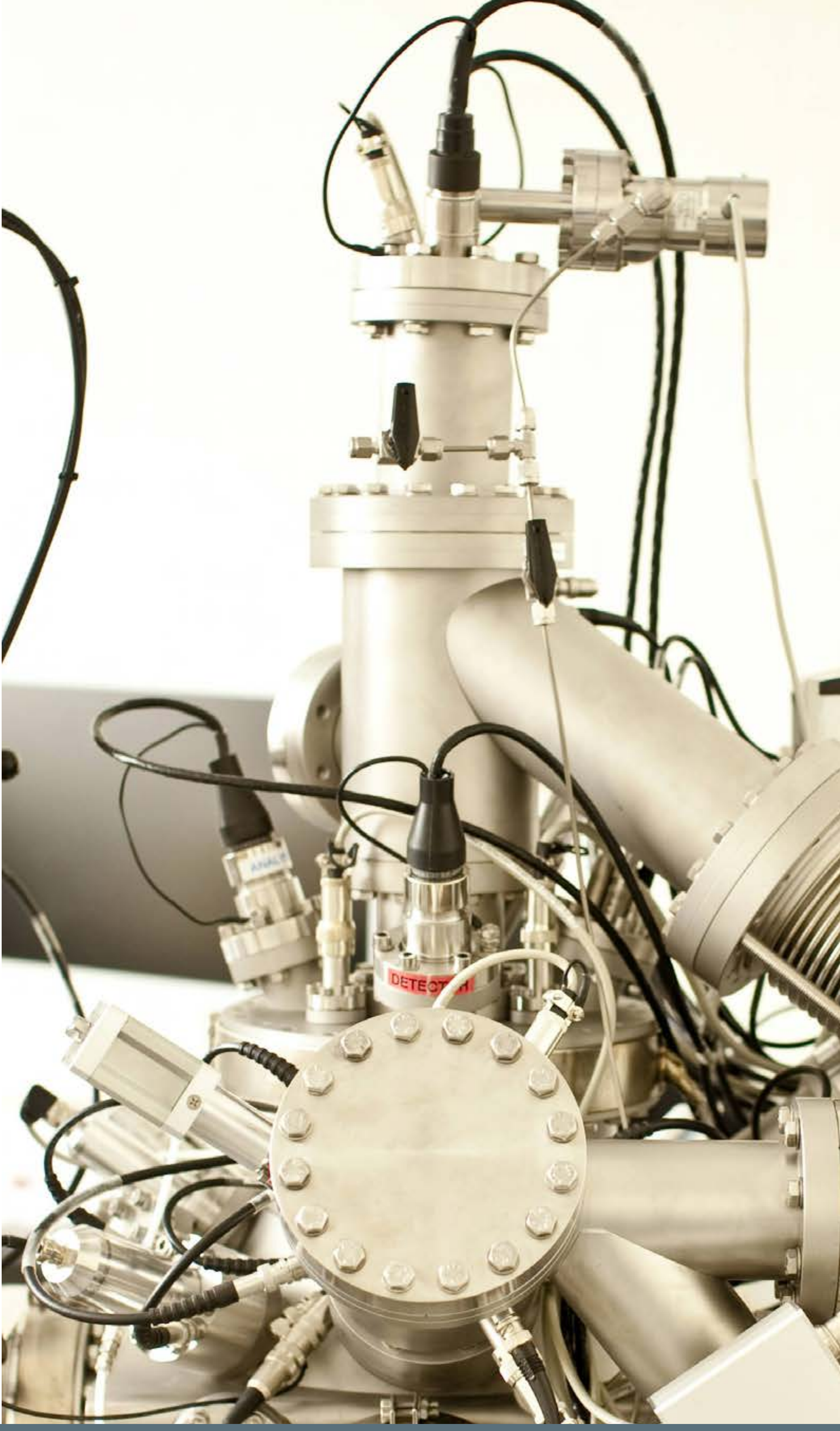
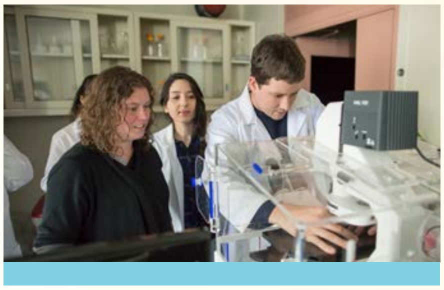




Chemical and Biomolecular Engineering

LEHIGH UNIVERSITY

Content

Faculty Listing

For a complete list of all the faculty in the Department of Chemical and Biomolecular Engineering please visit www.lehigh.edu/~incheme/faculty.html

Letter from the Chair

Welcome to the Department of Chemical and Biomolecular Engineering (CHBE) at Lehigh University. Our vision is to be a leading internationally recognized program in Chemical and Biomolecular Engineering that combines excellence in interdisciplinary research with rigorous and experiential education to prepare future leaders in academia, industry and government. Whether you are a prospective high school student considering enrolling in CHBE, a prospective graduate student looking for research and advanced degree options in CHBE, an alumnus, friend or colleague, we hope you will be excited with the depth and breadth of research and educational programs in our department.

Chemical Engineering at Lehigh is one of the oldest programs in the nation, established in 1902 as a bachelor's degree granting program that was formally constituted into a department in 1951. The program emerged from industrial chemistry, eventually integrating modern concepts of transport phenomena, unit operations and reaction engineering. In 2013, the department incorporated "Biomolecular" in its name, formally recognizing the growing role of biology as an enabling pillar for the discipline, alongside physics, chemistry and mathematics. Over the past 6 years, the department has added 7 new faculty members to its ranks, bringing a rich diversity of expertise to our program. Our newest faculty member, Professor Elsa Reichmanis, will join the department in Summer/Fall 2020 as our Carl R. Anderson Endowed Chair. Dr. Reichmanis is a member of the National Academy of Engineering and previously held appointments at GeorgiaTech and Bell Labs.

Today, our faculty and students engage in an integrated research and educational environment on topics of global importance in state-of-the-art laboratories. The accomplishments of our faculty, students and alumni continue to inspire us to reach ever higher levels of excellence. Notable alumni from our department include Monroe Rathbone (former CEO Standard Oil, inducted to Hall of Fame of US Business Leaders), William S. Pierce (cardiothoracic surgeon at PennState, inventor of first pneumatic heart assist pump), Michael Yaszemski (orthopedic surgeon at Mayo Clinic, member of National Academy of Medicine), Khaled Al-Fadhel (Kuwait Cabinet Minister of Oil, Water, Energy), Animangsu Ghatak (IIT Kanpur, member of Indian National Academy of Engineering) and William Amelio (CEO of Avnet, former CEO of Lenovo). Our current and past faculty have been recipients of numerous awards that include -- the Alan P. Colburn Award, the R. H. Wilhelm Award, Thomas Baron Award, Computing in Chemical Engineering and Computing Practice Awards all from AIChE; EPA Clean Air Excellence Award; DOE and NSF CAREER Awards; membership in the National Academy of Engineering (3) and National Academy of Inventors; and many more. A longer list can be found on page 3.

In the pages ahead, you will find descriptions of our various degree programs and the research profiles of our faculty members. Our faculty members work across traditional boundaries in interdisciplinary areas of research – sometimes working with material scientists or environmental engineers, other times with biologists, chemists, physicists, mechanical engineers or neuroengineers. This cross cutting research excellence provides fertile ground for innovative pedagogy in our educational mission. On page 3 is our faculty honor roll, listing some of the national and international awards won by our faculty over the years. I hope you will find this brochure informative in answering your questions about our department's selective and rigorous academic environment that prepares our students for lifelong learning and creation of lasting societal impact in their careers. Please visit our website: https://engineering.lehigh.edu/chbe for expanded descriptions and contact information. I look forward to hearing your comments.

Mayuresh V. Kothare,
Chairman and R. L. McCann Professor

Department
at a Glance (2016/17)

Degrees Offered

- BS in Chemical Engineering
- MS and ME in Chemical Engineering
- ME in Biological Chemical Engineering
- ME in Chemical Energy Engineering
- Ph.D. in Chemical Engineering

Full-time Faculty	19
Research Papers Published (Jan-Dec 2016)	65
Undergraduate Enrollment	220
BS Degrees Granted	49
Co-Op Positions	9
Student Participation in the Opportunities for Student Innovation (OSI) Program	21
Full-time Graduate Enrollment (45 Ph.D. & 13 MS)	58
Part-time Graduate Enrollment	27
Master's Degrees Awarded	14
Ph.D. Degrees Awarded	6

Faculty Honors include six NSF and DOE CAREER Awards, two AIChE Institute awards during the last three years.

Student Awards include two NSF GRFPs in the last two years.

Our Faculty is the Engine that Provides Innovative Learning and Creative Solutions to Societal Grand Challenges Based on Chemical Engineering Principles.

Current and Past Awards to CHBE Faculty

Member, National Academy of Engineering (3)
Donald Q. Kern Award, AIChE
Professional Progress Award, AIChE
R. H. Wilhelm Award, AIChE
Allan P. Colburn Award, AIChE
Thomas Baron Award, AIChE
Heat Transfer Award, AIChE
The Max Jakob Award, ASME/AIChE
Industrial Gas Technology Award, AIChE
Catalysis & Reaction Engineering Practice Award, AIChE
CAST W. David Smith Jr. Graduate Publication Award (2), AIChE
CAST Ted Peterson Graduate Publication Award, AIChE
CAST Computing and Systems Technology Award, AIChE
CAST Computing Practice Award, AIChE (2)
CAST Outstanding Young Researcher Award, AIChE
Separations Division Graduate Student Award, AIChE
NAMF Early career excellence award in mixing, AIChE
AIChE Distillation Division – special session
Roy W. Tess Award in Coatings, ACS
Victor K. LaMer Award, ACS
Ind. Eng. Chem. Research Festschrift, ACS
Industrial Innovation Award-SER, ACS
The George A. Olah Award in Hydrocarbon or Petroleum Chemistry, ACS
Langmuir Lecture Award, ACS
Doctoral New Investigator Award, ACS-PRF (3)
Collaboration Success Award, Council of Chemical Research
Melville Medal, ASME
Orr Award, ASME
Instrumentation Technology Award, ISA
Donald P. Eckman Education Award, ISA
Alan Glanville Award, Institute of Materials, Minerals and Mining
Award for Excellence in Adhesion Science, Adhesion Society (2)
Clean Air Excellence Award, EPA
Young Protein Scientist Award, Protein Society Annual Meeting
Alfred P. Sloan Research Fellowship in Chemistry
Fellow, AIChE (3)
Fellow, IEEE
Fellow, National Academy of Inventors
Fellow, ACS (2)
Fellow, International Adsorption Society
Fellow, ACS Division of Polymeric Materials Science and Engineering
Patrick Fellow, Adhesion Society
Fellow, Royal Society of Chemistry
TechConnect Innovation Award, TechConnect World (3)
Distinguished Young Rheologist Award, TA Instruments
La Jolla Interfaces in Science (Burroughs Wellcome Fund) Award
Exxon Research Incentive Award
DuPont bicentennial 'Scientist of the Month'
Herbert D. Doan Award for Excellence in Research, Dow
Dow Corning Chair, Lehigh
CAREER Awards (6), NSF
Presidential Young Investigators (2), NSF
BRIGE Award, NSF
Early Career Research Award, DOE
Alan Berman Research Publication Award, NRL
National Research Service Award, NIH (2)
Pathways to Independence Award, NIH
Process Control Hall of Fame
Foreign Member, Polish Academy of Arts and Sciences
Lee Hsun Lecture Award, Chinese Academy of Sciences
Lee Hsun Research Award in Materials Science, Chinese Academy of Sciences
Max Planck Research Prize
Invited Professor, University of Pierre et Marie Curie, 2012
Guest Professor, ECUST, Shanghai
The Humboldt Research Award (3)
EU Marie Curie Intra-European Fellowship, University of Twente
ESPCI Paris Tech-Michelin Visiting Professorship (2)
ESPCI Paris Tech-Total Chair
The International Vandis Award, Vanadium Chemistry Organization
Ramon y Cajal Award, Spanish Ministry of Science
DuPont Chair, IISc Bangalore

The **Undergraduate** Program

CHBE students learn the scientific principles of chemical engineering and apply them to technological and societal challenges. The department's laboratory facilities are among the best in the nation.

CHBE's renowned faculty members bring exceptional depth and breadth of knowledge and experience to the classroom. Students collaborate with professors and with their peers on a wide array of hands-on research projects.

At Lehigh, CHBE students gain:

- A sound background in biology, chemistry and physics
- A working capability with mathematics, numerical methods, and application of computer solutions
- A broad education in humanities, social sciences, and managerial techniques

Lehigh's CHBE graduates are equipped to:

- Pursue careers in industry, medicine, government, consulting, education, finance, business and law
- Pursue graduate studies or research
- Appreciate the social, ethical and technical implications of their work as it affects the environment, safety and health of people worldwide

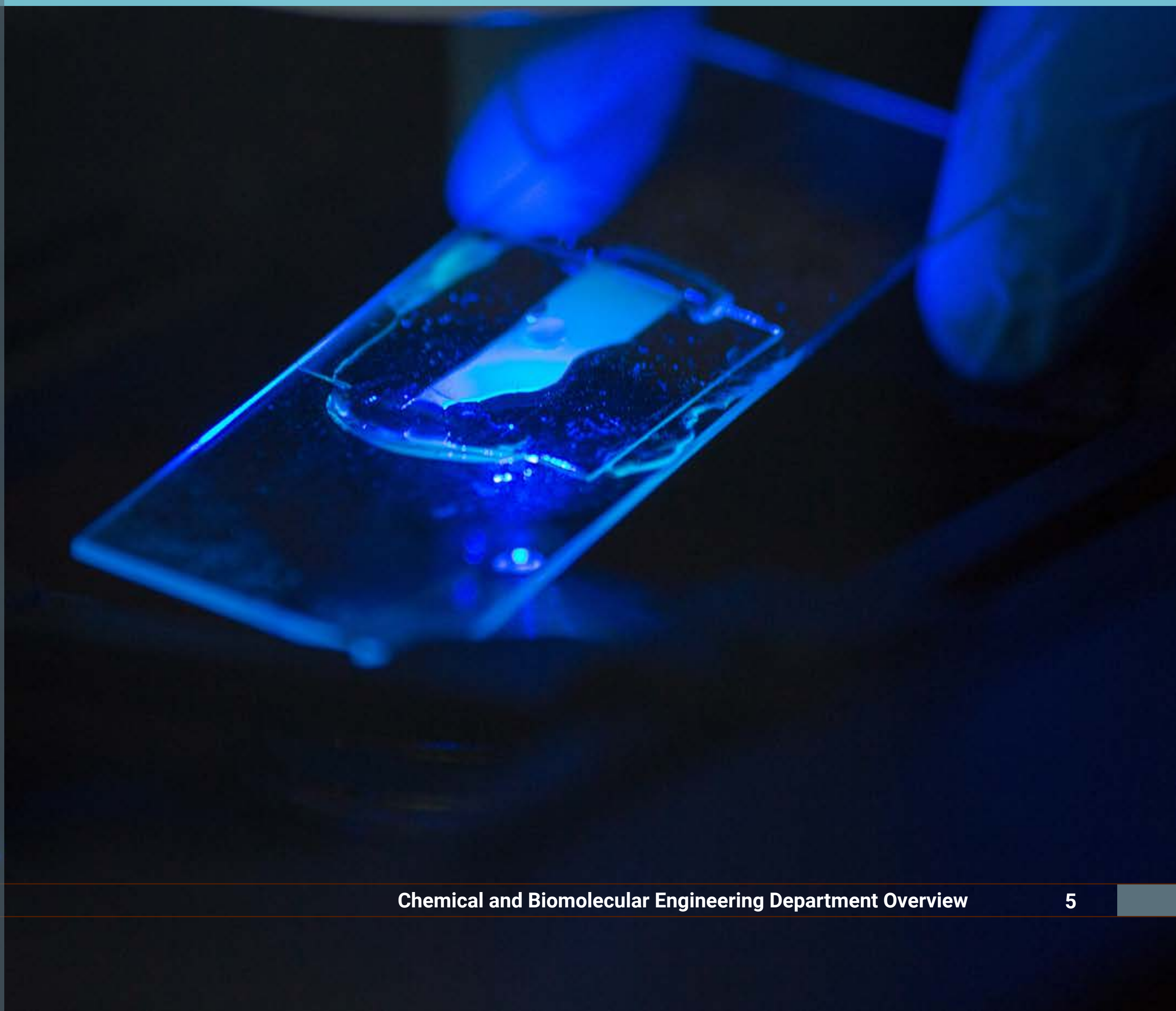
Curriculum

Coursework applies creativity and mathematics to chemical processing problems. A total of 131 credit hours are required to earn a B.S. in chemical engineering. A typical schedule and comprehensive course list can be found in the Lehigh Course Catalog.

Opportunities in Chemical Engineering

- The Co-op Program allows students to work with an industrial partner for two four-month rotations and still graduate in four years.
- Students may study abroad any semester or year they desire. We have exchange/ agreements with the U. of Nottingham (UK), TU Dortmund University (Germany) and other global universities for facilitating study abroad.
- In the Opportunities for Student Innovation (OSI) program, students spend two semesters working with faculty and industrial advisors on research projects.
- Focused technical and non-technical minors and concentration areas prepare students for specialized career paths.

Lehigh Chemical Engineers Leave Their Mark Across a Diverse Set of Global Industries.



Lehigh's CHBE Department – A Great Place to Earn an Advanced Degree in Chemical Engineering.

Industrial, faculty, and graduate student attendees at the Annual CHBE Graduate Student Symposium.

Graduate Life in CHBE

CHBE graduate degree programs combine exciting and novel research projects with rigorous classes. Degrees offered include Doctor of Philosophy (Ph.D.), Master of Science (M.S.) and Master of Engineering (M.E.) in Chemical Engineering, and M.E. in Biological Chemical Engineering or Chemical Energy Engineering. A Distance Education option is available for M.E. degrees.

The graduate curriculum includes core courses in thermodynamics, transport, kinetics and applied mathematics as well as specialized electives in advanced computing, molecular modeling, polymers, complex fluids, rheology, colloidal science, heterogeneous and environmental catalysis, and biomolecular/biomedical engineering. Research projects include a breadth of fundamental and applied topics in areas such as catalysis, systems engineering, bioengineering and materials processing. Students have access to a variety of equipment in their own labs, and can also use university labs with facilities in electron microscopy, atomic force microscopy, soft lithography, X-ray diffraction, confocal microscopy, Raman spectroscopy, FTIR and photoluminescence.

Graduate student organizations offer opportunities for socializing and professional development. The Chemical Engineering Graduate Association (ChEGA) hosts social and professional development activities throughout the year. Social events include department picnics as well as bowling, hiking, miniature golfing and ice skating trips. For professional development, there are the annual Chemical Engineering Graduate Student Symposium, student seminars and résumé workshops.

The Graduate Student Senate (GSS) holds breakfasts and social events, maintains a graduate student center, provides funding to graduate student organizations, and awards travel grants to help graduate students attend professional conferences. Special interest and multicultural graduate clubs provide a wide array of events and activities for the campus community throughout the academic year.

All of this makes Lehigh's CHBE department a great place to earn an advanced degree in chemical engineering.

Energy and the Environment

Researchers in this area study the fundamental phenomena guiding energy conversion between conventional and renewable energy forms within the bounds of the First Law of Thermodynamics.

We are addressing national challenges by developing green fuels, chemicals and solvents; by developing improved methods of capturing carbon and harvesting and converting solar energy; and by developing more energy-efficient catalysts and separations processes.

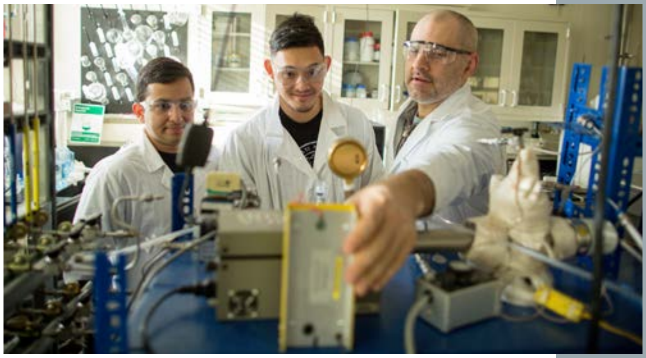
Our goals are twofold:

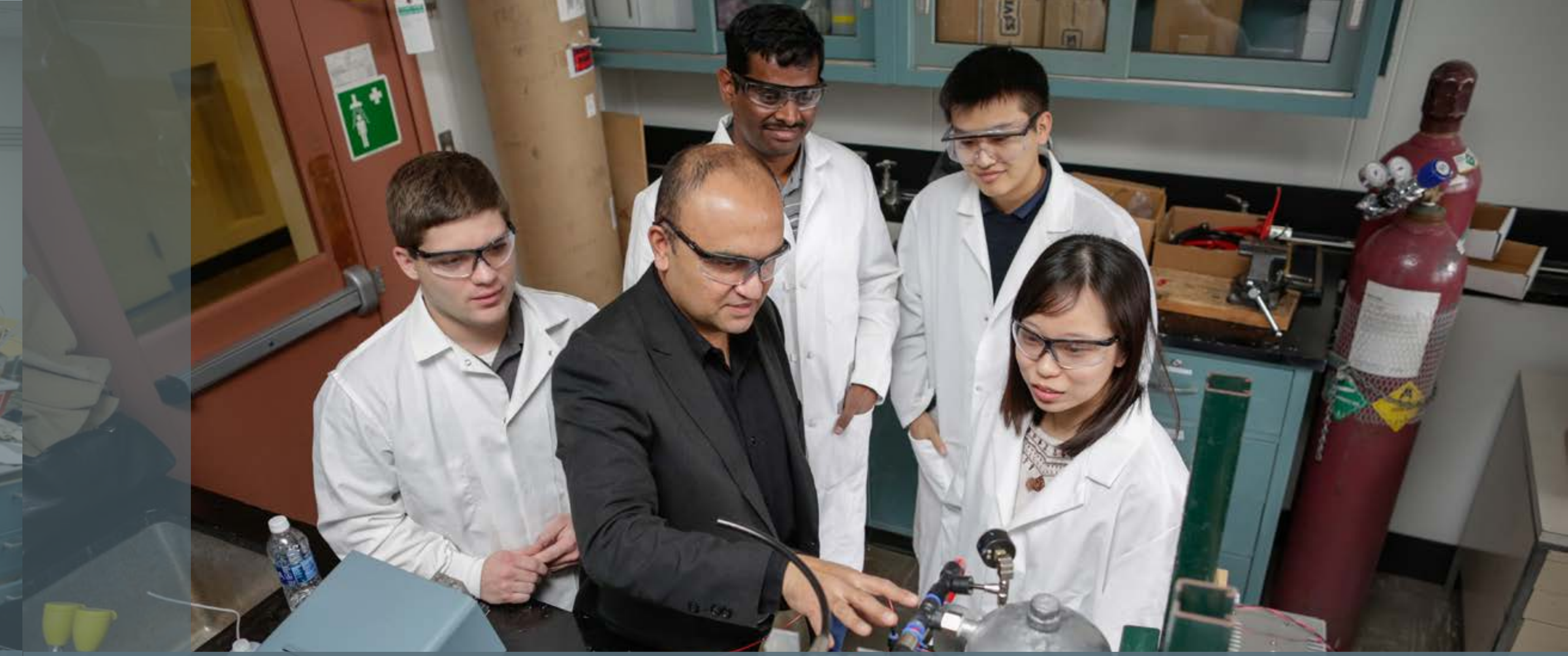
- To improve energy conversion efficiency using computer modeling and experimental approaches while minimizing or eliminating negative effects on the environment
- To design next-generation technologies that will be sustainable and carbon-free and have a low environmental footprint

Major projects include the catalytic conversion of bioethanol to green chemicals; the design of mesoporous catalysts and selective sorbents and membranes; the development of mixed ionic-electronic conducting materials for fuel cells; the biomanufacturing of solar absorber materials; and the sustainable processing of sulfur into sulfuric acid.

CORE FACULTY

Jonas Baltrusaitis	p. 12
Hugo Caram	p. 28
James Gilchrist	p. 16
Steven McIntosh	p. 19
Srinivas Rangarajan	p. 21
Shivaji Sircar	p. 28
Mark Snyder	p. 23
Kemal Tuzla	p. 25
Israel Wachs	p. 24





Systems and Computation

Researchers in this area develop and apply advanced computing methods to understand, design and control emerging technologies for energy, health and the environment.

We have expertise in an array of computing and systems methods, including process simulation, model predictive and feedback control, nonlinear optimization, statistical physics, stochastic modeling, molecular simulations, machine learning, data mining and quantum chemistry.

Our interests span a multitude of time (nanoseconds to hours) and length scales (individual atoms to collections of molecules to gigantic processes), and cover cutting-edge topics that range from the design and control of new technologies to the transport of colloids and macromolecules to biophysics of proteins, systems biology and heterogeneous catalysis. We work synergistically with experimentalists within and outside the department to derive fundamental insights about phenomena and processes that can otherwise not be obtained through experiments, theory, or simulations alone.

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Javier Buceta	p. 14
Vince Grassi	p. 25
Anand Jagota	p. 17
Mayuresh Kothare	p. 18
William Luyben	p. 18
Jeetain Mittal	p. 20
Srinivas Rangarajan	p. 21
Cesar Silebi	p. 26

Our projects include brain-machine interfaces that leverage model predictive control theories, energy-intensive chemical separation processes, new energy technologies for shale-gas upgrading, and elucidation of complex reaction mechanisms in new heterogeneous catalysts, modeling the outbreak of infectious diseases, design of functional materials, and elucidating bio-nano material interfaces.

Biomolecular Sciences

Researchers in this area use a multiscale perspective that aims at solving grand societal challenges in health, energy and sustainability.

Our goals

To provide quantitative and engineering dimensions to biological phenomena in order to explore and understand fundamental biological mechanisms and to develop new tools to tackle these societal challenges.

Research projects include biomanufacturing, biofilms and biosurfactants, bacterial toxins, lipid-protein interactions, stem cell differentiation, neuronal cell biology and cell-material interactions. Other projects include computational simulation of biological and neuronal processes, interfacial mechanical properties of proteins and carbon nanotubes, and molecular, cellular and tissue biomechanics.

Our research has impact on food safety, new drug development, the resistance of bacteria to antibiotics, the development of alternatives to antibiotics, the characterization of biomaterials and biomolecules, and the development of novel synthetic materials that promote wound healing and tissue regeneration.

CORE FACULTY	
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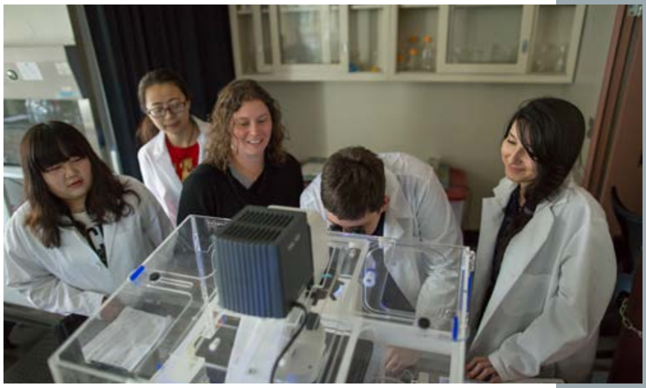
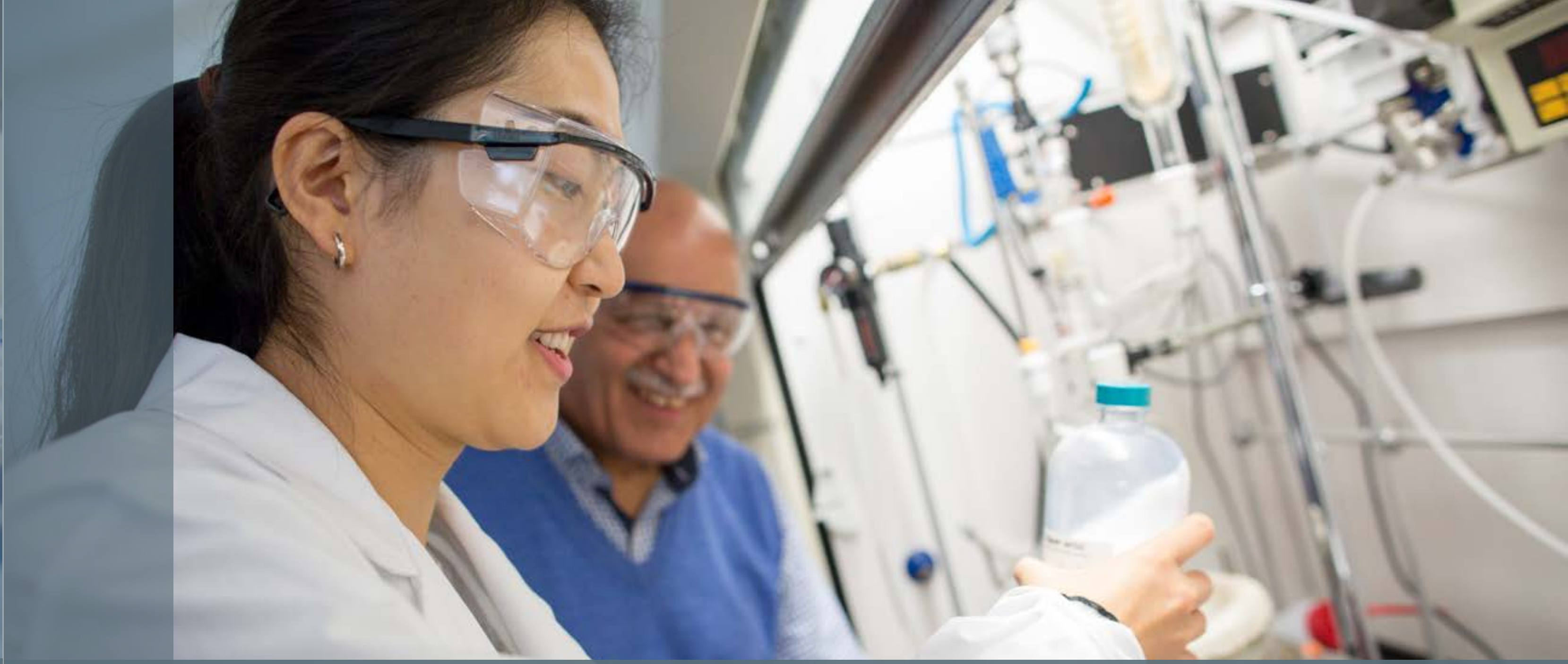
Kelly Schultz	p. 22





Materials and Interfaces

Researchers in this area work to rationally engineer existing materials and design new materials to meet grand challenges in energy, the environment, water, food and health. These materials include biomimetic surfaces, functional porous powders and thin films, nanocrystals and quantum dots, catalysts, ceramics, hydrogels and polymers.

Our goals

To improve material function by establishing and leveraging critical synthesis-structure-function relations for realizing materials capable of manipulating molecules, charge, fluids, photons and other species across structural and functional scales.

Our work has impacted various areas, including biomass catalysis, battery and alternative energy technologies, molecular separations and sensing, improved LED lighting and solar cell technologies, and tissue regeneration.

Projects include next-generation catalytic materials designed using operando molecular spectroscopy, biosynthetic quantum dots, nano-particulate assemblies, biomimetic and functional surfaces for enhanced adhesion and biocompatibility, ultrathin porous inorganic films and sorption-based molecular separations, functional ceramics for solid oxide fuel cells, multi-component structures for battery technologies, hydrogel scaffolds for hosting and guiding cell proliferation and growth, and emulsion polymer colloidal systems for coatings and adhesives.

CORE FACULTY

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Mohamed El-Aasser	p. 26	Kelly Schultz	p. 22
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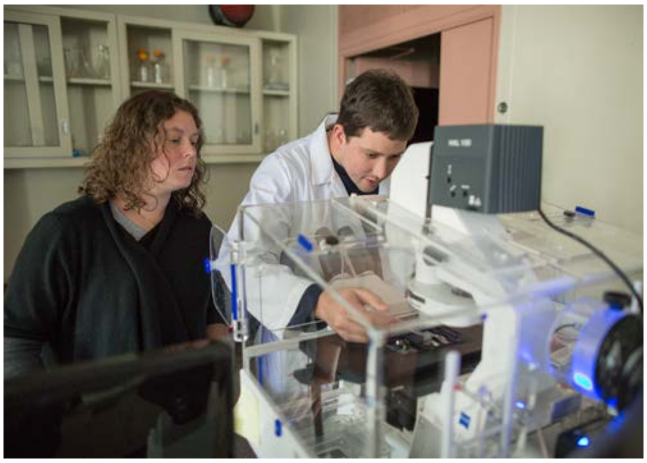
Anand Jagota	p. 17	Israel Wachs	p. 24
Anthony McHugh	p. 27		



Jonas Baltrusaitis

Associate Professor
job314@lehigh.edu

B.S., Chemical Engineering, Kaunas University of Technology, Lithuania, 1998
M.S., Chemical Engineering, Kaunas University of Technology, Lithuania, 2000
Ph.D., Chemistry, U. of Iowa, 2007

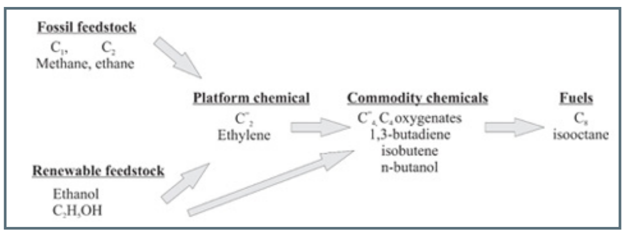
The Baltrusaitis laboratory focuses on catalysis utilizing short carbon chain feedstocks to obtain high value chemicals and fuels. Feedstocks include methane, ethanol and sour natural gas molecules such as carbon dioxide, hydrogen sulfide and methyl mercaptan.

ETHANOL CATALYTIC TRANSFORMATION TO 1,3-BUTADIENE
We apply quantum chemical calculations and optical spectroscopy under operating conditions to understand the reactive pathways and improve the selectivity of metal-promoted MgO/SiO_2 catalysts. We have achieved the highest 1,3-butadiene yields. We are identifying critical reactive intermediates, as well as thermodynamic and kinetic barriers, involved in the overall reactive landscape of ethanol to 1,3-butadiene. The nature of the reactive hydroxyl groups on the catalyst surface is being investigated using in situ infrared spectroscopy, while the bonding and oxidation state of the metal promoters is studied using X-ray spectroscopies. (William Taifan, Ph.D. 2018)

Instrumental techniques, including fixed bed reactor for steady state and mass spectrometer for kinetic measurements, are employed in Prof. Baltrusaitis's research.

ETHYLENE COUPLING INTO BUTENES USING SOLID ACID CATALYSTS
We are devising stable and selective solid acid catalysts for ethylene coupling to butenes. Liquid acid catalysts (H_2SO_4 and HF) present challenges in product separation, equipment corrosion, safety and environmental sustainability. We are designing solid acid catalysts based on ZrO_2 supported metal oxides for C_4 isomerization to yield clean transportation fuels. We are also applying fundamental knowledge in C_2= coupling reactions using homogeneous organometallic catalysts. (Lohit Sharma, Ph.D. 2021)

SOUR NATURAL GAS CATALYTIC SEPARATION
We are developing a fundamental knowledge base of acid gas-induced K_2O-WO_3/Al_2O_3 catalyst structural changes and the corresponding reactive intermediates and gas phase product distribution. This will guide rational catalyst design for efficient and cost-effective sour natural gas processing. The prediction and control of the CO_2 and H_2S molecular interactions, under reducing environments, with K_2O-WO_3/Al_2O_3 catalysts are being assessed for ability to form a reactive methyl mercaptan (CH_3SH) intermediate that can be converted to value-added hydrocarbons and H_2S. This work is supported in part by DOE EFRC UNCAGE ME. (Bin Li, M.S. 2017)



Conceptual design of obtaining high value chemicals and fuels from low value and abundant C1 and C2 feedstock via bottoms-up approach.

Angela C. Brown

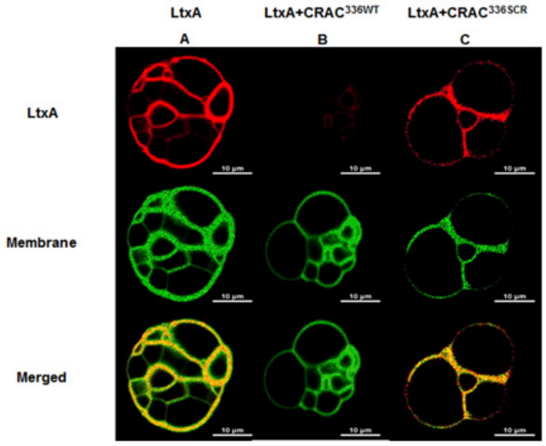
Associate Professor
acb313@lehigh.edu

B.S., Chemical Engineering, Pennsylvania State University, 2000
Ph.D., Chemical Engineering, Drexel University, 2008

Research in the Brown lab focuses on identifying targets for the development of novel therapeutics to treat bacterial diseases. We use chemical engineering principles to investigate the mechanisms of bacterial virulence factors during disease pathogenesis, with two goals: (1) identification of targets for the prevention of bacterial diseases, and (2) development of biologically inspired therapeutic agents.

ANTIBIOTIC ALTERNATIVES
Antibiotic resistance has become a major medical issue that is exacerbated by the rise of antibiotic-resistant organisms and the lack of development of new antibiotic options. Our approach to this problem is to focus on the virulence factors produced by pathogenic bacteria; these factors allow the organism to settle in a host and evade the immune response. We intend to study the mechanisms of these virulence factors to identify therapeutic targets to eliminate the pathogen's "support system," making it vulnerable to the host's immune system. Because we focus only on the pathogenic organisms, this approach will not affect beneficial bacteria, providing an additional advantage over traditional antibiotics which can destroy entire microbiomes. (Ph.D. candidates Evan Koufos and En Hyung Chang and postdoctoral associate Eric Krueger)

BIOLOGICALLY INSPIRED THERAPEUTICS
Although they appear to be "simple," bacteria have evolved numerous sophisticated mechanisms to deliver proteins and other factors to specific cells in their environment. We study these mechanisms to identify specific motifs, which we can then incorporate into the design of targeted drug delivery devices. (Ph.D. candidates Elnaz Rasti, Justin Nice, and Shannon Collins)

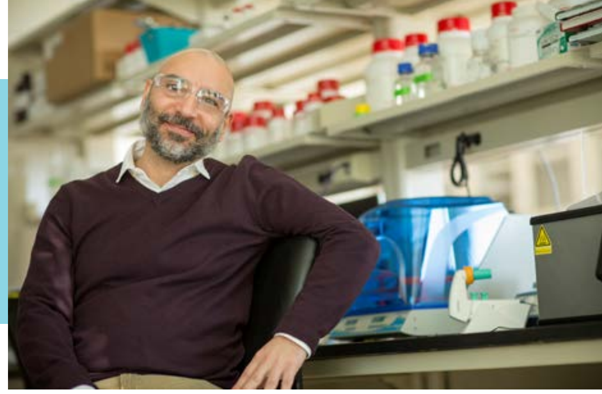


Inhibition of bacterial toxin (LtxA) binding to giant unilamellar vesicles (GUVs) by a cholesterol binding peptide (CRAC336WT). (A) Toxin (red) binds to the membrane (green) in the absence of peptide. (B) In the presence of CRAC336WT peptide, toxin does not bind to the membrane. (C) A scrambled control peptide (CRAC336SCR) does not inhibit toxin binding.

CHBE Ph.D student, Justin Nice (center), loads a gel filtration column as (L-R) Angela Brown, Elnaz Rasti, En Hyung Chang, and Shannon Collins observe.

Javier Buceta

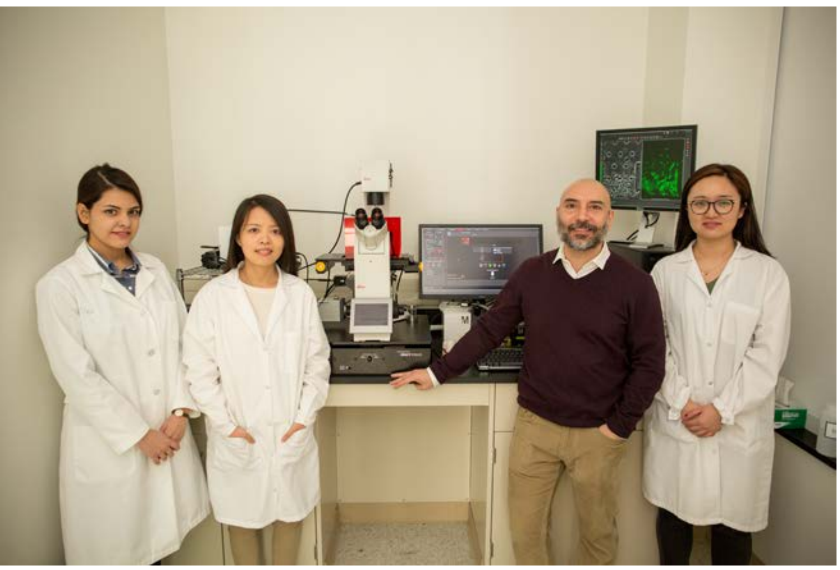
Associate Professor
Joint with Bioengineering Dept.
jab614@lehigh.edu



B.S. and MSc., Physics, Universidad Complutense de Madrid, Spain, 1994
Ph.D., Physics, Universidad Nacional de Educacion a Distancia, Spain, 2000

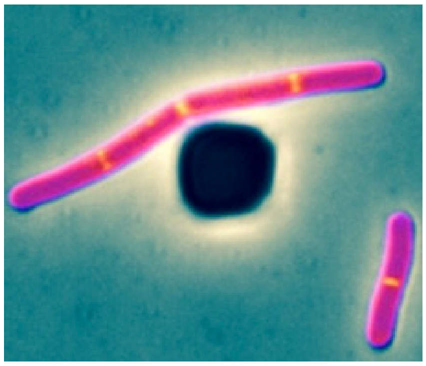
Our group combines theoretical, computational and experimental approaches to study tissue dynamics, cell size homeostasis, cell communication processes, and disease spreading among organisms.

CELL SIZE HOMEOSTASIS IN BACTERIA
Using bacteria as a model organism, we study the mechanisms of cell division, which are critical for developing novel antibiotics. We combine molecular biology techniques, microfluidic devices, advanced microscopy, computational image processing, and modeling to learn how cells establish the location of the cleavage plane and how they organize to achieve size homeostasis. We use microfluidic traps to exert mechanical perturbations (cell squeezing) and register the division dynamics. We have revealed the mechanosensitive properties of the bacterial divisome and the formation of previously unreported functional point-like complexes able to divide the cell. (Yanyan Chen, graduate student; Marta Dies, postdoctoral researcher)



Optical microscopy and microfluidics are used in Buceta's lab to obtain quantitative information at the single cell level. From left to right, graduate students Samira Anbari, Yanyan Chen, Professor Buceta, and graduate student Bixi Kang.

MECHANOBIOLOGY OF TISSUES
When cells organize into tissues, organs or tumors, gene regulatory circuits allow them to integrate signals from neighboring cells to decide which movements to make, which cell types to differentiate into and which communication signals



E. coli cells in a microfluidic device (false color). The division machinery (FtsZ protein: orange) has been marked with novel fluorescent tags that allow to quantify the dynamics of the division process.

to send out in return. Our in silico experiments integrate tissue mechanics cues with gene regulatory networks, and we compare those computer simulations with the quantification of real data using image processing techniques. In addition, we are developing force sensors to characterize cell-cell interactions experimentally. Our goal is to understand how cells develop an emergent collective behavior to shape tissues. (Samira Anbari and Bixi Kang, graduate students)

INFECTIOUS DISEASES OUTBREAKS AND SPILLOVERS
We are using modeling approaches to study the interplay between an organism's ecology and environmental and socioeconomic factors in disease spreading. As an example, in one of our projects we have implemented stochastic methods to understand the migration patterns of the bats that carry the Ebola virus and to develop tools able to estimate the risk of outbreaks at specific locations or times. (Graziano Fiorillo, postdoctoral researcher)

Manoj K. Chaudhury

Franklin J. Howes Jr. Distinguished Professor
mkc4@lehigh.edu

B.S., Physics, Calcutta University, 1976
M.S., Biophysics, State University of New York at Buffalo, 1980
Ph.D., Chemical Engineering, State University of New York at Buffalo, 1984

Chaudhury's group has made major contributions to surface phenomena, transport phenomena and mechanics.

MECHANICS OF SOFT MATERIALS
We have combined molecular level investigations (*Science* 1991, 1992) with continuum mechanics level modeling to investigate the adhesive, fracture and tribological properties of surfaces. We discovered the cooperative interaction of adhesion and frictional properties at interfaces (*Science* 1995) and a novel pattern-forming mechanism with soft elastic films (*PRL* 2001) that arise due to the competition between intermolecular and elastic forces in thin films. (Bimin Zhang Newby, Ph.D. 1993; Animangsu Ghatak, Ph.D. 2004; Jun Young Chung, Ph.D. 2006)

Ph.D. student Saheli Biswas is busy extracting water from a detergent stabilized oil-water emulsion. Research is supported by the Office of Naval Research.

GENERATING AND CONTROLLING MOTION ON SURFACES
We developed a method of making water droplets migrate on surfaces by controlling surface chemical forces. We showed that the cooperativity between surface energy gradient and condensation leads to rapid removal of droplets from surfaces. (Susan Daniel, Ph.D. 2005)

ROLE OF NOISE IN CONTROLLING MOTION
Working with Pierre Gilles de Gennes, we showed how a noise (structured or random) can induce motion of liquid drops, soft gels and even small solid particles on a surface. We also demonstrated how a flexible hydrogel can be moved on a surface by mimicking the motion of terrestrial animals. (Daniel)

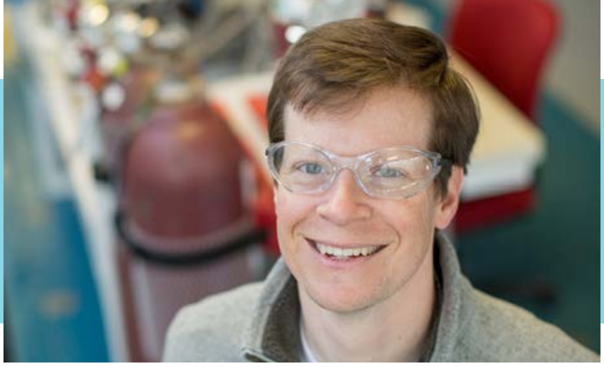
INTERACTIONS OF PARTICLES IN GELS
We recently discovered a new type of long-range interaction between rigid particles that occurs when they are suspended or floated in an ultrasoft elastic gel. (Aditi Chakrabarti, Ph.D. candidate)

BROWNIAN MOTION WITH NONLINEAR FRICTION
Our research motivated de Gennes to publish a paper in 2005 on a new type of Brownian motion with dry friction. Our experiments and simulations demonstrated that the Brownian motion induced by either a non-Gaussian noise or a non-linear friction leads to non-trivial mechanism underlying symmetry breaking and stochastic dynamics. (Srinivas Mettu, Ph.D. 2012; Parthosarathy Goohpattader, Ph.D. 2013)

IMPROVED ADHESION USING SURFACE PATTERNING
We demonstrated a mechanism of crack arrest in thin solid films due to discontinuity arising from morphology and/or mechanical properties. (Ghatak, Chung)

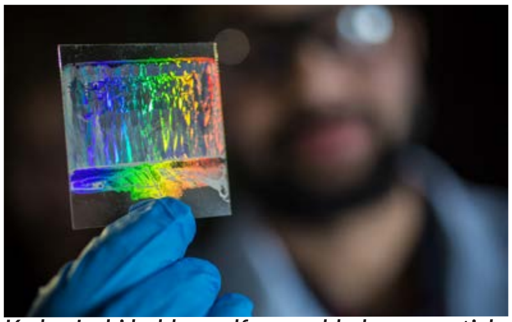
James F. Gilchrist

Professor
jfg204@lehigh.edu



B.S., Chemical Engineering, Washington University, 1997
Ph.D., Chemical Engineering, Northwestern University, 2003

Research in our lab focuses on flow, rheology, mixing/segregation and self-assembly of particulate systems.



Kedar Joshi holds a self-assembled nanoparticle thin film studying the effects of Marangoni stress on the coating flow.

FLOW-INDUCED ASSEMBLY OF PARTICULATE-BASED THIN FILMS

We use convective deposition of nano- and microscale particles as a platform for scalable nanomanufacturing of surface morphologies to control and enhance photon, electron and mass transport. The fundamental mechanism behind self-organization of these particles is attraction driven by the local capillary interactions and flow steering of particles confined in a thin film of an advancing meniscus. By studying and altering thin film dynamics, we can control morphology and various instabilities that occur during deposition of mono- and bidisperse suspensions (Zhiqiao Zeng, M.S. 2017, Thitiporn Kaewpetch, M.S. 2017). For instance, by adjusting the suspension profile we alter assembly from a particle-by-particle deposition to a pre-organized deposition mode that affects the deposited morphology (Kedar Joshi, Ph.D. 2017). Likewise, lateral mechanical oscillatory motion of the substrate alters the mode of deposition increasing the rate of deposition and reducing the sensitivity of the process to fabricate crystalline monolayers and the unique ability to form flow-templated long range thin film FCC 100 colloidal crystals with controllable stress-induced defects (Midhun Joy, Ph.D. 2016). This process has been successful in fabricating coatings with collaborators that enable or enhance performance of light emitting diodes (LEDs and OLEDs), dye sensitized solar cells (DSSCs), polymeric and inorganic membranes, and cell capture platforms (Alexander Weldon, Ph.D. 2014). This work has been recently extended to alignment of cellulose fibers as barrier films and drug delivery systems (Thitiporn Kaewpetch).

3D CHARACTERIZATION OF SUSPENSION DYNAMICS IN MICROSCALE FLOWS

Shear and imposed thermal and electric field gradients cause particles to self-assemble. We design microscale experiments to explore the interplay between flow and self-assembly. For example, suspensions of moderate-to-high volume fraction of solids in liquids demonstrate non-Newtonian rheology, demixing through shear-induced migration, and thixotropy. Understanding microstructure evolution in sheared suspensions is key for explaining their rheological behavior and eventually designing fluids with desired properties for applications. Our work explores 3D suspension microstructure using dynamic confocal laser scanning microscopy, directly resolving the particle pair distribution function and local flow characteristics (Tharanga Perera, Ph.D. 2014). Recently, we have explored the ability to characterize thermophoresis using microrheology and the utility of thermal gradients for particle migration in complex fluids.

NANOPARTICLE HETERONUCLEATION OF POLYMER CRYSTALLIZATION TO IMPROVE AC BREAKDOWN STRENGTH

Crystallization studies have shown that nanoparticles can function as nucleating agents in high density and low density polyethylenes (HDPE and LDPE, respectively). These nanoparticles can also improve dielectric strength in PE if adequate dispersive and distributive mixing is achieved in the base PE. However, most previous studies do not control material properties well enough to clarify the role of particle size and surface properties in nucleating polymer crystallization. This study systematically alters nanoparticle size and surface chemistry to the influence on dispersion, crystallization and AC breakdown (Karl Seven, Ph.D. 2018).

Anand Jagota

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B. Tech., Mechanical Engineering, Indian Institute of Technology New Delhi, 1983
M.S., Mechanical Engineering, Cornell University, 1986
Ph.D., Mechanical Engineering, Cornell University, 1988

The Jagota laboratory is interested in interfacial and surface mechanical properties of a variety of materials and systems, including biomolecule-nanomaterial hybrids, structured biomimetic materials for controlled adhesion and friction, biomechanics of synaptic vesicle adhesion and fusion, and the mechanics of soft materials.

BIOMOLECULE-NANOMATERIAL HYBRIDS
Our main focus is on hybrids of single wall carbon nanotubes (SWCNT) and DNA. This system has proven very useful for the processing and selection of SWCNTs and for the development of biomedical sensing and imaging applications. Our contribution has been in the understanding of the structure and thermodynamics of these materials and of the processes used for their manipulation. (Yoona Yang, graduate student)

Jagota fiddles with some sensitive equipment while graduate student Yoona Yang hopes he won't break it.

BIOMIMETIC ARCHITECTURES FOR CONTROLLED SURFACE MECHANICAL PROPERTIES
Contacting surfaces in organisms ranging from small insects to lizards have evolved into a set of architectures that result in unprecedented and remarkable surface mechanical properties such as enhanced and switchable adhesion and friction. We design and fabricate a variety of biomimetic structures and study them with experimental work and theoretical modeling. (Nichole Asermely, graduate student; Zhenping He, postdoctoral associate)

ROLE OF SURFACE STRESS IN THE MECHANICS OF SOFT SOLIDS
Most biomaterials are exceedingly compliant compared to conventional engineering materials. This has a profound effect on associated mechanical phenomena. In particular, surface stress, usually a negligible actor for conventional materials, can play an important or dominant role in phenomena such as wetting, indentation and surface deformation. (Zhenping He, postdoctoral associate)

MECHANISMS OF SNARE-MEDIATED SYNAPTIC TRANSMISSION
Synaptic transmission, a basic process at the junction between neurons, is driven by the adhesion of a bundle of proteins (SNARE). We study the function and dysfunction of this process by modeling its details using a variety of molecular through continuum methods. (Nicole Fortoul and Mark Lee, graduate students)

Mayuresh Kothare

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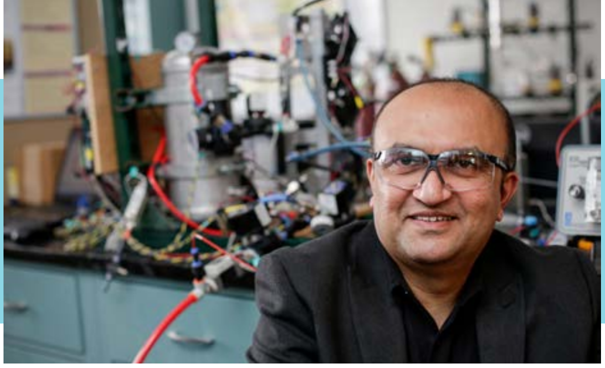

B. Tech., Chemical Engineering, Indian Institute of Technology, India, 1991
M.S., Chemical Engineering, California Institute of Technology, 1995
Ph.D., Chemical Engineering, California Institute of Technology, 1997

The Kothare group has made key contributions in the areas of robust and embedded Model Predictive Control, with applications in microreactors, neuroengineering and medical oxygen concentrators.

MODEL PREDICTIVE CONTROL: We have pioneered a new formulation of predictive control using Linear Matrix Inequalities, studied its computational cost and extension to multi-model nonlinear systems (Z. Wan, Ph.D. 2003), and application to polymerization control (L. Ozkan, Ph.D. 2002).

MICROREACTORS: We have demonstrated system-on-chip methanol reformers (A. Pattekar, Ph.D. 2004), their model-based feedback control (L. Bleris, Ph.D. 2006), and patented efficient embedded controller implementation (P. Vouzis, Ph.D. 2008).

CLOSED-LOOP NEUROENGINEERING: In collaboration with Johns Hopkins School of Medicine, we have developed a new predictive control interpretation of sensory feedback in closed-loop Brain Machine Interfaces (G. Kumar, Ph.D. 2013). Current work attempts to extend this formulation to closed-loop electrical stimulation therapies (electroceuticals) (Y. Yao, Ph.D. 2021).

CONTROL OF MEDICAL OXYGEN CONCENTRATORS: We have developed a patented air separation design to reduce the weight of a compact medical oxygen concentrator for rehabilitation of patients with chronic obstructive pulmonary disease (S-W. Chai, Ph.D. 2011; C-W. Wu, Ph.D. 2016). A related project involves implementation of closed-loop multi-model control of this device using a Raspberry Pi hardware platform (M. Urich, Ph.D. 2018).

William L. Luyben

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B.S., Chemical Engineering, Pennsylvania State University, 1955
M.S., Chemical Engineering, University of Delaware, 1962
Ph.D., Chemical Engineering, University of Delaware, 1963

Professor Luyben conducts research in the areas of process control and process design.

He is the author of a number of books, including *Distillation Design and Control Using Aspen Simulation* 2nd Edition (2013), *Principles and Case Studies of Simultaneous Design* (2011) and, with I-Lung Chien, *Design and Control of Distillation Systems to Separate Azeotropes* (2010).

Professor Luyben also publishes articles regularly in the top process control and process design journals. In the past two years, he has authored seven articles, including “Dynamic simulation of flooded condensers,” “Plantwide Control of a Triple-Column Pressure-Swing Distillation Process,” “Economic Trade-Offs in Acrylic Acid Reactor Design,” and “Distillation column pressure selection.”

Steven McIntosh

Professor

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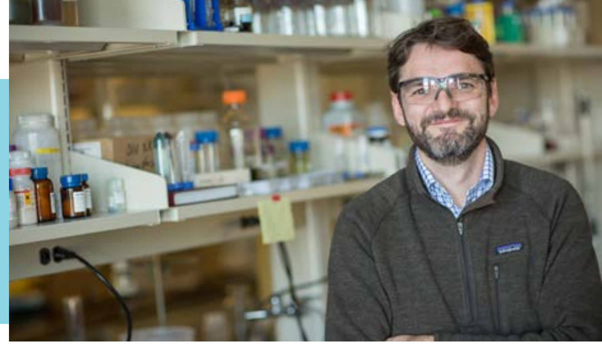
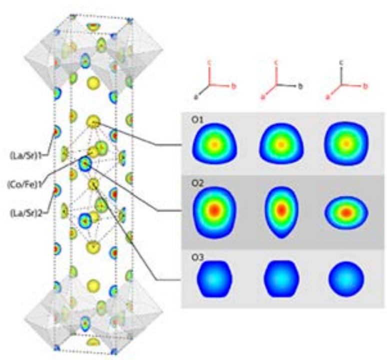


B. Eng., Chemical Engineering, University of Edinburgh, UK, 1999
M.S., Chemical Engineering, University of Pennsylvania, 2001
Ph.D., Chemical Engineering, University of Pennsylvania, 2004

McIntosh pursues interdisciplinary research in electrochemistry, materials chemistry, solid state ionics and catalysis. These fields come together in research projects centered on the development of novel materials and systems for energy applications.

STRUCTURE-FUNCTION RELATIONSHIPS IN SOLID OXIDE ELECTROCHEMICAL CELL ELECTRODE MATERIALS

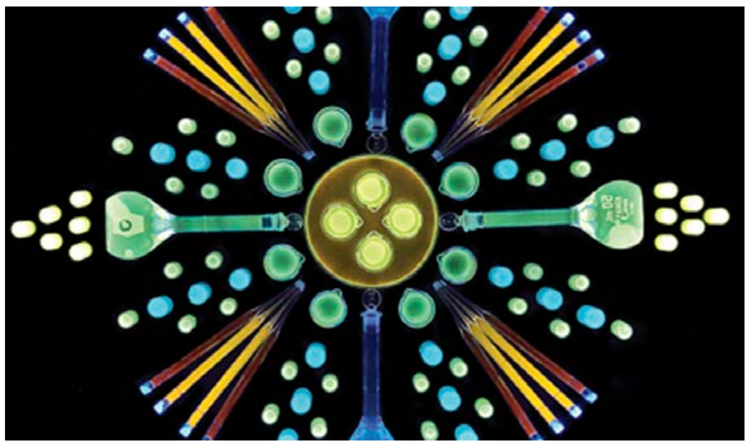
Solid oxide fuel cells (SOFCs) offer an efficient route for the direct conversion of the chemical energy in fuels to electrical energy. The reverse process, electrolysis, is a similarly efficient route to the storage of excess electrical energy as a chemical fuel. When combined in a reversible solid oxide electrochemical cell, these two processes offer a high capacity route to renewable energy storage. The McIntosh group utilizes a combination of techniques to study the bulk and surface of electrode materials and to relate these fundamental insights to device performance. Our most recent work combines in-situ neutron diffraction, surface analysis, isotopic switching experiments, and electrochemical studies to understand the links between bulk oxygen anion transport, surface catalysis and electrochemistry. (Alex Tomkiewicz, Ph.D. 2016; Mazim Tamimi, Ph.D. 2016; Caterina Sarno, visiting scholar from University of Rome Tor Vergata)



Nuclear density map of a potential SOFC electrode material indicating the oxygen anion transport pathway through the material. This is derived from in-situ neutron diffraction studies.

BIOMINERALIZATION OF FUNCTIONAL NANOMATERIALS

In contrast to typical chemical routes for material synthesis that require toxic reactants and solvents and high temperatures, biomineralization offers a green, water-based route to nanomaterial synthesis at room temperature. The goal of our collaborative work is to develop enzymatic routes that enable the control of nanoparticle size, shape, composition and crystallinity to create high performance nanomaterials for energy applications. This typically requires control of particles of less than 5 nanometers in diameter. Target nanomaterials include environmental catalysts and quantum confined semiconductors. (Christopher Curran, Ph.D. 2018; Leah Spangler, Ph.D. 2018; Zhou Yang, Ph.D. 2016; Abdolhamid Sadeghnejad, Ph.D. 2019; Siavash Rajabpour, Ph.D. 2020)



Photoluminescence of biomineralized CdS quantum dots. The observed differences in color are indicative of the size of the nanocrystals.

Jeetain Mittal

Professor
Ruth H. and Sam Madrid Endowed Chair
jem309@lehigh.edu

B. Tech., Chemical Engineering, Punjab Technical University, India, 2000
M. Tech., Chemical Engineering, Indian Institute of Technology, Kanpur, 2002
Ph.D., Chemical Engineering, University of Texas at Austin, 2007

Our research interests are in the areas of biophysics and soft matter. We use advanced molecular simulation methodologies to obtain system properties and then to develop theories fundamentally rooted in statistical mechanical principles.

FUNCTIONAL MATERIAL DESIGN BY DNA-MEDIATED INTERACTIONS
A promising approach to achieving precise organization of modular building blocks such as nanoparticles for the design of diverse, complex and functional structures is the use of particle-tethered, complementary single-stranded DNA (ssDNA). This work, supported by a DOE CAREER Award, aims to develop a comprehensive computational and theoretical strategy to overcome barriers in self-assembly of DNA-functionalized particles (DFPs). (Hasan Zerze, postdoctoral researcher; Runfang Mao, Ph.D. 2020; Tiara Ann Shalimar Maula, Ph.D. 2021; Evan Pretti, B.S. 2018)

BIOMOLECULAR ASSEMBLY PROCESSES AT BIO-NANO-INTERFACES
Many new technologies and therapies have been developed in which DNA is tethered to or adsorbed on a solid surface. We are developing new computational models, aided by experimental measurements, to predict the thermodynamic phase behavior and kinetics of nucleic acid assembly near nanomaterials such as graphene and carbon nanotubes. (Vahid Rahmanian, Ph.D. 2020; Huilai Gu, B.S. 2019)

MACROMOLECULAR CROWDING
Biomolecular folding, binding and assembly are usually conceived of as occurring in bulk aqueous solution. Within cells these processes occur at interfaces, including the surfaces of very large macromolecules such as ribosome tunnels, chaperones, and the cell membrane itself. We seek to predict the consequences of dynamic cellular environment on biochemical processes such as protein folding, protein binding and protein-DNA interactions. (Gregory Dignon, Ph.D. 2020; Eddie McGowan, B.S. 2020)

INTRINSICALLY DISORDERED PROTEINS
There is a growing need to develop predictive molecular models for the properties of intrinsically disordered proteins. These proteins play key roles in signaling and regulation (e.g., cell cycle, transcription, growth) and are associated with numerous human diseases. We have developed an accurate physics-based protein for predicting the equilibrium structural ensembles and kinetic properties of disordered proteins. (Halime Gul Zerze, Ph.D. 2017; Brandon Horan, Ph.D. 2019; Irem Elif Senyurt, Ph.D. 2020)

Srinivas Rangarajan

P.C. Rossin Assistant Professor

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B. Tech., Chemical Engineering, Indian Institute of Technology, Madras, 2007
Ph.D., Chemical Engineering, University of Minnesota, 2013

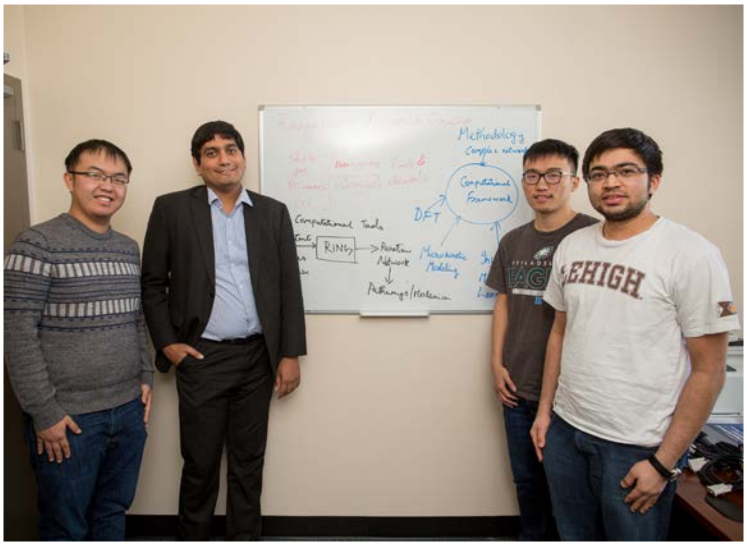
Rangarajan's expertise lies at the intersection of heterogeneous catalysis, reaction engineering, and process systems engineering. Rangarajan has developed the software RING that allows for constructing and exploring complex reaction networks, comprising several thousands of species and reactions, in an automated manner.

RING has been used by multiple research groups to study mechanisms of biomass conversion and to explore the synthesis network for upgrading biomass-derived oxygenates.

Rangarajan has also explored problems related to the origin of organonitrogen inhibition in industrial hydrotreating catalysts, the mechanism of formic acid dehydrogenation on transition metal catalysts, and graphene nanoribbon growth on germanium utilizing electronic structure calculations, in particular, density functional theory (DFT).

The current interests of the Rangarajan group are in modeling complex heterogeneous catalytic systems in biomass and natural gas conversion and in designing molecular materials for energy and environmental applications. His group (Huijie Tian, Ph.D. 2022) is developing a Bayesian self-consistent microkinetic modeling framework for systematically identifying the underlying reaction mechanism of catalytic processes utilizing techniques that include optimization, uncertainty quantification and machine learning. This is being adopted, in parallel with DFT, to elucidate the complex mechanism of, and thereby design new materials for, alkane conversion on solid catalysts such as transition metals and their oxides, sulfides, carbides, etc., to convert shale gas into higher value chemicals (Ronak Upadhyay, Ph.D. 2022).

The Rangarajan group (Bowen Li, M.S. 2019) is also developing new classes of computational high throughput screening tools that are cognizant of synthesis feasibility to design molecular materials for application in energy storage utilizing techniques from cheminformatics, graph theory, and linear programming.



Kelly M. Schultz

Associate Professor

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B.S., Chemical Engineering, Northeastern University, 2006
Ph.D., Chemical Engineering, University of Delaware, 2011

Professor Schultz uses bulk and microrheology to characterize biomaterials during dynamic transitions such as gelation and degradation.

COVALENTLY ADAPTABLE HYDROGEL SCAFFOLDS PUSHED OUT OF EQUILIBRIUM

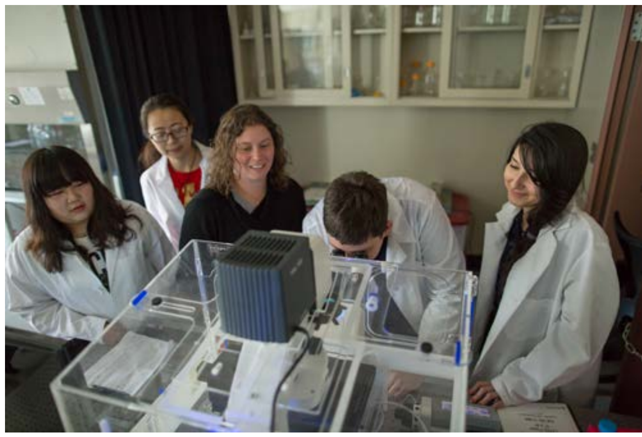
Covalently adaptable hydrogels mimic the native extracellular matrix that cells experience in vivo due to their ability to physically adapt to their environment. These gels yield when a stress is applied and reform covalent bonds once the stress is released, creating an environment cells can survive in and one that responds dynamically to cytoskeletal tension during basic processes. We use multiple particle tracking microrheology to measure dynamic material properties during scaffold degradation due to a change in pH or reaction equilibrium. (Francisco S. Escobar IV, M.Eng. 2016; Nan Wu, Ph.D. 2021)

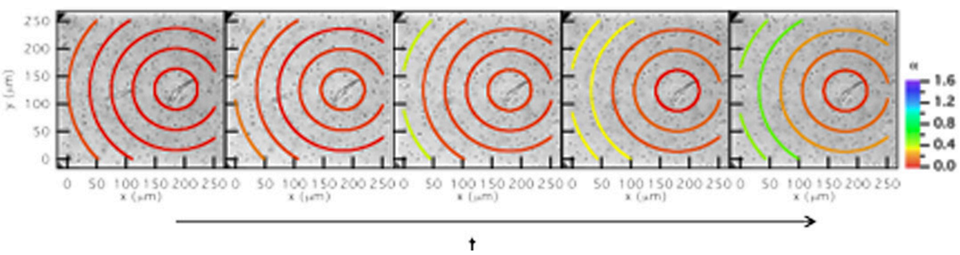
CHARACTERIZATION OF HETEROGENEOUS COLLOIDAL GEL SYSTEMS

Colloidal gels are widely used in commercial products and biomaterials due to their unique rheological characteristics, specifically the ability to shear thin. Environmental conditions cause dramatic changes to the structure and properties of the gels, decreasing their shelf life and performance. We characterize the dynamic, heterogeneous degradation and formation of a colloidal fiber gel using microrheology to enhance product design, development and manufacturing. (Matthew Wehrman, Ph.D. 2018)

UNDERSTANDING HOW MESENCHYMAL STEM CELLS CONTROLLABLY REMODEL THEIR ENVIRONMENT

Cells do not passively reside within materials, but actively reengineer their environment. The design of synthetic biomaterial scaffolds aims to recapitulate and harness the signaling that cells receive from their environment to create scaffolds that control motility. Using a unique combination of well-defined poly(ethylene glycol) (PEG)-peptide hydrogel scaffolds, 3D human mesenchymal stem cell (hMSC) encapsulation and high spatio-temporal modulus microrheological characterization, we identify how cells interact with their microenvironment and how these interactions change as the physical environment is varied to mimic native tissues. (Maryam Daviran, Ph.D. 2020)





Microrheological measurements of cell-mediated degradation of a PEG-peptide hydrogel

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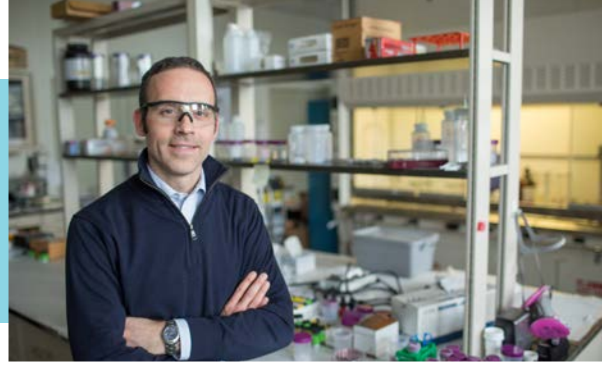
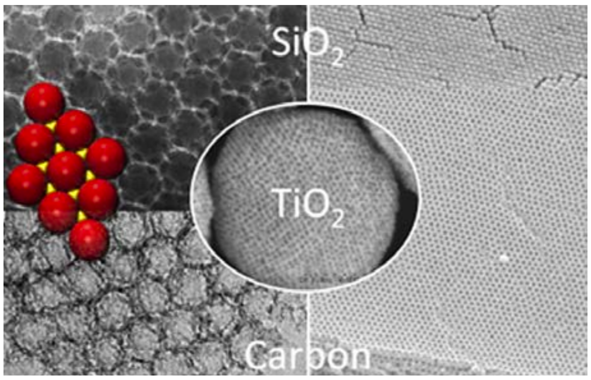


B.S., Chemical Engineering, Lehigh University, 2000
Ph.D., Chemical Engineering, University of Delaware, 2006

The Snyder lab designs and engineers functional inorganic nanoparticles, nanoparticle assemblies, and porous particles and thin films for applications such as novel sorbents, membranes, catalysts, and electrodes. Our goal is to support the development of next-generation materials for alternative energy technologies spanning efficient molecular separations to efficient biomass catalysts and solar cell technologies. Research has been supported by NSF, DOE and PRF, including an NSF CAREER Award.



Leveraging multi-modal assembly of size-tuned silica nanoparticles (top left) for sacrificial templating of uni- and multi-modal three-dimensionally ordered mesoporous (3DOm) powders and thin films from among a diverse materials palette (e.g., metal oxides to carbon).

NANOPARTICLE SYNTHESIS AND MULTI-MODAL ASSEMBLY
The synthesis of complex functional materials through bottom-up assembly of particulate building blocks represents a Holy Grail for materials with potential applications spanning shape and size-selective catalysis, complex composites and energy storage. We have established fundamental mechanistic insight into how multi-modal assembly of size-tuned silica nanoparticles can be employed as a facile route to hierarchically ordered mesoporous silicas (S.-C. Kung, Ph.D. 2015). We are pursuing strategies to extend structural diversity achieved through DNA-based particle 'flavoring' (M. Song, Ph.D. 2016) and stress-driven relaxation during convective particle assembly (M. Joy, Ph.D. 2016). We exploit nanoparticle crystalline assemblies as a sacrificial templating platform for structuring of a diversity of distinct porous replica phases.

TEMPLATE-MEDIATED HIERARCHICAL STRUCTURING OF POROUS CARBON POWDERS AND STRUCTURED THIN FILMS TOWARD NOVEL ELECTRODES, HIGH-FLUX MEMBRANES, SELECTIVE ADSORBENTS
We exploit the juxtaposition of the geometric simplicity of nanoparticle crystalline templates with the hierarchical complexity they cast in replica structures. We have demonstrated templated synthesis of symmetric and asymmetric 3D-ordered mesoporous (3DOm) carbon films (membranes) as well as novel bimodal and interdigitated-bimodal 3DOm (ib3DOm) structures. These methods have been proven by Z. Tian (Ph.D. 2014) and M. Sharma (Ph.D. candidate) to enhance surface areas, dramatically improve hierarchical pore size control and molecular accessibility, and enable independent replica microstructuring through template-mediated interfacial phenomena.

STRUCTURAL AND INTERFACIAL ENGINEERING OF CATALYTIC MATERIALS
Our efforts to extend the multi-modal sacrificial templating platform to a broader materials palette have resulted in realization of hierarchically porous oxides (e.g., TiO_2, ZrO_2, and oxide/oxide systems) that display novel interface-mediated polymorph stabilization (D. Gregory, Ph.D. 2016), and hierarchically porous zeolites.

Snyder and student Megha Sharma with small-angle X-ray diffractometer used for non-destructive characterization of particle suspensions to porous materials.

Israel E. Wachs

G. Whitney Snyder Professor
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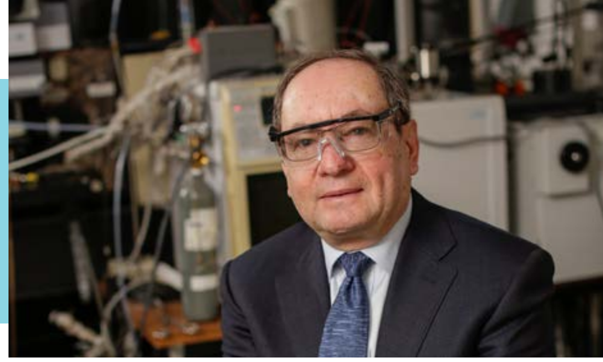


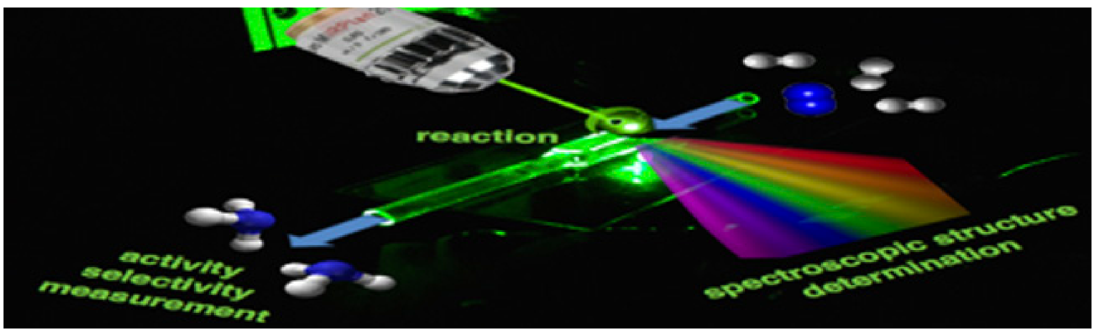
B.S., Chemical Engineering, City College of the City University of New York, 1973
M.S., Chemical Engineering, Stanford University, 1974
Ph.D., Chemical Engineering, Stanford University, 1978

The Wachs group develops fundamental molecular-level structure-activity/selectivity relationships for catalysts with the aid of modern spectroscopic techniques operating under reaction conditions. Our goal is to guide the rational design of advanced catalysts for energy and environmental applications.

CONVERSION OF BIOETHANOL TO BUTADIENE FOR MANUFACTURE OF GREEN TIRES
The shortage of butenes from petroleum fluid catalytic cracking has created demand for on-purpose production of butenes, especially 1,3-butadiene, that can be produced from sustainable biomass-derived bioethanol for the manufacture of green butyl rubber tires. Our group seeks to establish the structure-activity/selectivity relationships of this reaction by supported ZnO-ZrO_2/SiO_2 catalysts. Cutting-edge spectroscopic studies that simultaneously monitor the catalyst (bulk and surface phases), reaction intermediates and reaction products are unraveling the molecular details of this catalytic system and guiding design of superior catalysts. Brianna Ruggiero (B.S. 2018), Benjamin Moskowitz (Ph.D. 2020).

SELECTIVE CATALYTIC REDUCTION OF NOx WITH NH_3 TO N_2 AND H_2O FROM POWER PLANTS AND TRUCKS
The high-temperature combustion of fossil fuels for energy production is accompanied by NOx emissions having an undesirable impact on the environment (acid rain and global warming). The catalyst system industrially employed for the selective catalytic reduction (SCR) of NOx with NH_3 is supported V_2O_5-WO_3/TiO_2. In spite of its successful application, many of the fundamental details of this important catalyst are not fully understood, hampering the development of improved robust catalysts. By applying state-of-the-art spectroscopic techniques during the SCR reaction, we have resolved many of the details and suggested paths to design improved catalysts. Minghui Zhu (Ph.D. 2017), Jun-Kun Lai (Ph.D. 2020).

Ph.D. student Anisha Chakrabarti focusing the optical spectroscopic measurements (Raman, IR, and UV-vis) onto the catalyst.



Spectroscopic structural determination and activity/selectivity measurement during ammonia synthesis.

Vincent G. Grassi

Professor of Practice
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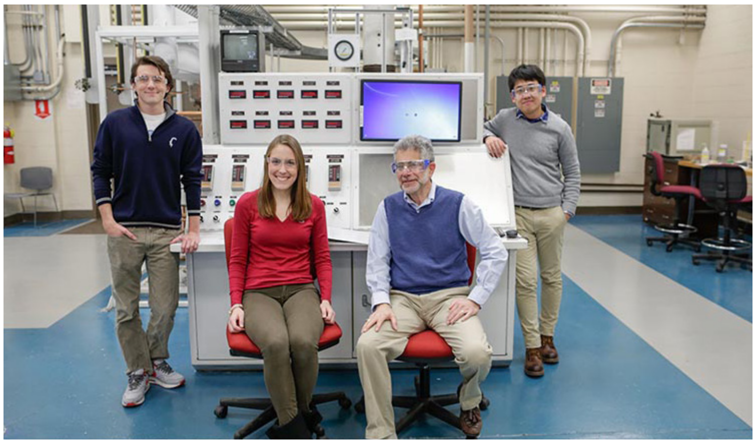
B.S., Chemical Engineering, University of Rochester, 1978
M.S., Chemical Engineering, Lehigh University, 1985
Ph.D., Chemical Engineering, Lehigh University, 1991

Professor Grassi came to Lehigh following a 35-year career with Air Products and Chemicals Inc. His interests are in process systems, undergraduate engineering pedagogy and professional development. He teaches the capstone senior-level process design course, the Unit Operations laboratory, first year engineering, and professional development. A Fellow of the American Institute of Chemical Engineers, Grassi works with the global chemical industry, AIChE, ABET and other professional organizations to advance CHBE research and education. He also leads the CHBE Master's Distance Education program.



Kemal Tuzla

Professor of Practice and Associate Chair
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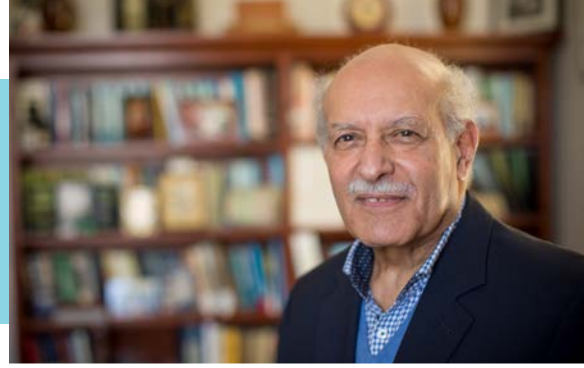
B.S. and M.S., Mechanical Engineering, Istanbul Technical University, Turkey, 1966
Ph.D., Mechanical Engineering, Istanbul Technical University, Turkey, 1972

Professor Tuzla studies heat transfer and fluid mechanics problems related to energy generation and conversion. In one project, he utilizes solid-to-liquid phase changes to increase the temperature and energy storage density of media that store solar energy. He has tested storage materials that melt at 400-700 degrees C. and conducted calorimetric experiments to determine the stability of storage and the release of energy into storage materials. Tuzla also studies the hydrodynamics of the flow and heat-transfer mechanisms in the gas-solid fluidized beds used in the chemical and environmental remediation industries. Professor Tuzla is the primary coordinator and manager of the Unit Operations undergraduate laboratory.

Chemical Engineering majors Francesca Cicciari, Emilia Galka, and James Wilkinson discuss mixing of fluids in an agitated vessel and its effects on heat and mass transfer in the Undergraduate Unit Ops Laboratory.



Mohamed El-Aasser

Professor Emeritus

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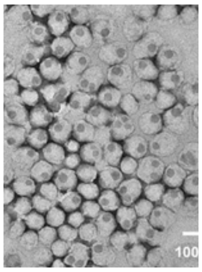
B.S., Physical Chemistry, Alexandria University, Egypt, 1962

M.S., Physical Chemistry, Alexandria University, Egypt, 1966

Ph.D., Physical Chemistry, McGill University, Canada, 1972



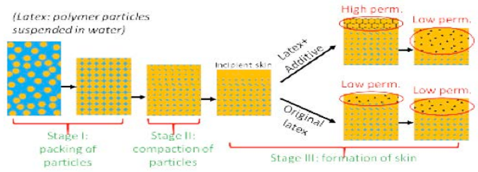
Multilayer Latex Particles

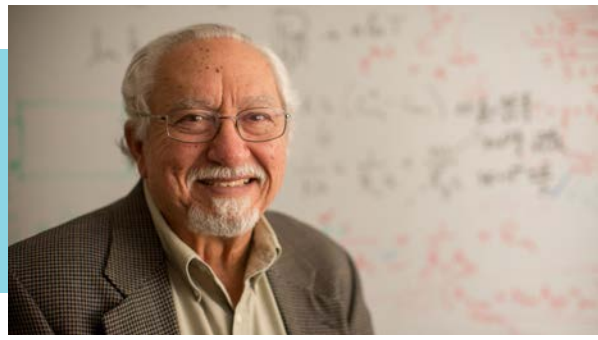
The focus of our research is polymer colloids (latex) systems, their synthesis, characterization and applications. Latex is a colloidal dispersion of submicron polymer particles in aqueous phase, with applications in coatings, adhesives, rubber products, inks and biomedical devices.

We use reactor calorimetry to study the kinetics and role of surfactants to develop mechanistic understanding of emulsion, dispersion, microemulsion and miniemulsion polymerization processes. Thermodynamic and kinetic analysis are essential to develop latexes with the required physical, chemical and microstructure properties to match the application needs. Broad particle size distributions are needed for high solids, whereas monodisperse latex particles with specific surface functionality are used in biomedical and diagnostic tests. We use NMR, microscopic, spectroscopic and dynamic mechanical methods for complete characterization of latex systems.

Yuanyuan Wang, a CHBE Ph.D. student, synthesizes silica/PBA/PMMA multilayer latex particles for her mechanistic study of toughening epoxy matrix.

Hao Huang, a CHBE Ph.D. student, studies the drying rate of hydrophobic latex system and film formation, essential for coatings, using optical coherence microscopy. (See below.)





Cesar Silebi

Professor Emeritus

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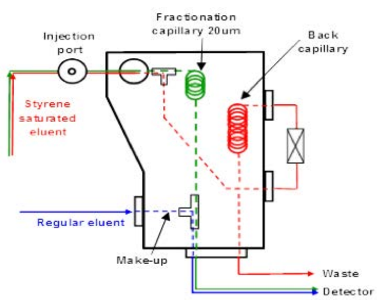
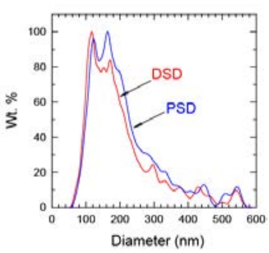
B.S., Chemical Engineering, Universidad del Atlantico, Colombia, 1968

M.S., Chemical Engineering, Lehigh University, 1974

Ph.D., Chemical Engineering, Lehigh University, 1978



Professor Silebi's research interests include particle separation processes, rheological and colloidal properties of latexes, multi-component transport in emulsions, and stability of colloidal systems. His teaching interests include transport phenomena, mass transfer and capstone design.



Megan B. Casey CHE Ph.D. '09 modified the Capillary Hydrodynamic Fractionation (CHDF) to determine droplet size distribution (DSD) of styrene-in-water miniemulsions, and resulting polystyrene latex particles (PSD).

James T. Hsu

Professor
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B.S., Chemical Engineering, National Cheng-Kung University, Taiwan, 1969
M.S., Chemical Engineering, University of Rhode Island, 1972
Ph.D., Chemical Engineering, Northwestern University, 1979

In our research, we are seeking to develop novel large-scale bioseparation processes for the biotechnology industry and cell separation processes for clinical cell therapy.

We are interested in bioseparations using selective precipitation and affinity adsorption. Affinity adsorption employs the extraordinary selectivity of antibody-antigen interaction to recover specific proteins or other bioactive molecules. The same approach can be applied to therapeutic cells, such as T cells and stem cells, and their production and purification.

We use mathematical modeling and experimental correlations to improve the resolution of various types of anion-exchange and cation-exchange chromatography, as well as affinity chromatography. One focus is to replace Protein A or Protein G adsorbents with less expensive ion-exchange chromatography to purify the therapeutic antibody.

We are also formulating a comprehensive correlation of polymer-solution thermodynamics to predict the phase behavior of a promising separation technique that recovers biomolecules from complex mixtures.

Anthony J. McHugh

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B.S., Chemical Engineering, Cleveland State University, 1966
M.S., Chemical Engineering, University of Delaware, 1970
Ph.D., Chemical Engineering, University of Delaware, 1972

Professor McHugh's research centers on polymer science and engineering, membrane formation, and controlled-release drug delivery.

McHugh's lab investigates fundamental problems in the processing behavior of polymeric materials, including interactions among chain architecture, phase transitions, morphology development, and final properties. A number of McHugh's experiments involve the use of rheology and rheo-optics, coupled with video imaging, to generate quantitative information. His lab also developed novel optical techniques, in combination with thermodynamic and transport-based models, to quantify the dynamics of the diffusion, phase separation, and structuring processes that take place when a polymer-solvent mixture is quenched in a non-solvent environment. This process, known as phase inversion, is the principal means of fabrication of asymmetric membranes that are used in the chemical and processing industries as energy-efficient separation devices and as drug delivery devices in the bio-pharmaceutical industry. McHugh's group has also been active in modeling various aspects of polymer processing, particularly processing-induced structure formation. These include flow-induced phase separation and/or crystallization in fiber spinning (melt, dry, and wet) and film blowing.

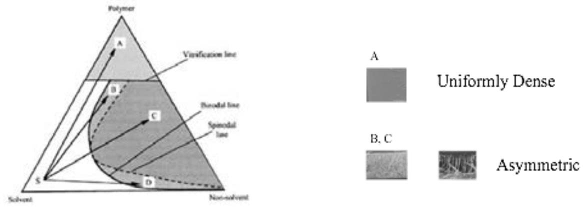

Illustration of mass transfer quench paths on the ternary phase diagram (left) corresponding to formation of uniformly dense (A) or asymmetric (B, C) structures.

Hugo S. Caram

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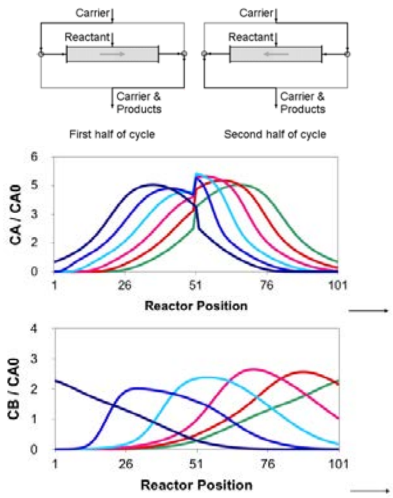
B.A., Chemical Engineering, University of Buenos Aires, Argentina, 1967
Ph.D., Chemical Engineering, University of Minnesota, 1977

Our interests include materials and powder processing and reaction engineering for energy applications. We are active in energy and environmental processes for synthetic fuel production. This includes hydrogen production with CO_2 capture using high temperature sorbents, the development of novel reactors for the production of high octane hydrocarbons, and the synthesis of higher alcohols. A key has been the study of simultaneous reaction and separation for process intensification. This has been applied to reverse flow chromatographic reactors. We have applied similar tools to high temperature reversible energy storage. Our current interest is in integrating carbon capture processes with power production using liquid and solid sorbents. These studies combine lab work with the development of fundamental thermodynamic theory of separation processes.



In a reverse flow reactor carrying out a reversible reaction A→B and containing a sorbent that preferentially adsorbs the reactant but not the product, periodic reversal of the carrier flow traps the reactant A, allows the product B to escape and thus allows for much higher conversions.

Shivaji Sircar

University Distinguished Research Fellow
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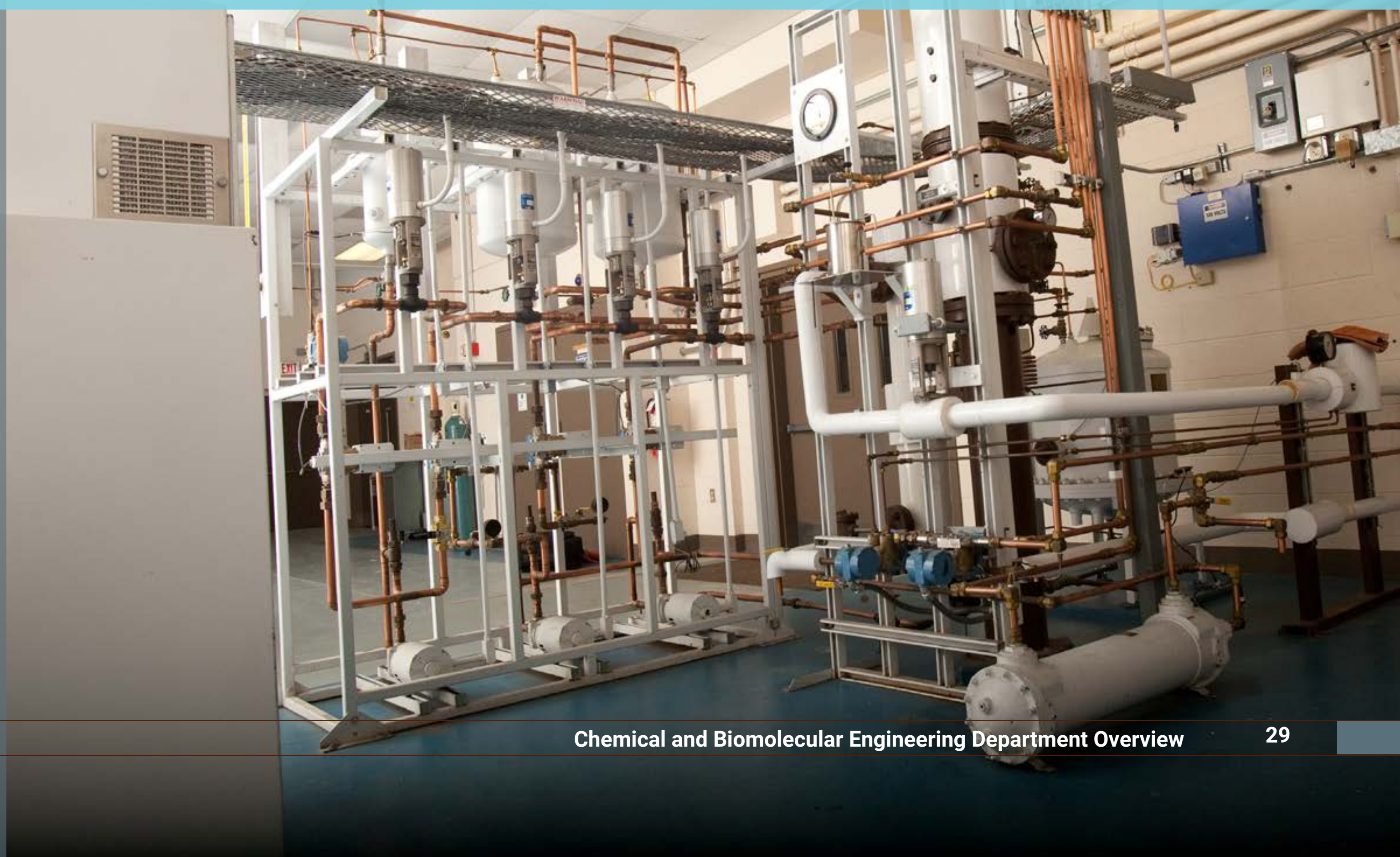
B.Ch.E., Chemical Engineering, Jadavpur University, India, 1964
M.S., Chemical Engineering, University of Pennsylvania, 1968
Ph.D., Chemical Engineering, University of Pennsylvania, 1970

Sircar is internationally known for his in depth work in adsorption science and technology. He was elected to the National Academy of Engineering in 2004, which cited him for his contributions to the fundamental science and technology of adsorption separations and their applications in process industries. He was also elected a Fellow of the International Adsorption Society in 2013. In addition, he was awarded the AIChE Professional Progress Award in 1988 and the AIChE Institute award for Excellence in Industrial Gases Technology in 2001.

Sircar joined the CHBE faculty in 2002, following 29 years with Air Products and Chemicals Inc., where he was chief scientist in the company's adsorption science division. He holds 60 U.S. and 65 international patents, and is the author of more than 205 scientific publications in refereed journals.

In a recent project, Sircar has collaborated with Mayuresh Kothare of the CHBE department to develop a patented technology that improves quality of life for patients with chronic obstructive pulmonary disease (COPD) by decreasing the size and increasing the efficiency of portable medical oxygen concentrators. Earlier, in a Department of Energy funded project, he collaborated with Hugo Caram of CHBE in research on chemi-sorbents for CO_2 and processes for production of fuel-cell grade H_2 from steam reformer off gas.

Unit Ops Lab



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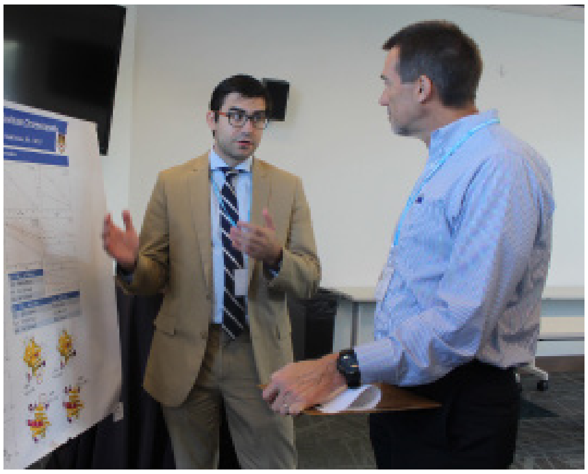
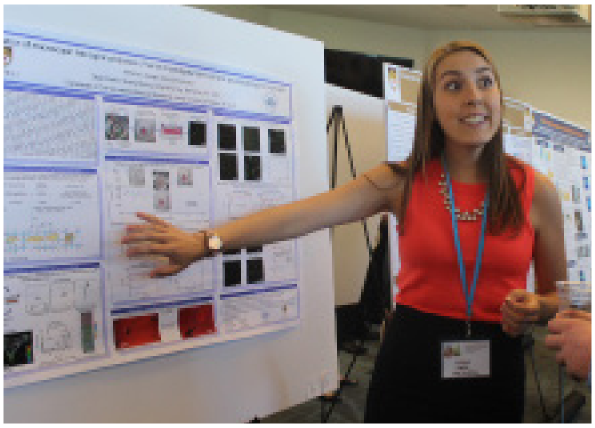
Getting Involved with the Department





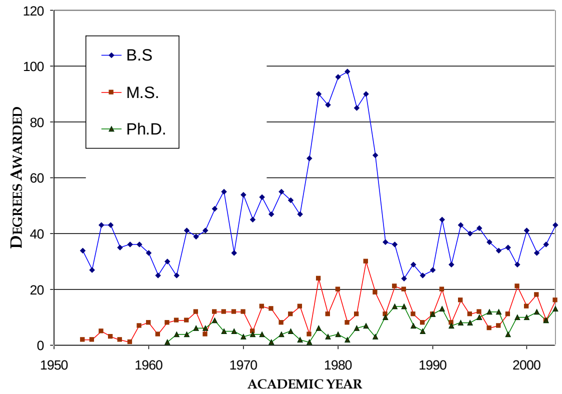
Throughout its history of 115 years, the Department of Chemical and Biomolecular Engineering has benefited from the loyalty of its alumni and friends to support its efforts to build a nationally and internationally visible research and educational environment for our students. We are looking to our alumni and friends, once again, to carry on this tradition. The state-of-the-art unit operations and research laboratories, undergraduate interdisciplinary research experiences, the capstone design projects and the annual graduate student research symposium are examples of experiential learning opportunities that stimulate student creativity, develop their independent thinking and problem solving, and build their communication skills. Alumni involvement in serving as capstone design consultants, research mentors, guest lecturers, industrial projects advisers or as initiators and contributors to faculty initiatives are some of the many ways that you can enhance these experiences and build the long term reputation, visibility and quality of the department.

If you would like to get involved in supporting any of the departmental initiatives, please contact the department chair at mayuresh.kothare@lehigh.edu

Lehigh CHBE Department Historical Highlights

Chemical Engineering Programs Over the Past 115 Years

Lehigh began offering a bachelor's level degree in chemical engineering in 1902. Enrollment grew to 32 by 1907, when the first class graduated. Designed by Profs. Harry Mass Ullmann and William Henry Chandler, the program incorporated principles of mechanical and electrical engineering as well as chemistry. It became one of Lehigh's most rigorous majors. In 1949, 55 freshmen in chemistry or chemical engineering got a D or F in at least one course. The faculty formed a "guidance unit," launching a tradition of mentoring that continues today.



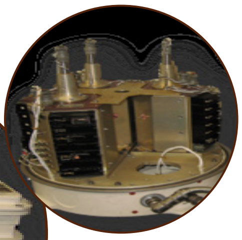
Chemical Engineering Degrees Over the Past 50 Years

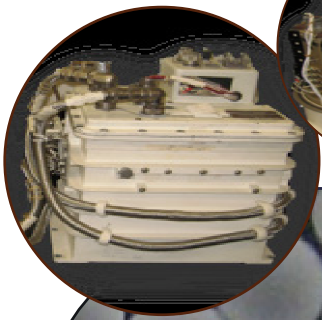
Most Widely Used Textbook

In 1960, *Principles of Unit Operations* was published by John Wiley & Sons. Written by Lehigh Profs. Alan Foust, Leonard Wenzel, Curtis Clump, Louis Maus and Bryce Andersen, the book was the first undergraduate text to use a unified approach to transport equations. It has become one of the most widely used textbooks of its kind and has been translated into several languages.

Leonard Wenzel Joined Faculty

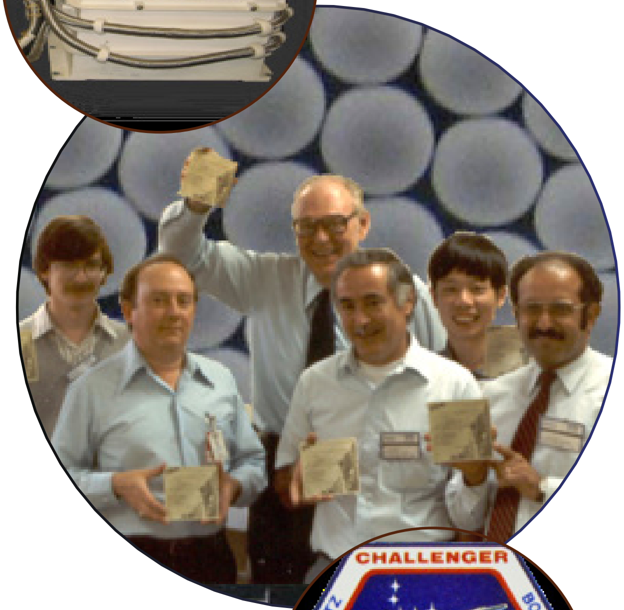
Lehigh's Department of Chemical Engineering was established in 1951. That same year Leonard Wenzel joined the faculty; his tenure would last 52 years, including 21 as chair. In 1968, he approved the purchase of a CDC 6400 computer, one of the largest and most powerful instruments of its kind.





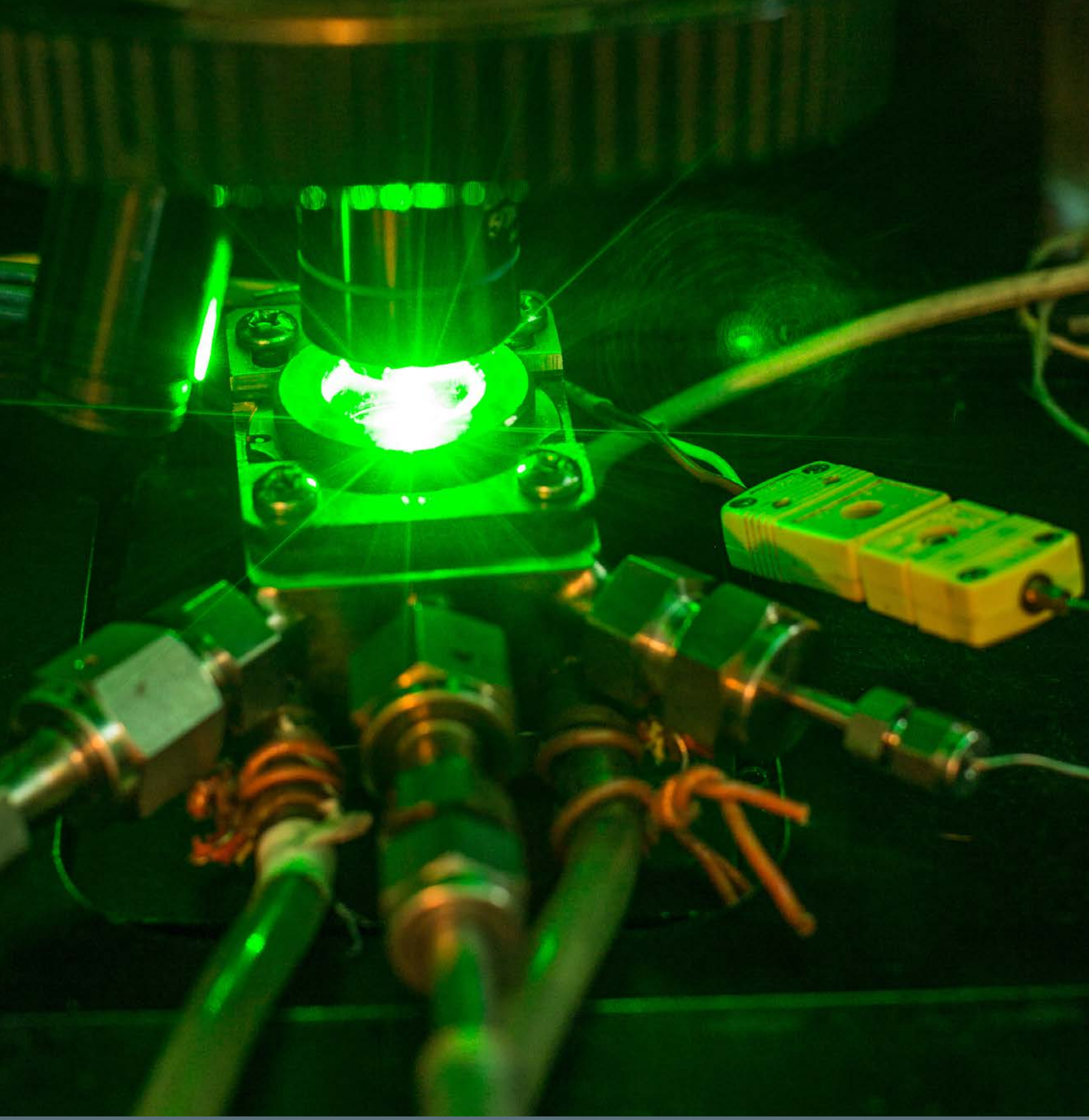
First Manmade Product in Space

From 1978 to 1984, chemical engineering Professor Mohamed S. El-Aasser along with chemistry professors John W. Vanderhoff and Fortunato J. Micale and chemical engineering graduate students E. David Sudol (Ph.D. '83), Chi-Ming Tseng (Ph.D. '83), and Anthony Silwanowicz (M.S. '83) collaborated with NASA and GE in the design, development, and application of space flight reactors used in the preparation of polystyrene microspheres on five flights of the Space Shuttles Columbia and Challenger. The 10 micrometer spheres prepared during Columbia's STS-6 '83 mission were certified by the National Bureau of Standards as a Standard Reference Material, thereby becoming the first product made in space for sale on earth. El-Aasser, Vanderhoff and Micale were named "NASA Inventors of the Year" in 1984.



First Artificial Heart Pump

While earning a B.S. in chemical engineering from Lehigh, Dr. William S. Pierce '58 conducted research into the motion of blood through a cardiovascular system. Pierce then enrolled at the University of Pennsylvania School of Medicine, where he built a model of an electrically powered artificial heart. Later, at the Hershey Medical Center, he helped design the most advanced artificial heart pump to date. The heart gained FDA approval and was used as a bridge for cardiac transplantation. Pierce also helped develop an implantable, wireless, motor-driven left ventricular assist pump named the "LionHeart." He has performed thousands of heart bypass operations, including one on the late Pennsylvania Governor Bob Casey.



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