322	Engr. Physics II	3
	Humanities Core	3
	Adv. Chem. elective	3
		18

SPRING SEMESTER

Course #	Course	Hrs.
CHEE 3367	Proc. Mod./Control	3
CHEE 3369	ChE Transport Proc.	3
CHEE 3462	Unit Operations	4
CHEE 3466	Bio & Physical Chem.	4
	Social & Behavior Science core	3
		17

FOURTH YEAR

FALL SEMESTER

Course #	Course	Hrs.
CHEE 4321	ChE Design I	3
CHEE 4361	ChE Practices	3
CHEE 4367	Chem. Reaction Eng.	3
HIST 1378/9	US Hist. since 1877	3
	Technical elective	3
	Vis./Perf. Arts core	3
		18

SPRING SEMESTER

Course #	Course	Hrs.
CHEE 4322	ChE Design II	3
CHEE 4366	Biochem Engr or	
CHEE 4300	Mat Sci & Engr II	3
	Technical elective	3
	Adv. Sci. elective	3
	Soc./Beh. Sci.WI core	3
		15

TOTAL UNDERGRADUATE HOURS: 130

// Scholarships //

UNDERGRADUATE SCHOLARSHIP RECIPIENTS

Our undergraduate program enjoys a robust level of support from industrial and organizational donors. Following are the 2002–2003 recipients of these undergraduate scholarships:

BP/AMOCO FOUNDATION

Lior Azulai
Andrea Jimenez
Adetunyi Onikoyi
Frank Truong

LUBRIZOL FOUNDATION

Emil Enache-Pommer
David Ladd
Ni Nguyen
Michael Rauschhuber

SOUTHWEST CHEMICAL ASSOCIATION

Alfred E. Delumpa (nominee)
Nhi Nguyen (nominee)
Lazaro Medrano (nominee)

DONALD F. OTHMER SOPHOMORE ACADEMIC EXCELLENCE AWARD

Nhi Nguyen

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

Mansour Abdulbaki
Paul Rico

DOW OUTSTANDING JUNIOR AWARD

Elizabeth Nguyen

UNDERGRADUATE AIChE CHAPTER

The Department has an active undergraduate chapter of the South Texas Section of the American Institute of Chemical Engineers (AIChE). The chapter is advised by Prof. Richard Willson.

THE GRADUATE PROGRAM

The Department offers four graduate programs:

1. **FULL-TIME MS/PHD:** This program supports the research activity of the faculty and is designed for full-time graduate students receiving financial support. Most students pursue the PhD degree, which may be completed (without an intermediate MS) in four years of study.

2. **PART-TIME MS (NON-THESIS OPTION):** Intended for part-time students from local industry who have a BS ChE degree, this program requires 30 semester hours of coursework, including the same core required for full-time MS students.

3. **PART-TIME MCHE:** This is a separate Master's program that emphasizes advanced engineering and business management. Admission and graduation requirements are the same as for the MS degree, but mastery of advanced engineering is the main goal. Approximately 25 students enroll annually. The MChE degree may be completed in four semesters (two years).

4. **MASTERS OF PETROLEUM ENGINEERING:** Similar to the MChE degree, this program offers advanced thesis or non-thesis studies to full- or part-time students in petroleum engineering. Annual enrollments range from 40 to 80 students, with an additional number of postbaccalaureate students involved in the coursework.

Details of these programs, and descriptions of the coursework offered, appear on the pages following.

The **CHEMICAL ENGINEERING GRADUATE PROGRAM** at the **UNIVERSITY OF HOUSTON** is among the **TOP 20 IN THE NATION** (17th in the 1995 National Research Council ratings). Our doctoral program is among the highest-rated doctoral programs in the entire University. This is due to the excellence of our faculty in research, the international reputation of our professors, and the success of our graduates. On the average, the Department has total overall annual research expenditures of approximately $3 million.

// Full-Time Graduate Programs in ChE //

Current areas:

Reaction engineering

Catalytic engineering

Electronic materials

Polymer science and engineering

Biochemical engineering

Colloids & supra-molecular fluids

Advanced inorganic materials

Petroleum engineering

Multiphase flow

Computer-aided process engineering

FULL-TIME PROGRAMS OF STUDY (REQUIRING A THESIS)

The Department of Chemical Engineering offers Master of Science (MS) and Doctor of Philosophy (PhD) degree programs, both of which focus on advanced engineering fundamentals and research.

Recipients of the MS degree are qualified for employment in industry or for continued studies toward the PhD degree. Coursework for the MS degree includes four specific classes (Engineering Mathematics, Reaction Engineering, Transport Processes, and Classical & Statistical Thermodynamics) and two electives of the student's choice. The student also completes a research project and writes a Master's thesis describing the work. Candidates entering the program with a Bachelor of Science in Chemical Engineering can complete all requirements in 12 to 18 months.

Candidates for the PhD degree enjoy intensive exposure to a specific field of engineering research in addition to continued study of engineering fundamentals. Individual research is the major focal point for these students, who will learn, absorb, and otherwise experience the general philosophy, methods, and concepts of research and scholarly inquiry. After graduation, UH ChE PhD recipients will be qualified to contribute to the solution of significant problems related or unrelated to their doctoral research. For students considering an academic career, instructorships are available. Coursework for the PhD degree includes five specific courses (Transport Processes II, and the four courses listed in the preceding paragraph) and five elective courses, which allow for specialization in the student's research area. In addition, all students undertake a doctoral research project and dissertation to expand the frontiers of knowledge in their research areas. Acceptance into this full-time program is generally accompanied by Departmental financial support. Candidates with a BS in Chemical Engineering can complete all requirements in about four years.

A student must pass the PhD Qualifying Exam to be formally accepted as a doctoral candidate. To be eligible to take this examination, a student must have completed the five specifically required PhD courses with a minimum cumulative GPA of 3.0/4.0. There is no foreign-language requirement. Highly qualified students may bypass the MS degree and pursue the doctorate directly.

The ratio of graduate students to faculty is low, typically four to six students per research advisor. After new students have spent their first semester in the Department, the ChE faculty make presentations of their research programs and interests to better enable the students to submit their requests for choice of research advisor. Every reasonable effort is made to accommodate students' first choice of advisor.

RESEARCH AREAS & EQUIPMENT

The Department's research programs are broad and innovative, encompassing traditional and emerging chemical engineering disciplines. Departmental research equipment includes an X-ray diffractometer with a hot stage, a pulsed excimer-pumped dye laser, a quasielastic laser-light-scattering spectroscopy unit, a computerized axial tomographic scanner (CATscan) system, rheometers, a fluorescence-polarization stopped-flow kinetics apparatus, and a titration microcalorimeter. Additionally, the Department houses numerous workstations and personal computers for graduate research. Access to a university VAX network and Hitachi AS/9000N mainframe is also available. For large computations, many faculty have reserved time on various national supercomputers.

ENTRANCE REQUIREMENTS (U.S. STUDENTS)

Admission to the Department's graduate programs is competitive, based on GPAs from undergraduate and graduate studies, GRE scores, and letters of recommendation. The U.S. applicant must generally have achieved a minimum undergraduate GPA of 3.0/4.0 and a minimum GRE score (Verbal + Quantitative) of 1100. Students with undergraduate degrees in fields other than Chemical Engineering may apply, but these students may need to take preparatory courses prior to or concurrently with ChE graduate study.

ENTRANCE REQUIREMENTS (INTERNATIONAL STUDENTS)

The international students offered admission over recent years have ranked in the top 10% of their class, and they have scored over 1200 on the GRE (Verbal + Quantitative) and over 550 on the TOEFL.

International applicants thus qualified should be prepared to submit unofficial copies of GRE scores, TOEFL scores, and transcripts well in advance of the Department's request for official documents. Official GRE and TOEFL scores should then be sent, using ETS Institutional Code 6870. The TOEFL requirement is waived for applicants from primarily English-speaking countries and for applicants who have earned a lesser ChE degree from a U.S. institution. The University of Houston requires a fee of $75 (in U.S. funds) to process graduate applications from non-U.S. citizens.

All applicants (U.S. and international) must also submit a completed University of Houston application form and a Chemical Engineering Department application form. Transcripts and all other documents should be mailed directly to one of the two addresses below, as application requests or components addressed to the UH Office of Admissions frequently fail to reach the Chemical Engineering Department in timely fashion. Note: Incoming UH ChE graduate students are admitted for Fall semesters only. Fall-semester applications that are received by the preceding February 1 are most favorably considered, although later applications may also be considered.

Qualified U.S. and international students may request a complete application package for the full-time, thesis-option MS or PhD programs from the appropriate agent below:

U.S. CITIZENS/PERMANENT RESIDENTS:
Graduate Studies Coordinator
University of Houston
Department of Chemical Engineering
S222 Engineering Bldg 1
Houston, TX 77204-4004

INTERNATIONAL CITIZENS:
International Graduate Coordinator
University of Houston
Department of Chemical Engineering
S222 Engineering Bldg 1
Houston, TX 77204-4004, U.S.A.

FINANCIAL AID

Fellowships that typically consist of a stipend, tuition and fees are available for qualified PhD and full-time MS candidates. These fellowships are awarded on a competitive basis. Applicants may apply for financial assistance when requesting admission to the graduate program.

// Master of Chemical Engineering (MChE) Degree (part-time) //

For complete information, prospective students should contact the MChE Program Director:

Prof. Mike Nikolaou
University of Houston
Chemical Engineering
S222 Engineering Bldg. 1
Houston, TX 77204-4004

MASTER OF CHEMICAL ENGINEERING (MCHE) DEGREE

The MChE degree is a non-thesis program for the working professional. This program has been designed for those persons who plan careers in plant operations, design, and management. It is intended to be competitive neither with the Master of Science degree (which is specifically research-oriented) nor with an MBA degree. Rather, the goal of this program is to permit earlier productive use of young engineers' technical skills and to impart broad concepts of systems analysis, advanced process economics, and technical management. The program is aimed at improving opportunities for chemical engineers in chemical-process and related industries.

The program comprises a core of six required courses, plus four elective courses selected to meet the student's interests in the areas of process control, management and business economics, biochemical and environmental engineering, and petroleum engineering. The courses are available in the late afternoon and evenings, and the degree program can be completed in two to three years of part-time study.

Entrance requirements include a Bachelor's degree in Chemical Engineering, industrial employment, and approvals of the MChE Program Director, the Chairman of the Chemical Engineering Department, and the Dean of Engineering. Unconditional admission may be granted for a minimum undergraduate GPA of 3.0 (4.0 scale) and a minimum GRE score (verbal + quantitative) of 1100. Conditional admission may be granted for a minimum undergraduate GPA of 2.6/4.0 and a minimum GRE of 1000, with special permission of the Program Director and the Dean of Engineering. Achievement of a grade of "B" or better in the first 12 hours of coursework removes the conditional status.

// Master of Science in Petroleum Engineering (MSPE) //

For application forms, contact the Program Director. All correspondence and supporting documents (official transcripts and test scores) should also be mailed to this address:

Petroleum Engineering Program Director
University of Houston
Chemical Engineering
S222 Engineering Bldg 1
Houston, TX 77204-4004

MASTER OF SCIENCE IN PETROLEUM ENGINEERING

The MSPE degree is ideal for any engineering graduate who desires to begin working or to improve his position in the upstream petroleum industry. This program offers courses held 5:30–8:30 p.m. Monday through Thursday, enabling attendance after business hours for full-time professionals.

Students may elect whether to complete the Nonthesis Option, which requires 36 credit hours of approved courses beyond the introductory level in Petroleum Engineering, or the Thesis Option, which requires 24 credit hours beyond the introductory level in Petroleum Engineering plus six credit hours dedicated to the Master's thesis. Petroleum Engineering courses can also be taken for Continuing Education credit, and they can be applied as Professional Development Hours for maintaining professional competency for the Professional Engineer (PE) certification.

A Bachelor's degree in Engineering from an accredited institution is normally required for admission to the MSPE program. Undergraduate degrees in Petroleum, Chemical, or Mechanical Engineering provide all or most of the prerequisite courses for this program. Holders of other scientific degrees, as well as some Engineering graduates, must complete prerequisite requirements. All candidates should have credit for courses equivalent to the University of Houston's prerequisites for this degree.

For unconditional admission to the program, a minimum undergraduate GPA of 3.0 (4.0 scale) and an acceptable GRE score (verbal + quantitative) are required. For conditional admission, a minimum undergraduate GPA of 2.6, an acceptable GRE score, and special consent of the Program Director and the Dean of Engineering are required. International applicants must qualify for unconditional admission and satisfy the University of Houston's requirement of a minimum TOEFL score of 550.

Once accepted into the graduate program, part-time students will be advised how to schedule courses sufficient for the MSPE degree program. (Part-time students commonly take one or two courses per semester.) Full-time students will be advised how to complete the required courses within a period of 1.5 years.

// Graduate Courses //

CHEMICAL ENGINEERING (CHEE)

6111: Graduate Seminar Cr. 1 (1-0). May be repeated for credit.

6197:6297:6397: Selected Topics Cr. 1-3 per semester (1-0; 2-0; 3-0). May be repeated for credit.

6198:6298:6398:6498:6598: Research Cr. 1-5 per semester, or more by concurrent enrollment. *Prerequisite:* approval of Chairman.

6289:6389: Chemical Engineering Project Cr. 2 or 3 per semester (2-0; 3-0). *Prerequisite:* approval of instructor. May be repeated for credit. Industrial-scale chemical engineering economics and/or engineering project.

6330: Computational Methods for Chemical Engineers Cr. 3 (3-0). *Prerequisite:* consent of instructor. Advanced computational and numerical methods for the solution of chemical engineering problems. Solution of linear and nonlinear equations. Conjugate-gradient-like methods. Newton and quasi-Newton techniques. Solutions of elliptic and hyperbolic partial differential equations using finite-difference and finite-element techniques. Applications to chemical engineering problems.

6331:6332: Mathematical Methods in Chemical Engineering Cr. 3 per semester (3-0). *Prerequisite:* approval of Department. Linear methods applied to chemical engineering, matrices, transforms, series, complex variable methods, boundary-layer problems.

6333:6334: Transport Processes Cr. 3 per semester (3-0). *Prerequisite:* CHEE 3369. Advanced principles of fluid mechanics and heat/mass transfer, with application to problems in research and design. Emphasis on unified point of view to transport processes in laminar- and turbulent-flow situations.

6335:6336: Classical & Statistical Thermodynamics Cr. 3 per semester (3-0). *Prerequisite:* CHEE 3460. Advanced methods.

6337: Advanced Reactor Engineering Cr. 3 (3-0). *Prerequisite:* undergraduate kinetics or reactor-design course. Introduction to modern concepts and techniques of chemical-reactor analysis and design.

6360: Biochemical Engineering Fundamentals Cr. 3 (3-0). *Prerequisite:* graduate standing, or senior with consent of instructor. Analysis and design fundamentals for biochemical processes: introductory biochemistry, microbiology, biological kinetics, reactor design, transport phenomena; applications of enzymes and single mixed microbial populations.

6365: Fundamentals of Catalysis Cr. 3 (3-0). *Prerequisite:* CHEE 4367 or equivalent. Theories and experimental procedures in modern heterogeneous catalysis, catalyst preparation and properties, absorption, surface mechanisms, catalyst design, and catalytic processes.

6367: Advanced Process Control Cr. 3 (3-0). *Prerequisite:* CHEE 3367 or equivalent, or consent of instructor. Application of high-speed computers in the control of chemical processes, reactors, and units.

6368: Chemical Process Economics I Cr. 3 (3-0). *Prerequisite:* graduate standing in chemical engineering and CHEE 6350. Managerial economics of chemical processes and products; development of decision-making methods using examples from the chemical industry.

6369: Chemical Process Economics II Cr. 3 (3-0). *Prerequisites:* CHEE 6350, 6368. Study of profitability, process-comparison, and risk analysis from an advanced viewpoint, followed by extensive case-history studies of managerial economics in process industries.

6370: Advanced Topics in Biochemical Engineering Cr. 3 (3-0). *Prerequisite:* CHEE 6360, or consent of instructor. Mathematical modeling and optimization of separation-unit operations in biochemical engineering, including chromatography, flocculation, centrifugation, and filtration. Engineering analysis and design of mammalian-cell bioreactors.

6371: Pollution-Control Engineering Cr. 3 (3-0). *Prerequisite:* Credit for or concurrent enrollment in CHEE 4321 and 4367 or equivalent. General survey of problems and remedies with the Earth as an environmentally closed system. Limitations of absorption and self-cleansing of the terrasphere, hydrosphere and atmosphere, and their interaction and interrelationship.

6372: Fluid/Particle Separation Cr. 3 (3-0). *Prerequisite:* ENGI 3363 or equivalent. Introduction to heterogeneous, fluid/particle, multiphase systems. Development of fundamental principles of flow through compactible beds. Application to solid/liquid separation. Brief study of aerosols, coalescence, and flotation.

6373: Environmental Remediation Cr. 3 (3-0). *Prerequisites:* ENGI 3363, CHEE 3462, and credit for or concurrent enrollment in CHEE 4367. In situ and ex situ methods of remediation or restoration of contaminated environmental sites. Emphasis is on hydrocarbon contaminants in soil, surface water, and groundwater.

6374: Reaction Kinetics for Industrial Processes Cr. 3 (3.0). *Prerequisite:* credit for or concurrent enrollment in CHEE 4367. Fundamental methods for predicting product distributions in practical chemical reactors. Determination of thermochemical and kinetic constants from statistical mechanics and transition-state theory. Applications from vapor-phase processes to catalysis.

6375: Chemical Processing for Microelectronics Cr. 3 (3-0). *Prerequisites:* CHEE 4367 or equivalent, or consent of instructor. Chemical Engineering principles applied to microelectronic-device fabrication and processing.

6376: Solid/Liquid Separation—Environmental Processes Cr. 3 (3-0). *Prerequisite:* ENGI 3363. Introduction to solid/fluid separation and processing. Particulate characteristics, porous media, interfacial phenomena, flow through compactible and granular beds; sedimentation, clarification, filtration, centrifugation, expression, washing.

6377: Introduction to Polymer Science Cr. 3 (3-0). *Prerequisite:* consent of instructor. Introduction to the synthesis, characterization, physical properties, and processing of polymeric materials. Methods to measure, characterize, and tailor structure-processing-property correlations for polymeric materials.

6379: Safety & Reliability Cr. 3 (3-0). *Prerequisites:* CHEE 3363, 3367, 3369. Overview of risks, safeguards, and hazards associated with chemical process engineering. Layers of protection, hazard identification, source-term models, toxic release and dispersion models, fires and explosions, probabilistic analysis, fault-tree analysis, designs to prevent accidents, safety-instrumented systems, and safety-related standards and regulations.

6380: Biochemical Separations Cr. 3 (3-0). *Prerequisite:* Senior standing in Chemical Engineering, or consent of instructor. Producing a cloned protein in useful amounts; use of recombinant DNA methodologies to produce proteins; characterization methods.

6383: Advanced Unit Operations Cr. 3 (3-0). *Prerequisite:* CHEE 3462. Property-prediction of multi-component fluids. Advanced principles of heat-exchanger design, multicomponent fractionation, absorption, stripping, and extraction from a unified point of view.

6384: Petrochemical Processes Cr. 3 (3.0). *Prerequisite:* consent of instructor. Description of the petrochemical industry in terms of products, feedstocks, companies, and future trends. Markets, technology, and economics are provided for each of the major building blocks and derivatives to the end products.

6386: Air-Pollution Problems & Control Cr. 3 (3-0). *Prerequisite:* consent of instructor. Air-pollutant identification and control technology; estimation of pollutant transport, dispersion, and conversion; computer application for design of control units.

6388: Catalytic Processes Cr. 3 (3-0). *Prerequisite:* Credit for or concurrent enrollment in CHEE 4321 and 4367. Process-oriented survey of catalytic technology; catalyst selection and design; catalytic processes, engineering, and economics in the petroleum, chemical, and pollution-control industries.

6399-7399: Master's Thesis Cr. 3 per semester.

7350: Applied Nonlinear Methods for Engineers Cr. 3 (3-0). *Prerequisite:* CHEE 6331, 6332, or consent of instructor. Recent nonlinear methods, with emphasis on Engineering applications. Nonlinear functional analysis, steady-state bifurcation theory, dynamical systems, nonlinear partial differential equations, nonlinear waves, computation methods in bifurcation theory.

7387: Plasma Processing: Principles & Applications Cr. 3 (3-0). *Prerequisite:* graduate standing in Engineering or Natural Sciences, or consent of instructor. Principles of low-pressure glow-discharge plasma; plasma generation and maintenance; plasma chemistry; plasma diagnostics. Applications with emphasis on semiconductor manufacturing.

7397: Selected Topics Cr. 3 per semester (3-0). May be repeated for credit.

PETROLEUM ENGINEERING (PETR)

5361: Introduction to Petroleum Engineering Cr. 3 (3-0). *Prerequisite:* senior, post-baccalaureate, or graduate standing in Engineering or Geology. Petroleum origin and migration, major oil and gas fields, drilling and production methods, petroleum composition and phase behavior, reservoir-engineering methods of oil-resource estimation and optimization.

5362/6362: Reservoir Engineering I Cr. 3 (3-0). *Prerequisite:* senior, postbaccalaureate, or graduate standing in Engineering or Geology. Rock and fluid properties and interactions, P-V-T behavior of crude oil and natural gas, fundamentals of fluid flow through subsurface porous media, reservoir-energy mechanisms in recovery, material balance, and reserves estimation.

5364: Origin & Development of Oil & Gas Reservoirs Cr. 3 (3-0). *Prerequisite:* senior, post-baccalaureate, or graduate standing in Engineering. Major oil provinces of the world reviewed from the standpoints of geologic and depositional environment, and of diagenetic changes affecting petroleum entrapment.

5368: Well-Drilling & Completion Cr. 3 (3-0). *Prerequisite:* senior, postbaccalaureate, or graduate standing in Engineering or Science. Drilling-rig design and operation; drilling programs; drill string and bit designs; drilling-mud composition, properties, and functions; casing design and cementing; methods of well-completion.

5370: Petroleum-Production Operations Cr. 3 (3-0). *Prerequisite:* senior, postbaccalaureate, or graduate standing in Engineering or Science. Subsurface and surface facilities for producing oil and gas; gas-oil and water-oil separation and measuring systems; gathering systems; gas-processing facilities; injection systems for gas or water.

5397: Selected Topics Cr. 3 (3-0). May be repeated for credit when topics vary.

6298:6398:6498:6598: Research Cr. 2–5 per semester, or more by concurrent enrollment. *Prerequisite:* approval of Chairman.

6302: Reservoir Engineering II Cr. 3 (3-0). *Prerequisites:* PETR 5361 and 5362, or consent of instructor. Capillary pressures and vertical distribution of gas, oil, and water saturations, relative permeability and fractional flow relationships, Buckley-Leverett equation and linear-displacement efficiency of gas and water drives; effect of well patterns, mobility ratio, and reservoir heterogeneity on areal and vertical-sweep-efficiency performance of black-oil reservoirs.

6304: Evaluation of Petroleum-Bearing Formations I Cr. 3 (3-0). *Prerequisites:* PETR 5361 & 5362, or consent of instructor. Characterization of formations by geologic and petrographic examination, by analysis of fluid contents of cores, and by a suite of well-logging tests and their combined interpretation.

6306: Oilfield Facilities Design & Operation I Cr. 3 (3-4). *Prerequisites:* PETR 5361, 5368, and 5370, or consent of instructor. Design and operating principles of gas and water-surface separation and ratio-testing equipment, water-supply and water-disposal systems, gas-dehydration and -purification systems, gas compression, corrosion control, and clathrate prevention.

6308: Advanced Petroleum-Production Operations Cr. 3 (3-0). *Prerequisites:* PETR 5361, 5368, and 5370, or consent of instructor. Inflow performance relationships for oil, two-phase, and natural-gas wells; near-well zone and damage; vertical-lift performance; well-delivery. Forecast of well performance; methods of diagnosis of well performance. Well-testing and production-logging; well stimulation by acid treatments and hydraulic fracturing. Artificial lift (gas- and pump-assisted). Systems analysis.

6310: Petroleum-Production Economics I Cr. 3 (3-0). *Prerequisites:* PETR 5361, 5362, and 6302, or consent of instructor. Estimation of initial reservoir contents and forecasts of production vs. time of crude oil and natural gas by primary, secondary, and tertiary recovery methods, evaluation of costs and risks vs. expected rewards by alternative recovery methods, measures of profitability by discounting and cash-flow calculations, effects of taxation, and external financing.

6312: Evaluation of Petroleum-Bearing Formations II Cr. 3 (3-0). *Prerequisites:* PETR 5361, 5362, and 6304, or consent of instructor. Advanced well-log interpretation and logging-tool theory. A continuation of PETR 6304 (Evaluation of Petroleum-Bearing Formations I).

6314: Pressure-Transient Testing Cr. 3 (3-0). *Prerequisites:* PETR 5362 and 6302. Theory and application of pressure-transient testing of oil and gas wells for determination of reservoir properties and near-well damage or stimulation.

6316: Well Drilling & Completion II Cr. 3 (3-0). *Prerequisites:* PETR 5368 and graduate standing in petroleum engineering. Principles and procedures for cost-effective casing design; materials, design, and procedures for cementing; optimization of bits, weight, and R.P.M. for minimum cost for drilling; directional drilling.

6318: Oilfield Facilities Design & Operation II Cr. 3 (3-0). *Prerequisites:* PETR 5361, 5370, and 6306. Design theory and practice for facilities for unusual situations as may be required of practicing engineers; adaptations for offshore and other hostile environments.

6320: Enhanced Oil-Recovery Processes Cr. 3 (3-0). *Prerequisites:* PETR 5361, 5362, and 6302, or consent of instructor. Review of waterflood-calculation methods, extension to polymer flooding, caustic flooding, and carbonated-water flooding. Hydrocarbon-miscible flooding and CO flooding; estimation of recovery.

6324: Theory of Reservoir Modeling Cr. 3 (3-0). *Prerequisites:* PETR 5361, 5362, and 6302, or consent of instructor. Survey of reservoir-simulation methods, stream-tube simulator, finite-difference, finite-element, and collocation methods. Theory of finite-difference simulators; formulation of equations and resulting matrices, alternative solution methods.

6325: Integrated Reservoir Characterization Cr. 3 (3-0). *Prerequisites:* Senior, postbaccalaureate or graduate standing in engineering or science. Focuses on modern reservoir-characterization techniques, including pixel-based and object-based geostatistical methods designed to capture the influence of geology on fluid flow and storage.

6326: Applied Reservoir Simulation Cr. 3 (3-0). *Prerequisite:* PETR 6324, or consent of instructor. Application of reservoir simulators to demonstrate effects of reservoir characteristics on oil recovery by a variety of processes. Simplified representation of complex reservoir structures by use of cross-sections and areal models with pseudo-functions.

6350: Natural-Gas Engineering Cr. 3 (3-0). *Prerequisites:* PETR 5362, 6328, or consent of instructor. Comprehensive study that focuses on natural-gas engineering, the energy situation today, and the emerging technologies of tomorrow. Covers the supply of natural gas, including exploration, production, unconventional resources, transportation, processing, conversion, and fuel cells.

6387: Drilling & Completion of Complex Well Architectures Cr. 3 (3-0). *Prerequisites:* PETR 6316, 6368. Examination of the most recent well-construction technologies and the reservoir characteristics required for designing horizontal and multibranch wells. Description of specialized drilling strategies, including extended reach, underbalance, coiled tubing, and geosteering.

6388: Petroleum Engineering Project Cr. 3 per semester (3-0). *Prerequisites:* PETR 5361, 5362, 5368, and 5370, or consent of the project advisor. May be repeated once for credit.

6397: Selected Topics in Petroleum Engineering Cr. 3 (3-0). May be repeated for credit.

7397: Selected Topics Cr. 3 (3-0). May be repeated for credit.

// Graduate-Student Organization //

The **ORGANIZATION OF CHEMICAL ENGINEERING GRADUATE STUDENTS (OCHEGS)** is an educational and social student group that supplements formal departmental activities and functions. As part of the Department's weekly seminar program (*q.v.*), OChEGS annually organizes and conducts an all-day symposium, featuring keynote speakers specially recruited from industry, academia, or government. At the symposium, several students give oral presentations of their research while others display posters. The organization holds social events (picnics, get-togethers for sports, *et al.*) and elects officers annually.

Corporate sponsors of the 2003 OChEGS Symposium, to whom the Department and OChEGS are most grateful, were: ABB Lummus; Cutler Johnston Corporation; ExxonMobil Chemical; Kellogg Brown & Root; SAIC Consulting; and Specialty Gas Products. Additional support was provided by the University of Houston Department of Chemical Engineering and the University of Houston Activities Funding Board.

Here is the technical program of the 18th-annual Chemical Engineering Graduate Students' Symposium (Fall 2003). Philip Hamilton presided as OChEGS President:

Friday, 24 October 2003

8:00 – 8:30 a.m. Registration & Breakfast
8:30 – 8:35 a.m. Welcome Message from **Philip Hamilton**, Pres.
8:35 – 8:45 a.m. Welcome Message from Prof. Mike Harold
8:45 – 9:05 a.m. **Cynthia Mitchell**, "Dispersion of Single-Walled Carbon Nanotubes in Poly (e-caprolactone)"
9:05 – 9:25 a.m. **Luis F. Filobelo**, "Fundamental Aspects & Control Mechanisms for the Nucleation of Protein Crystals"
9:25 – 9:45 a.m. **Damilola O. Ajose Ogunlana**, "Compositional Upscaling in Heterogeneous Reservoirs: Effect of Gravity, Capillary Pressure, & Dispersion"
9:45 – 10:05 a.m. **Karthik Ramanathan**, "Light-Off & Transient Emission Analysis in Monoliths with Nonuniform Catalyst-Loading"
10:05 – 10:25 a.m. **Dimitra K. Georgiou**, "Why Do Protein Crystals Grow Slowly? AFM Studies of Insulin Crystallization"
10:25 – 10:35 a.m. Coffee Break
10:35 – 10:55 a.m. **Xuefei Sun**, "Modeling of Natural-Gas Production from Hydrate Deposits"
10:55 – 11:15 a.m. **Jeremy Strauch**, "Investigating Block-Copolymer Conformation in a Vesicle Bilayer"
11:15 – 11:35 a.m. **Mona Setoodeh**, "Formation of Electric Field during the Combustion of Titanium in Nitrogen"
11:35 – 11:55 a.m. **Panagiotis Katsonis**, "The Law of Corresponding States for Protein Solutions"
11:55 – 1:00 p.m. Lunch
1:00 – 3:00 p.m. Poster Presentations

// Weekly Seminar Series //

The Department attracts renowned speakers to address our graduate students on virtually a weekly basis. These speakers provide lecture abstracts that are distributed not just intradepartmentally, but to key industrial and academic figures statewide who may wish to attend. Unless exceptional circumstances apply, all ChE seminars are held on Fridays at 10:30 a.m. in room W122 of Bldg. D3, Cullen College of Engineering.

These seminars were presented in 2003–2004:

SPRING SEMESTER 2003

JANUARY 17: **Dr. Wendy E. Krause**, *Lynntech, Inc. (College Station, TX):* "Rheological Properties of Synovial Fluid & Its Components"

JANUARY 24: **Prof. George J. Hirasaki**, Department of *Chemical Engineering, Rice University (Houston, TX):* "NMR Properties of Petroleum Reservoir Fluids"

JANUARY 31: **Dr. Jeffrey P. Youngblood**, *Department of Materials Science & Engineering, Cornell University (Ithaca, NY):* "The Nature of Surfaces: Relevance to Wettability & Biology"

FEBRUARY 7: **Pin Wang**, *Division of Chemistry & Chemical Engineering, California Institute of Technology (Pasadena, CA):* "Expanding the Scope of Protein Biosynthesis by Incorporation of Unnatural Amino Acids into Protein in Vivo"

FEBRUARY 14: **Prof. Stephen Perusich**, Department of *Chemical Engineering, Auburn University (Auburn, AL):* "Structure, Relaxations, & Transport in Perfluoroionomeric Polymers"

MARCH 14: **Saravanapriyan Sriraman**, Department of Chemical Engineering, *Chemistry Department, University Of California, Santa Barbara:* "Understanding Radical-Surface Interactions during Plasma Deposition of Si Thin Films through Atomistic Simulations"

MARCH 21: **Dr. Ioannis P. Androulakis**, *Complex Systems Modeling Section, Corporate Strategic Research Exxonmobil Research & Engineering Company (Annandale, NJ):* "Informative-Feature Selection: A Prerequisite for Effective Data-Driven Research"

APRIL 4: **Prof. Anatoly Kolomeisky**, *Department of Chemistry, Rice University (Houston, TX):* "Dynamics of Polymer Translocation through a Long Nanopore"

APRIL 11: **Prof. Raymond J. Gorte**, *Department of Chemical Engineering, University of Pennsylvania (Philadelphia, PA):* "Developing Solid-Oxide Fuel Cells that Operate on Real Fuels"

APRIL 18: **Prof. Julio M. Ottino**, *Department of Chemical Engineering, Northwestern University (Evanston, IL):* "A Window into Complexity: Simple Examples of Self-Organizing Systems"

APRIL 25: **Prof. Ananth Annapragada**, *Applied Biomedical Engineering Program, Cleveland State University / Cleveland Clinic Foundation (Cleveland, OH):* "Platform Technologies: Targeting Delivery of Imaging-Contrast Agents & Chemotherapeutic Drugs"

FALL SEMESTER 2003

AUGUST 29: **Prof. Jan A. Puszynski**, Departments of *Chemistry & Chemical Engineering, South Dakota School of Mines & Technology (Rapid City, SD):* "Formation & Reactivity of Aluminum Nanopowders"

SEPTEMBER 5: **Dr. Timothy J. Anderson**, *Associate Dean, University of Florida (Gainesville, FL):* "The Role of Chemical Engineering in Chemical Vapor Deposition of Compound Semiconductors"

SEPTEMBER 12: **Prof. Richard A. Register**, *Department of Chemical Engineering , Princeton University (Princeton, NJ):* "Controlling Crystal Morphology in Block Copolymers"

SEPTEMBER 19: **Prof. Ronald G. Larson**, *Department of Chemical Engineering, University of Michigan (Ann Arbor, MI):* "DNA in Micro-Flows"

OCTOBER 3: **Prof. Joan F. Brennecke**, *Department of Chemical Engineering, University of Notre Dame (Notre Dame, IN):* "Ionic Liquids: What Controls Phase Behavior"

OCTOBER 17: **Prof. Yunfeng Lu**, *Department of Chemical & Biomolecular Engineering, Tulane University (New Orleans, LA):* "Hierarchical Metallic, Semiconductor, & Polymeric Nanowire/Mesh Thin Films for Device Applications"

OCTOBER 24: **18th-Annual OChEGS Symposium**

OCTOBER 31: **Prof. Michael S. Wong**, *Departments of Chemistry & Chemical Engineering, Rice University (Houston, TX):* "Design & Fabrication of Nanoparticle-Based Materials for Catalytic & Encapsulation Applications"

NOVEMBER 7: **Prof. Robert L. Shambaugh**, *School of Chemical Engineering, University of Oklahoma (Norman, OK):* "Fiber Science of the 21st Century"

NOVEMBER 14: **Dr. Guy B. Marin**, *Director, Laboratorium voor Petrochemische Techniek, University of Gent (Gent, Belgium):* "Steam-Cracking: From Molecule to Furnace"

DECEMBER 5: **Prof. Ioannis Pavlidis**, *Department of Computer Science, University of Houston:* "Estimation of Blood-Flow Rate & Vessel Location from Thermal Video"

SPRING SEMESTER 2004

JANUARY 23: **Dr. Eric W. Kaler**, *Dean of Engineering, Center for Molecular & Engineering Thermodynamics, Department of Chemical Engineering , University of Delaware (Newark, DE):* "Polymerization in Complex Fluids"

FEBRUARY 6: **Dr. Pierre M. Adler**, *Directeur de Recherches, CNRS, Institut de Physique du Globe de Paris (Paris, France):* "Single & Multiphase Flow in Fractured Porous Media"

FEBRUARY 13: **Prof. Jianzhong Wu**, *Department of Chemical & Environmental Engineering, University of California, Riverside (Riverside, CA):* "Statistical Thermodynamics of Soft Materials"

FEBRUARY 20: **Dr. Steven Mcintosh**, *Department of Chemical & Biomolecular Engineering, University of Pennsylvania (Philadelphia, PA):* "Direct-Hydrocarbon Solid Oxide Fuel Cells"

FEBRUARY 27: **A. Omolola Eniola**, *Department of Chemical & Biomolecular Engineering, University of Pennsylvania (Philadelphia, PA):* "Design & in Vitro Characterization of Biodegradable Drug-Delivery Vehicle with the Adhesive Properties of Leukocytes"

MARCH 8: **Dr. Chang Lu**, *School of Applied Engineering & Physics, Cornell University (Ithaca, NY):* "Microsystems: From Power Generation to Bioanalysis"

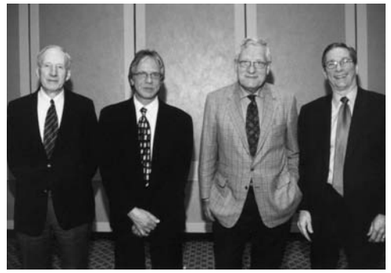
MARCH 22: **John R. Kitchin**, *Department of Chemical Engineering, University of Delaware (Newark, DE):* "Towards the Rational Design of Bimetallic & Carbide Catalysts: A Combined Experimental & Theoretical Approach"

APRIL 2: **Dr. Peter Strasser**, *Symyx Technologies, Inc. (Santa Clara, CA):* "Rapid Mapping of Activity-Stability-Composition Relationships for the Discovery of Improved Fuel-Cell Catalysts"

50TH ANNIVERSARY OF UH CHEMICAL ENGINEERING & THE NEAL R. AMUNDSON LECTURE

The University of Houston Department of Chemical Engineering celebrated its 50th Anniversary during the annual Neal R. Amundson Lecture and Dinner on February 28, 2003 at the UH Hilton Hotel.

The Neal R. Amundson Lecture was presented by Roy Jackson, professor emeritus from Princeton University on "Some Puzzles Posed by Particulate Suspensions." His presentation was followed by Henry Weinberg, senior vice president and chief technology officer for Symyx Technologies, and Doug Selman, vice president of research and development at ExxonMobil Chemical Company on "High-Throughput Experimentation & Its Applications." The UH Tenneco Lecture Series was presented by Professor John Villadsen, BioCentrum DTV, National Technical University of Denmark on "The Impact of Chemical Engineering on Bio-Reaction Engineering."



Top left: Presenters at the Neal R. Amundson Lecture Series included Roy Jackson from Princeton University, Henry Weinberg from Symyx Technologies, John Villadsen from the National Technical University of Denmark, and Doug Selman from ExxonMobil Chemical Company. Photo by Phil Busby.

Top right: Professor Neil Amundson and his wife Shirley toast the department's 50th anniversary. Photo by Phil Busby.

Bottom left: Professor Emeritus Frank Tiller and his wife Martha (left) at the commemorative dinner. Photo by Phil Busby.

Bottom right: Professor Dan Luss makes a few remarks at the dinner. Photo by Phil Busby.

// Continuing Education //

The following fee-basis Continuing Education course is presented semiannually (generally in May and December) by a team of UH ChE professors and outside experts:

"APPLICATIONS OF HETEROGENEOUS CATALYSIS"

INSTRUCTORS:

Prof. Dan Luss (University of Houston)

Prof. James T. Richardson (University of Houston)

Prof. Joe W. Hightower (Rice University)

Dr. Vern W. Weekman, Jr. (Retired Director, Central Research, Mobil R&D Corporation)

HIGHLIGHTS OF THE COURSE DESCRIPTION:

Successful applications of the principles of catalysis to process design require a combination of physics, chemistry and engineering, together with state-of-the-art "know-how." Contemporary catalysis has made significant progress in recent years toward the scientific design of optimal catalyst systems for specific process requirements. The purpose of this course is to cover current knowledge for both the researcher in catalysis and the engineer interested in process applications. It will serve as a review for those knowledgeable in the subject and as an introduction to newcomers to the field.

The course considers how to select, prepare, characterize, test, and use a catalyst. Both laboratory and commercial methods of catalyst preparation are reviewed, with emphasis on practical applications. Modern instrumental methods for the characterization of catalysts' physical and chemical properties are also included. Techniques for the measurement of surface areas, pore properties, diffusivities, crystallite sizes, acidities, etc. are discussed. All aspects of catalytic kinetics, both chemical and diffusional, are considered with reference to specific problems. Common mechanisms and their relationship to catalyst properties are outlined fully.

To inquire about course dates, registration, and fees, contact:

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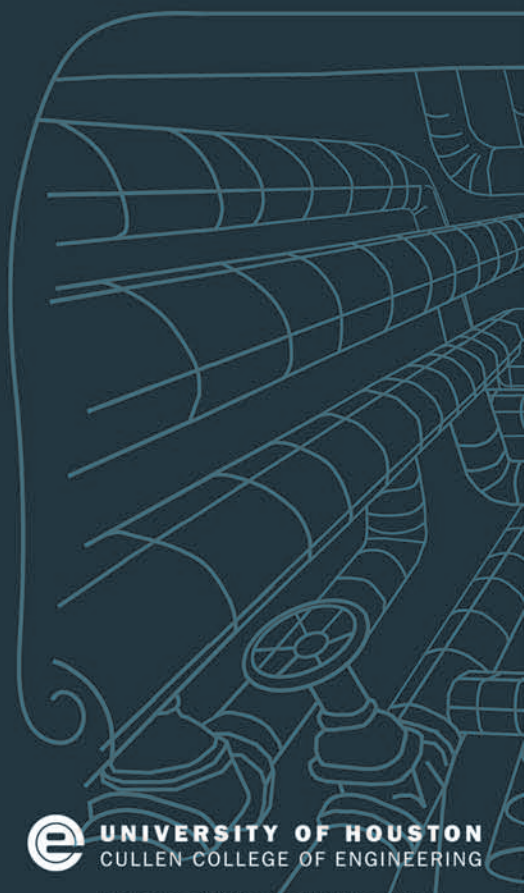

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