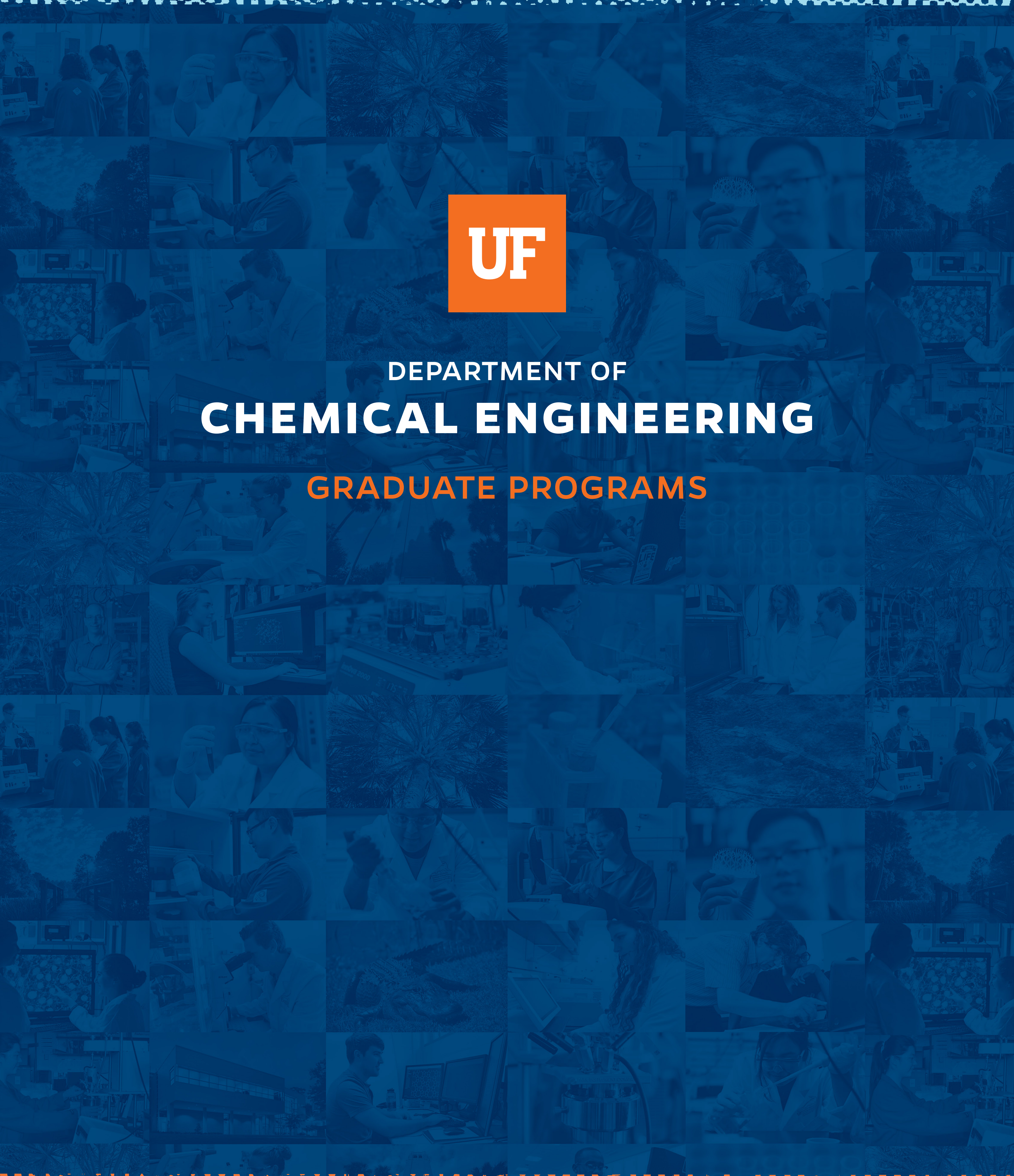


DEPARTMENT OF

CHEMICAL ENGINEERING

GRADUATE PROGRAMS

MESSAGE FROM THE CHAIR

Carlos Rinaldi, Ph.D.
DEPARTMENT CHAIR & DEAN'S LEADERSHIP PROFESSOR

WE ARE DELIGHTED TO PROVIDE YOU WITH INFORMATION ABOUT our department and its exciting graduate programs. The University of Florida has over 100 years of history and tradition in excellence in chemical engineering research and education, and is among the largest and highest ranked chemical engineering programs in the southeastern region.

Our faculty are leaders in research and education. They include Distinguished Professors, Fellows of professional societies, and recipients of national and international awards. Our students are passionate about finding solutions to societal problems through application of chemical engineering principles. Our staff are committed to supporting faculty and students alike. Together, we strive to create an environment supportive of scholarly work that is also welcoming to diverse backgrounds and thinking.

Our research and educational activities extend beyond the department, as many of our faculty collaborate with peers in other disciplines and either lead or are active members of multidisciplinary centers. We are located within a short walk to the Nanoscale Research Facility, UF College of Medicine, the Emerging Pathogens Institute, the UF Cancer & Genetics Research Complex, and the UF Clinical & Translation Science Institute, which facilitate fruitful interdisciplinary collaborations.

While the University of Florida provides a wonderful academic environment, the quality of life in the city of Gainesville and the surrounding community is second to none. Serving as the cultural, educational, and commerce center of beautiful North Central Florida, Gainesville is only an hour from both the Atlantic Ocean and the Gulf of Mexico and less than two hours from Jacksonville, Orlando, and Tampa.

Thank you for your interest, we invite you to apply today.

- Carlos Rinaldi - Department Chair

CONTENTS

THE DEPARTMENT OF CHEMICAL ENGINEERING AT THE UNIVERSITY OF FLORIDA PROVIDES A WONDERFUL ACADEMIC ENVIRONMENT FOR GRADUATE SCHOOL, INCLUDING EXCEPTIONAL FACULTY, RESOURCES, AND A PICTURESQUE CAMPUS.

The Department of Chemical Engineering has 23 faculty members engaged in graduate research and teaching. Their interests span a wide range of topics including bioengineering, nanotechnology, complex fluids, catalysis, advanced materials processing, and surface and interfacial phenomena. This diversity of interests is reflected in the types of graduate courses available at both the department and the college, allowing our students excellent opportunities to obtain a broad background in chemical engineering.

Many faculty are leading members or directors of special university centers, such as the Florida Energy Systems Consortium, the Institute for Cell & Tissue Science and Engineering, the Nanoscale Institute for Medical Engineering Technology, the Particle Engineering Research Center, the UF Health Cancer Center, and the National High Magnetic Field Laboratory.

Support for our programs comes from federal agencies such, as NSF, NIH, NASA, DOE, DOD, and non-profit organizations, such as the American Chemical Society and the Gas Research Institute.

The department emphasizes fundamental academic work that traditionally provides the basis for commercial development and manufacturing. The relevance of our research studies is demonstrated by industrial funds from a large number of chemical, aerospace, defense and semiconductor companies that also complement the support we receive from government funding agencies.

Our graduate degree programs offer students everything from basic science research to applied engineering programs to succeed and thrive as tomorrow's industry, academic and government leaders.

TOP 20

CHEMICAL ENGINEERING GRADUATE PROGRAM AMONG PUBLIC UNIVERSITIES

U.S. News & World Report, 2019

DOCTORAL DEGREE PROGRAM:

#8 in total number of **Doctoral** degrees awarded
#2 in number of degrees awarded to **African Americans**
#3 in number of degrees awarded to **Hispanics**
#7 in number of degrees awarded to **Women**

MASTERS DEGREE PROGRAM:

#6 in total number of **Masters** degrees awarded
#6 in number of degrees awarded to **Women**

Information sourced from ASEE's "Engineering by the Numbers" 2017 Report

150+

GRADUATE STUDENTS FROM DIVERSE BACKGROUNDS AND CULTURES

OVER

4,150

CHE ALUMNI

SUPPORTING YOU ALONG THE WAY

- All Ph.D. students making satisfactory progress receive **guaranteed funding**, including tuition and medical & dental insurance, from first semester until degree awarded
- Competitive university fellowships and opportunities for professional development and outreach
- College and department sponsored activities for students to interact with industry leaders and academic mentors in preparation for a variety of careers
- Award-winning faculty recognized for their role in Ph.D. mentoring

DEGREE PROGRAMS

- DOCTOR OF PHILOSOPHY (Ph.D.)
- MASTER OF SCIENCE (M.S.)
- MASTER OF ENGINEERING (M.E.)
- BACHELOR OF SCIENCE (B.S.)

ENGAGED STUDENT ORGANIZATIONS

- Peer mentoring program for Ph.D. students
- Social and cultural events
- Community outreach
- Annual student research symposium

27

RESEARCH AND TEACHING FACULTY AND **GROWING**

8

NEW FACULTY
SINCE FALL 2018

35%

OF FACULTY AWARDED PROFESSORSHIPS

#7

UF NUMBER 7 AMONG PUBLIC UNIVERSITIES
U.S. NEWS & WORLD REPORT
2020

CENTRALLY LOCATED NEAR THE COLLEGE OF MEDICINE AND WORLD-CLASS RESEARCH CENTERS

MORE THAN A CHEMICAL ENGINEERING DEPARTMENT, WE'RE EMBEDDED IN THE DYNAMIC HERBERT WERTHEIM COLLEGE OF ENGINEERING.

OUR DEPARTMENT IS HOUSED IN OUR FOUR-STORY, 51,000-SQUARE-FOOT BUILDING, MUCH OF WHICH IS DEVOTED TO RESEARCH.

415,000+

UF ALUMNI RESIDING IN EVERY STATE AND IN MORE THAN 150 COUNTRIES

OUR GRADUATES ARE EMPLOYED BY (PARTIAL LIST):

ACADEMIC

Kansas State University
Korea Institute of Science and Technology (S. Korea)
Massachusetts Institute of Technology
Oregon State University
University of Alabama
University of South Florida
University of Tulsa
University of Virginia
Vanderbilt University
Virginia Polytechnic Institute and State University

INDUSTRIAL

Albemarle
AMD
Applied Materials
ASM International
Corning
ExxonMobil
Honeywell
Intel
Keysight
LG Chem
Mainstream Engineering
Medtronics
Samsung
Shell
Shire Pharmaceuticals
Sun Chemical
Taiwan Semiconductor

NATIONAL LABS

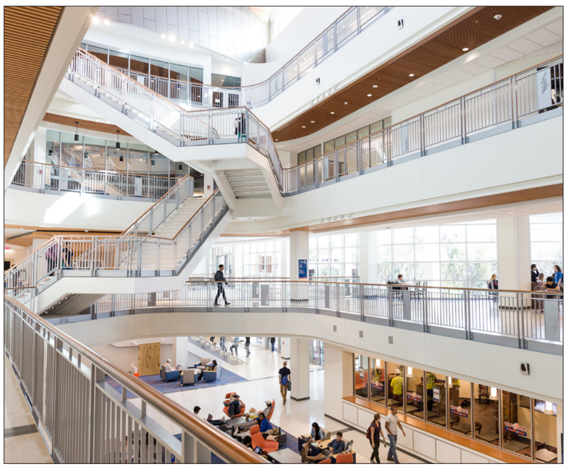
Army Research Laboratory
Idaho National Laboratory
NASA
National High Magnetic Field Laboratory
Naval Research Laboratory
Wright-Patterson Air Force Base

THE HERBERT WERTHEIM COLLEGE OF ENGINEERING HOUSES ONE OF THE LARGEST AND MOST DYNAMIC ENGINEERING PROGRAMS IN THE NATION.

- Curriculum offered across 10 departments, 15 degree programs, and more than 20 centers and institutes produces leaders and problem-solvers who take a multidisciplinary approach to innovative and human-centered solutions.
- Engineering is the second largest college, and one of the top three research units at UF.
- In 2018, annual research expenditures exceeded $74 million.
- The college produces inventions at twice the national average – and startups at three times the national average – for every research dollar spent.
- A significant amount of interdisciplinary research is conducted through centers, such as the Florida Institute for National Security, the Florida Institute for Sustainable Energy, the Nanoscience Institute for Medical and Engineering Technology, the Institute for Cell Engineering and Regenerative Medicine and the Institute for Computational Engineering.
- Students, faculty and alumni are hailed as New Engineers who aim to transform the way we live, work and play.

"This is a great school with many opportunities for interdisciplinary research and a strong graduate community."
-Chaker Fares

THE HERBERT WERTHEIM LABORATORY FOR ENGINEERING EXCELLENCE (below) will be the college's flagship building with an 84,000 square foot state-of-the-art research and educational environment.



WITH OVER 55,000 STUDENTS, THE UNIVERSITY OF FLORIDA IS THE FIFTH LARGEST UNIVERSITY IN THE UNITED STATES.

- UF is ranked among the nation's top research universities and is one of only 17 public, land-grant universities that belong to the Association of American Universities.
- The Graduate School coordinates more than 200 graduate programs.
- Over 100 interdisciplinary research centers, bureaus and institutes on campus.
- As a land-grant university identified by the Morrill Act of 1862, UF has a special focus on engineering, as well as agriculture, with a mandate to deliver the practical benefits of university research throughout the state.
- In addition to the 2,000-acre main Gainesville campus, UF has research centers, extension operations, clinics and other facilities and affiliates in every Florida county.

PROGRAMS OF STUDY

GRADUATE STUDENTS IN THE DEPARTMENT OF CHEMICAL ENGINEERING CAN PURSUE A DOCTORATE OF PHILOSOPHY, MASTER OF SCIENCE (THESIS OR NON-THESIS), AND A MASTER OF ENGINEERING DEGREE.

DOCTORATE OF PHILOSOPHY DEGREE

The Ph.D. degree plan is primarily a research program. Graduate students enrolled in the Ph.D. program will have the opportunity to work closely with our dynamic, internationally-recognized faculty. Many Ph.D. students will have the opportunity to work on innovative research problems through interdisciplinary collaborations in the colleges of engineering, liberal arts and sciences, and medicine, which are all co-located on the Gainesville campus. Ph.D. students will observe a strong commitment to excellence in research and education in both the classroom and the laboratory.

The granting of the degree is based on general proficiency and distinctive achievements of the Ph.D. candidate in their research field. Ph.D. students are expected to demonstrate the ability to conduct independent investigation of research problems and attain mastery of a field of knowledge. Ph.D. students will also have opportunities to gain valuable teaching and communication experience by assisting instructors in the classroom and supervising undergraduate and other graduate researchers in the laboratory.

Briefly, the requirements for the Ph.D. degree are:

1. Completion of at least 90 credits (minimum of 24 credits of coursework) beyond the B.S. degree while maintaining an overall and major GPA of 3.0 or higher. Specific coursework requirements include completion of Continuum Basis, Molecular Basis, Mathematical Basis, and Chemical Engineering Kinetics.
2. Successful completion of a written research proposal and oral qualifying examination based on the candidate's research plan to achieve the objectives for his/her doctoral dissertation and his/her general knowledge of chemical engineering fundamentals.
3. Successful completion of a written doctoral dissertation and final oral examination based on the candidate's original research.

Final acceptance into the Ph.D. program requires successful completion of both the research proposal and the oral qualifying examination. Although the time to complete all Ph.D. degree requirements is dependent on the specific research program and student motivation, the minimum requirements for the Ph.D. program are typically met in 3 – 5 years following a B.S. degree.

All Ph.D. students that maintain good academic standing receive competitive stipends, tuition waivers, and medical insurance.

MASTER OF SCIENCE DEGREE

The Master of Science program provides an opportunity to develop an in-depth knowledge of chemical engineering fundamentals. M.S. students are encouraged to emphasize their coursework on a specific specialization area within chemical engineering. M.S. students are also strongly encouraged to take advantage of courses that focus on valuable management experience in chemical engineering settings. Many students also acquire applied and fundamental skills through departmental research or industrial internships.

All new M.S. students are admitted to the Non-Thesis option at the time of admission. M.S. students enrolled in the Thesis option are required to add a research component to the degree plan. Those M.S. students that desire to improve their research skills may convert to the Thesis option upon approval of their research advisor and the Associate Chair for Graduate Studies.

M.S. students typically complete the degree requirements within 12 to 24 months. Briefly, the formal requirements for the M.S. degree are:

1. Completion of at least 30 credits of coursework beyond the B.S. degree, including Continuum Basis, Mathematical Basis, Chemical Engineering Kinetics, and Advanced Chemical and Biological Processing Laboratory.
2. Successful completion of a written thesis or report on a research project, internship, or a contemporary chemical engineering topic.
3. Successful completion of final oral examination based on the student's innovative and original research (Thesis Option).

M.S. students who demonstrate exceptional understanding of chemical engineering fundamentals and outstanding progress in research achievements may advance to the Ph.D. program when there are available opportunities.

MASTER OF ENGINEERING DEGREE

The Master of Engineering program is designed for students that already hold a Bachelor of Science degree in biology, chemistry, physics, mathematics, or another branch of engineering. The program provides an opportunity for M.E. students to develop an in-depth knowledge of chemical engineering fundamentals through both undergraduate and graduate coursework. M.E. students need to complete core classes associated with an undergraduate degree in chemical engineering before enrolling in most graduate-level courses. Many students also acquire basic experience in research or industrial practice through a short internship.

Advanced Materials, Devices, and Nanotechnology

CORE FACULTY

Catalysis, Reaction Engineering, and Surface Science

CORE FACULTY

Applied Math, Modeling, Optimization, and Control

CORE FACULTY

Energy, Environment, and Sustainability

CORE FACULTY

Biomedical, Pharmaceutical, and Biotechnology

CORE FACULTY

Transport, Thermodynamics, and Electrochemical Engineering

CORE FACULTY

JASON E. BUTLER, PROFESSOR

Ph.D., 1998, University of Texas at Austin

butler@che.ufl.edu

MY RESEARCH GROUP GENERATES INSIGHTS AND SOLUTIONS to problems regarding the transport of complex fluids using experimental, computational, and theoretical methods. Complex fluids, which encompass suspensions of particulates, emulsions, polymer solutions, and more, serve important roles in a wide range of industries as well as emerging technologies. Efficient control and processing of these fluids requires predictive capabilities that, in most cases, are lacking, as they often demonstrate nonlinear dynamics that create unexpected and intriguing observations.

Some specific examples from our work are described:

MACROMOLECULAR TRANSPORT IN MICROFLUIDICS

Microfluidic, or lab-on-chip, technologies have the potential to significantly improve medical diagnostic capabilities and accelerate advances in biological and biochemical research. Realizing this promise requires the ability to model and manipulate macromolecular motion within these small devices. As one effort, we have been examining transport dynamics of DNA, a polyelectrolyte, through electrodeless channels. The work has demonstrated new and unexpected methods that can be harnessed to control the cross-stream distribution of DNA using a combination of pressure gradients and electric fields. We are validating our model of this phenomenon through rigorous comparison of experimental results and simulations while simultaneously investigating technological applications such as the extraction of DNA from biological samples.

SUSPENSION RHEOLOGY AND DYNAMICS

Suspensions of particles in viscous fluids are found in everyday materials such as concrete, in industrial advanced technological applications, and even in natural processes. Consequently, advances in evaluation in the transport properties and predictive capabilities for the dynamics will have a widely distributed impact through improved ability to rationally design processes. Some recent work in our group is focused on assessing the precise origin of irreversibilities in non-colloidal suspensions of spheres; these irreversibilities can cause, as one example, suspensions to demix during rheological testing and create inaccurate estimates of viscosities. Much of our work examines suspensions of rod-like particles, where coupling of the orientational dynamics with the flow field and center-of-mass motion creates truly complex results.

OSCAR CRISALLE, PROFESSOR

Ph.D., 1990, University of California, Santa Barbara

crisalle@che.ufl.edu

OUR RESEARCH FOCUSES ON THE ANALYSIS AND DESIGN of advanced multivariable control systems. Our approach is to establish new theoretical foundations and validate advances through computer simulation studies and experimental implementations. The applications include energy production systems and fuel cells, the manufacture of integrated microelectronic and photovoltaic devices, control of autonomous vehicles, and the development of on-line measurement instrumentation, among other fields of interest.

CONTROL SCIENCE

We design controllers that deliver high performance in spite of the presence of modeling uncertainty. Ongoing research seeks the synthesis of robust multivariable controllers such as predictive-control, variable-structure control, and frequency-domain techniques, including our formulation of the *Nyquist Robust Stability Margin* as a robustness metric.

VIRTUAL SENSORS

Often critical process variables needed for diagnostics and control cannot be measured because of the inability to place a physical sensor inside constrained geometries. Our group designs software sensors that estimate the value of inaccessible measurements using mathematical models and data from other locations. The technology involves Kalman and Luenberger observers, as well as integral observers that can preserve accuracy even under conditions of data uncertainty.

FUEL CELLS

We are developing direct methanol fuel cells designed to serve as long lasting power supplies for small electrical appliances. Our group conducts first-principles fuel cell modeling work to serve as the basis for designing real-time control manipulations. The objective is to optimize operations and ensure high quality performance. The effort seeks to contribute new green and renewable energy production technologies that can effectively address our society's growing need for a sustainable energy infrastructure.

CARL DENARD, ASSISTANT PROFESSOR

Ph.D., 2012, University of Illinois at Urbana-Champaign **cdenard@ufl.edu**

My research is in the area of molecular and cellular bioengineering. We apply our expertise in cellular and protein engineering to develop novel strategies to diagnose, target and fight disease.

"DESIGNER" PROTEIN-MODIFYING ENZYMES FOR BIOMEDICINE, BIOTECHNOLOGY AND SYNTHETIC BIOLOGY

Enzymes that catalyze site-specific protein modifications play vital roles in regulating cellular processes. Understanding their substrate specificity not only provides insight into their physiological mechanisms but also enables their selective targeting to remediate disease states. In addition, leveraging the specificity of protein-modifying enzymes enables the development of novel therapeutics, biomedical and biotechnological tools. However, there is a need to expand the limited substrate scope and low catalytic activity of protein-modifying enzymes to fully realize their potential in these domains.

Using methods of protein engineering and synthetic biology, my lab seeks to redefine and redesign the substrate specificity of protein-modifying enzymes in order to repurpose them as novel therapeutic and diagnostic modalities. In one area of focus, we are evolving the specificity of **proteases to target misfolded and aberrant proteins involved in neurodegenerative, autoimmune diseases and cancer.** We hypothesize that catalytic degradation of disease-related proteins can help fight diseases in ways that can be complementary to and mechanistically distinct from current therapeutic approaches.

In a related area of research, we aim to **evolve enzymes for the site-specific labeling of proteins, cells and biomaterials to improve their therapeutic efficacy and disease targeting.** We envision to generate highly-functionalized therapeutic agents with multipronged and synergistic modes of action.

A complementary research focus is to take advantage of site-specific protein modifications to build circuit-level logic functions that reprogram cellular behavior along rapid time scales. Highly programmable, responsive and predictable synthetic protein circuits will augment genetic engineering by introducing novel design principles that facilitate cellular engineering. In addition to applications in biosensing, successes in this area are central to developing on-demand delivery of catalytic actuators to disease sites.

RICHARD DICKINSON, PROFESSOR

Ph.D., 1992, University of Minnesota **dickinso@ufl.edu**

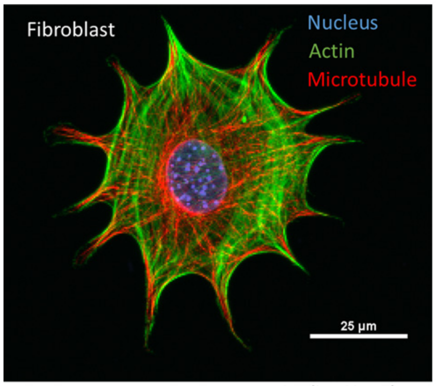
OUR RESEARCH IS IN THE AREA OF MOLECULAR/ CELLULAR bioengineering. We apply engineering principles to study the behavior of living cells or other small-scale biological systems. Using a combination of engineering modeling/analysis, quantitative experimentation, together with the tools of molecular cell biology, we seek to better understand the relationship between cell function and the physical and molecular properties of cells and their environment. Our projects are typically in collaboration with experts in microscopy and cell biology.

FORCE GENERATION BY INTRACELLULAR BIOPOLYMERS

Living cells have a cytoskeleton comprised of semi-flexible filaments (actin microfilaments, microtubules, and intermediate filaments), which determine the cell's mechanical properties and, through their interactions with molecular motors, are responsible for cell movements and intracellular force generation. In one area of focus, we study the reaction/diffusion processes involved with filament assembly that lead to cellular protrusions during cell crawling and propel intracellular pathogens such as Listeria monocytogenes. We are also investigating how the molecular motor protein complex dynein generating force on microtubules moves the nucleus and allows the cell to locate its center. Another area of interest is to understand the dynamics and mechanical properties of muscle-like actin filament bundles called stress fibers in non-muscle cells.

FORCE GENERATION OF THE NUCLEUS

Cell behavior depends strongly on the chemical and mechanical properties of its environment. For example, stem cells cultured on compliant materials will differentiate to cells of the tissue type that has similar rigidity. Mechanical cues change gene expression in a process called "mechanotransduction", which often involves transmission of force from the outside to the cell to the nucleus. One current focus is to understand how these forces are transmitted to generate stresses on the nuclear surface that result in shape changes and positioning of the nucleus.



Credit: Qiao Zhang

HELENA HAGELIN-WEAVER, ASSOCIATE PROFESSOR AND PH.D. RECRUITMENT COORDINATOR

Ph.D., 1999, Royal Institute of Stockholm, Sweden **hweaver@che.ufl.edu**

WE WORK ON HETEROGENEOUS CATALYST DEVELOPMENT in my laboratory and our ultimate goal is to obtain a fundamental understanding of these catalysts at the atomic level. Our approach is to synthesize well-defined heterogeneous catalysts using nanoparticle oxides with various shapes and sizes as supports and use different methods, including conventional precipitation deposition and incipient wetness impregnation as well as atomic layer deposition, to deposit active metals onto these supports. Since different shapes of nanoparticle oxides expose different surface facets, the use of these materials allows us to investigate how the active metal-support interactions vary with surface facets, and how this ultimately affects the catalytic activities and selectivities. Furthermore, the fraction of coordinatively unsaturated corner and edge sites (relative to terrace sites) increases with decreasing particle size. Therefore, by varying the size of the nanoparticle oxides, the effects of coordinatively unsaturated sites on the active metal can be investigated. The use of atomic layer deposition of metal (or metal oxide) onto these nanoparticle oxides can provide better control over the metal particle size on the support.

OUR RESEARCH INVOLVES CAREFUL CHARACTERIZATION OF the synthesized heterogeneous catalysts using a number of analytical techniques to determine important catalyst properties. We routinely perform surface area measurements, chemisorption of selected molecules to probe specific sites, temperature programmed reduction and oxidation (TPR and TPO) experiments to determine reduction-oxidation (redox) properties, X-ray diffraction (XRD) measurements to determine crystal structures and crystallite sizes, X-ray photoelectron spectroscopy (XPS) to determine electronic structure and surface chemical composition, high-resolution transmission electron microscopy (TEM) to determine particle sizes and shapes, and use the information to determine structure-activity relationships.

WE FOCUS MAINLY ON ENVIRONMENTALLY FRIENDLY, ENERGY-RELATED REACTIONS

Our projects include catalyst development for selective oxidation and hydrogenation reactions. Examples include oxidative coupling of methane (methane to higher-value chemicals), selective hydrogenations for parahydrogen-induced polarization nuclear magnetic resonance applications, and thermochemical water-splitting using solar energy.

CHARLES HAGES, ASSISTANT PROFESSOR

Ph.D., 2015, Purdue University **c.hages@ufl.edu**

DEVELOPING NEXT-GENERATION SEMICONDUCTORS for energy research is the primary focus of our group. Fundamental device physics and unique processing routes are combined to design new materials and device architectures, with particular focus on developing high-performance, low-cost electronics from low-energy, high-throughput processing techniques and earth-abundant resources. Using holistic material research techniques – including material simulation, synthesis, device fabrication, and optoelectronic characterization – enhanced understanding and rapid feedback between processing parameters and fundamental device properties is achieved to accelerate the material development process.

NEW MATERIAL DISCOVERY in our lab starts with screening for desired material properties from first-principles theoretical calculations. Next, solution-based techniques are used to synthesize nanomaterial films and low-dimensional electronic materials. Subsequently, controlled recrystallization techniques can be applied to form thin-films. Lastly, state-of-the-art electronic devices are fabricated. The use of nanomaterials in this process allows for unique device architectures, novel control over material optoelectronic properties, as well as highly-tunable recrystallization routes. Furthermore, such solution-based techniques are well suited for high-throughput research and the fabrication of next-generation technology such as light-weight, low-cost flexible electronics.

ADVANCED OPTOELECTRONIC CHARACTERIZATION at all stages of the material development process is a key aspect of material development in our lab. Such characterization provides rapid feedback for the accurate screening of relevant optoelectronic properties and optimal synthesis parameters in early-stage materials. We specialize in the characterization of non-ideal semiconductors – common to such early-stage materials – as well as novel all-optical measurement techniques to extract relevant material and device properties at very early stages of development. Our work combines a unique blend of engineering, chemistry, materials science, and physics resulting in highly-collaborative research at the forefront of modern chemical engineering.

DAVID HIBBITTS, ASSISTANT PROFESSOR

Ph.D., 2012, University of Virginia **hibbitts@che.ufl.edu**

DEVELOP ATOMIC-LEVEL UNDERSTANDING OF HETEROGENEOUS CATALYSTS using experiments and density functional theory (DFT) calculations to develop structure-function relationships critical to the development of new catalysts and chemical processes. Experiments are used to determine reaction kinetics with lab-scale reactors, trace chemical pathways with isotopes, and observe reaction intermediates with spectroscopy. DFT calculations estimate activation barriers and reaction energies for reaction pathways and allow one to directly model the effects of catalyst composition, morphology, and reaction conditions. We combine experiments and DFT calculations to provide a comprehensive understanding of reactions at catalyst surfaces and train well-rounded students who understand practical and fundamental issues in heterogeneous catalysis.

DRIVE ENERGY- AND CARBON-EFFICIENT TRANSFORMATIONS of traditional and renewable chemical and fuel feedstocks. Catalysis is a critical part of our world, playing a huge role in the production of energy and chemicals from traditional fossil fuel resources. Catalysis, furthermore, will be critical to develop new processes based on renewable energy and chemical resources such as solar and wind power as well as biomass-based chemicals. This transformation from fossil- to renewables-based energy, fuels, and chemicals is critical to curb climate change caused by increasing CO_2-emissions. Our research focuses on reactions that convert methane and biomass-derived compounds into value-added fuels and chemicals; furthermore, we research novel catalysts to reduce polluting emissions in car exhausts.

DESIGN A COMPUTATIONAL CATALYSIS INTERFACE that combines command-line and graphical-user interfaces to facilitate theoretical studies of chemical reactions. "Standard" DFT calculations can be difficult, expensive, and time consuming; however, our group has developed the Computational Catalysis Interface (CCI) which makes DFT studies much easier to perform. CCI provides user-friendly set up of DFT calculations through natural language commands allowing novices to immediately generate meaningful data. Calculations are automatically split into multiple steps to decrease the amount of time they require and therefore their cost. Calculations are easily monitored, can trigger subsequent calculations, and can be used as templates to initiate hundreds of additional calculations enabling high-throughput studies with minimal user interaction.

PIYUSH JAIN, ASSISTANT PROFESSOR

Ph.D., 2013, University of Missouri, Kansas City **jainp@ufl.edu**

MY RESEARCH GROUP IS GENERATING INSIGHTS AND SOLUTIONS TO problems with genome engineering, specifically CRISPR/Cas systems. Over the past few years, the slow-progressing field of genome engineering has been transformed by the breakthrough of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) with astronomical applications in science, medicine, agriculture, biotechnology, and biomanufacturing. Originally derived from the bacterial immune system, the CRISPR/Cas9 technology works by introducing two components inside cells, a Cas9 nuclease that acts like molecular scissors and a guide RNA (sgRNA) that binds with Cas9 and directs the complex to the target DNA to create double-stranded cuts in the DNA. Due to its ease of use, it is becoming a standard tool for genome engineering and the toolbox is exponentially increasing with other variants of CRISPR/Cas systems with applications in DNA and RNA manipulation. The biggest challenges for CRISPR/Cas technology that are affecting the bridge between in vitro and in vivo applications are safety, efficacy, and delivery. To address these pressing concerns, the Jain lab is focused on developing a multi-scale biomolecular engineering platform using nucleic acids chemistry, protein engineering, and nanoengineering. Specific examples include:

UNDERSTANDING AND IMPROVING SPECIFICITY
CRISPR/Cas9 can tolerate several mutations in the DNA resulting into undesirable off-target cleavage. What if we change the length and chemistry of the guide RNA? What if we can control the degradation of the CRISPR/Cas complex immediately after it cuts the on-target DNA? Our primary goal is to understand the molecular basis of this issue to be able to engineer CRISPR/Cas systems with improved specificity by modifying its components using nucleic acids design and protein engineering. We employ an array of bioanalytical techniques with immediate applications for the detection and treatment of genetic disorders.

TARGETED DELIVERY OF CRISPR/CAS SYSTEMS
Despite the vast literature highlighting the delivery issues with CRISPR/Cas systems, it remains a major concern. How can we get large molecules like Cas9 protein and sgRNA inside the nucleus of a cell? How can we protect the components from degradation or immune response? The answer lies in developing safe and effective non-viral delivery methods. We aim to design multifunctional targeted nanoparticle systems that can protect CRISPR/Cas from degradation and target specific tissues in vivo with immediate applications for detection and treatment of cancer.

YEONGSEON JANG, ASSISTANT PROFESSOR

Ph.D., 2013, Seoul National University **y.jang@ufl.edu**

MY RESEARCH GROUP SEEKS TO PROVIDE INSIGHTS AND SOLUTIONS IN THE FIELD OF SUPRAMOLECULAR BIOMATERIALS. We are aiming at engineering structural and functional properties of supramolecular biomaterials for target applications including smart capsules, micro-reactors, antibacterial and/or drug release coatings. The vision of our lab is to utilize soft matter assembly and recombinant technology for the creation of advanced biomaterials. From the deep understanding of the interactions between soft matters, including polymers, proteins, and colloids, we develop supramolecular biomaterials to present target microscopic structure, physical properties, and functionality. We also apply recombinant protein technology to rationally design functional building blocks. The supramolecular biomaterials developed in my research group include multicompartment vesicles, porous thin films, multilayer coatings, and a variety of self-assembled structures in solutions or at surfaces.

MULTICOMPARTMENT PROTEIN VESICLES FOR PROTOCELL DEVELOPMENT

We seek to create multicompartment vesicles made from functional globular fusion proteins with controlled geometry by using microfluidics and microarrays fabricated via soft lithography. Micro-protein vesicles can carry multiple biological cargoes, which enables rational design of smart capsules for targeted drug delivery, bioreactors, and/or directional assembly to a hierarchical structure.

FUNCTIONAL PROTEIN THIN FILMS FOR CELL FATE CONTROL

We develop functional protein thin films and coatings to control cell fate at the surfaces. Thin films with controlled nanostructure (i.e., nanoscale pores or multilayers) are developed by non-solvent induced phase separation or layer-by-layer deposition with a spin-coating process. The functional protein thin films have a variety of biomedical applications, such as stem cell co-culture platforms, antibacterial surfaces, and drug release patches.

PHASE STUDY OF GLOBULAR PROTEIN-FUSED DIBLOCK COPOLYMERS

We aim to provide the fundamental understanding of the self-assembly of globular proteins fused with diblock copolymers that exhibit complex interactions. We study the phase transition/separation behavior of the globular fusion proteins in solution and at interface/surface under diverse physical and chemical stimuli, mainly using scattering and microscopic techniques. This study enables us to create new suprastructure with functional globular proteins.

PENG JIANG, PROFESSOR

Ph.D., 2001, Rice University **pjiang@che.ufl.edu**

WE ARE BROADLY INTERESTED IN DEVELOPING new chemical, physical, engineering, and biological applications related to self-assembled nanostructured materials. Our current research is focused on the following four topics:

SELF-ASSEMBLED PHOTONIC & PLASMONIC CRYSTALS

Photonic crystals and plasmonic crystals offer unprecedented opportunities for the realization of all-optical integrated circuits and high-speed optical computation. Our group is developing a number of scalable colloidal self-assembly technologies to control, manipulate, and amplify light on the sub-wavelength scale. We are also involved in the fabrication, characterization, and modeling of a large variety of functional nanooptical and plasmonic devices enabled by the bottom-up approaches.

BIOMIMETIC BROADBAND ANTIREFLECTION COATINGS

By mimicking the nanostructured antireflection layer on the cornea of a moth and the water-shedding coating on the wings of a cicada, we are developing self-cleaning broadband antireflection coatings for a wide spectrum of applications ranging from highly efficient solar cells and light emitting diodes to high-sensitivity spectroscopy for space exploration. Once again, we are interested in scalable nanomanufacturing technologies that can be inexpensively applied to large areas.

NOVEL STIMULI-RESPONSIVE SHAPE MEMORY POLYMERS

By integrating scientific principles drawn from two disparate fields—the fast-growing photonic crystal and shape memory polymer (SMP) technologies, we have developed a new type of shape memory polymer (SMP) that enables unusual “cold” programming and instantaneous shape recovery triggered by applying a large variety of unconventional stimuli (e.g., static pressure, vapors, and shear stress) at ambient conditions. These new stimuli-responsive SMPs differ greatly from currently available SMPs as they enable orders of magnitude faster response and room-temperature operations for the entire shape memory cycle. We are now exploring the broad applications of these smart materials in detecting Weapons of Mass Destruction (WMD) materials and aerospace morphing structures.

SMART WINDOW COATINGS FOR ENERGY-EFFICIENT BUILDINGS

Windows are typically regarded as a less energy efficient building component, and they contribute about 30 percent of overall building heating and cooling loads. We are developing a transformative dynamic window technology that enables dynamic and independent control of visible and near infrared light and eliminates expensive transparent conductors in the final devices. The innovative dynamic windows are inspired by the mature heat pipe and photonic crystal technologies, which have been widely used in controlling the flow of heat and light, respectively.

DMITRY KOPELEVICH, ASSOCIATE PROFESSOR AND UNIT OPERATIONS LABORATORY DIRECTOR

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OUR RESEARCH FOCUSES ON THEORETICAL & COMPUTATIONAL investigation of transport phenomena and non-equilibrium processes in nanoscale systems. We apply molecular dynamics and multi-scale simulations, as well as theoretical tools, to various nanoscale systems whose understanding is of significant scientific and technological importance.

SELF-ASSEMBLED SURFACTANT SYSTEMS

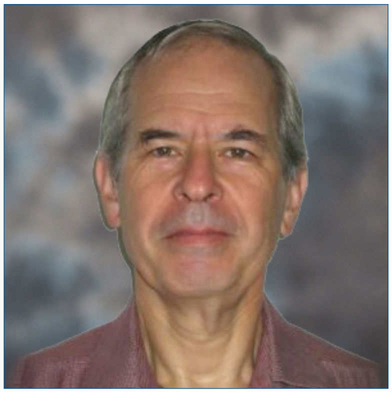
Surfactants (or amphiphiles) are molecules that contain both hydrophobic and hydrophilic segments. In aqueous solutions, surfactants spontaneously self-assemble into a variety of microstructures that find use in numerous applications, including drug delivery vehicles and templates for advanced nanostructured materials. In addition to their industrial uses, self-assembled structures of amphiphilic molecules, such as lipid bilayers, are building blocks for various biological systems. In all of these systems, the dynamics of self-assembly and transitions between different self-assembled structures plays an important role. Our goal is to understand molecular mechanisms of these transitions. Currently, we are investigating several systems, including formation and break-up of spherical micelles and dynamics of lipid membranes.

STABILITY OF BIOMEMBRANES

One of the common causes of cell death is disruption of the cellular membrane. Therefore, understanding mechanisms of membrane instability is important in various biomedical applications. For example, improvement of antimicrobial agents (e.g., peptides) which efficiently kill bacteria by destabilizing their membranes may lead to development of medications which do not promote antibiotic resistant strains of bacteria. On the other hand, reduction of toxicity of various industrial products calls for the development of materials which do not destabilize cellular membranes on contact. Our current research is focused on investigation of stability of the major constituent of cellular membranes (lipid bilayers) to perturbations created by manufactured nanoparticles (such as fullerenes and carbon nanotubes) and surfactant molecules.

TRANSPORT IN SELF-ASSEMBLED SYSTEMS

The process of mass transfer across surfactant-covered microemulsion interfaces and lipid bilayers plays an important role in numerous applications, including separations, reactions, drug delivery, and detoxification. We investigate the molecular mechanisms of solute transport across an interface composed of tightly packed amphiphilic molecules and assess various factors that affect this transport.



ANTHONY LADD, PROFESSOR

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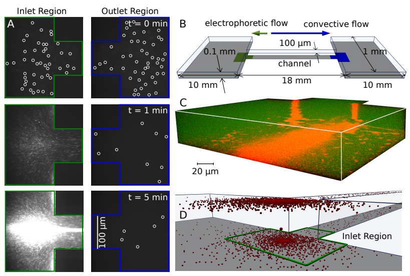
OUR RESEARCH FOCUSES ON DYNAMICS at scales that are small macroscopically (μm to mm), but are large compared to molecular sizes. The research combines statistical mechanics and fluid dynamics with advanced computing to elucidate the key physical processes that underlie laboratory observations and measurements. Current applications include:

REACTIVE TRANSPORT IN POROUS MEDIA

Flow and transport in porous media are usually modeled at the Darcy scale, where the system is described locally by average properties, such as porosity, permeability, dispersion coefficients, and reactive surface area. Although this allows large volumes to be simulated efficiently, there are serious difficulties in developing suitable models for the properties of the individual elements. Pore-scale modeling overcomes many of the limitations of Darcy-scale models, replacing unknown functions with well-defined parameters. Nevertheless, it is not yet clear that a single set of parameters – fluid viscosity, ion diffusion coefficients, and surface reaction rates – can consistently describe the dissolution of samples with different pore structures. The goal of our DOE sponsored project is to investigate the dissolution of idealized samples both numerically and experimentally to prove (or disprove) the correctness of the underlying equations.

MIGRATION OF DNA IN COMBINED FLOW AND ELECTRIC FIELDS

This project (in collaboration with Dr. Jason Butler) aims to investigate both the fundamental physics and potential biotechnological applications of the effect of a combination of hydrodynamic shear and electric field. From a fundamental point of view, the interest is to better understand the novel mechanism by which a charged polymer (like DNA) can be manipulated in directions perpendicular to the field lines. In a simple microfluidic device this can cause a rapid accumulation and trapping of the DNA, with implications for both biosensing and DNA extraction applications.



A. Epifluorescent images at the device inlet (green) and outlet (blue). B. Schematic of the device showing the direction of flow (blue) and electrophoresis (green); the diagram is not entirely to scale. C. A confocal scan showing the three-dimensional distribution of DNA within a 40 micron slab located on the lower wall of the inlet. DNA (orange) is concentrated on the wall of the device. D. A perspective sketch of the inlet region, indicating the distribution of trapped DNA.

TANMAY LELE, CHARLES A. STOKES PROFESSOR

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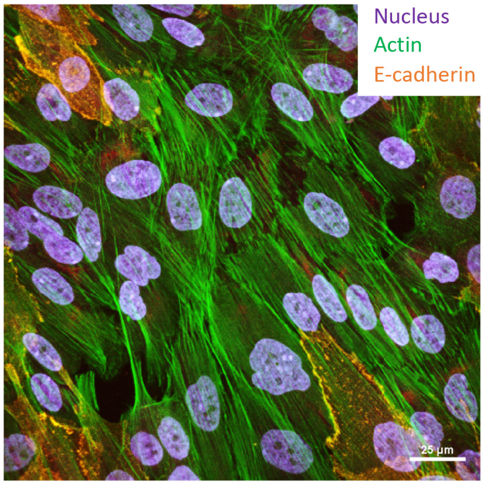
Our research is in the area of Mechanobiology, with focused efforts in understanding the molecular mechanisms by which cell generated mechanical forces and associated signaling pathways enable cell and tissue functions. We have contributed to the development and application of new methods for sub-cellular mechanical perturbations including laser ablation of cytoskeletal structures and direct nuclear force probes. A distinctive feature of our work is that experimental findings are either motivated by or interpreted with mathematical modeling/ computational predictions. Using these platforms, we have proposed new explanations for why microtubules adopt certain conformations during cell motility, how tension is established in dynamic stress fibers which enables cell adhesion and migration, how cells find their geometric center, and how the cell shapes and positions the nucleus for establishing cell polarity. In addition, we have established the concept that nuclear-cytoskeletal linkages are functionally involved in tissue development and cell mechanotransduction. Current research projects in the laboratory include quantitative measurements of nuclear forces, the effect of mechanical stresses on nuclear functions and gene expression, cellular adaptation to mechanical properties of the extracellular matrix, and the mechanics of tissue development. A key interest is in the field of Cancer Mechanobiology, with a focus on the role of the nucleus in the development of aberrant tissue structure and function.



RANGA NARAYANAN, DISTINGUISHED PROFESSOR, DISTINGUISHED TEACHER-SCHOLAR, AND WILLIAM AND TRACY CIRIOLLI PROFESSOR

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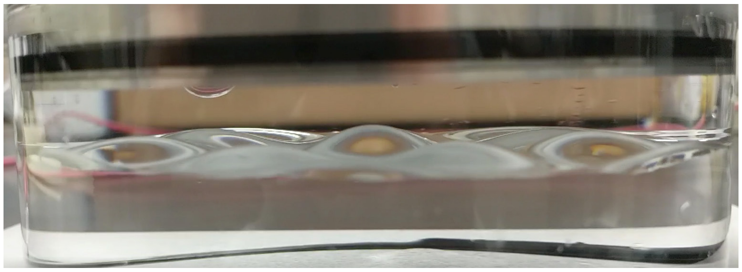
TRANSPORT OF HEAT, MASS, AND MOMENTUM ARE OFTEN accompanied by spatial and temporal pattern formation. Understanding the cause of pattern formation is pivotal as this research has application to the processing of materials on earth and under microgravity conditions. Such processes include additive manufacturing of metals, bulk crystal growth of semiconductors, thin film growth during evaporation, and electroplating.

IN THE AREA OF INSTABILITIES, IT IS THE GOAL of the present research to examine the physics of the spontaneous generation of spatial patterns in processes that involve solidification, electrodeposition, resonance, and free-surface convection. The pattern formation is associated with instabilities of a parent state as a control parameter is changed. Other processes of interest that involve instabilities are shearing flows with viscous dissipation of heat and oscillatory flows where flow reversal is the cause of non-rectilinear patterns.

THE MATHEMATICAL METHODS USED IN OUR RESEARCH are related to bifurcation theory, non-linear energy methods, and perturbation techniques. The experimental methods involve flow sensing by infrared imaging, shadowgraphy, and electrochemical titration.



Interfacial wave formation between layers of water (bottom) and silicone oil (top) when the fluids are subjected to an oscillatory electric field.

MARK ORAZEM, DISTINGUISHED PROFESSOR AND DR. AND MRS. FREDERICK C. EDIE PROFESSOR

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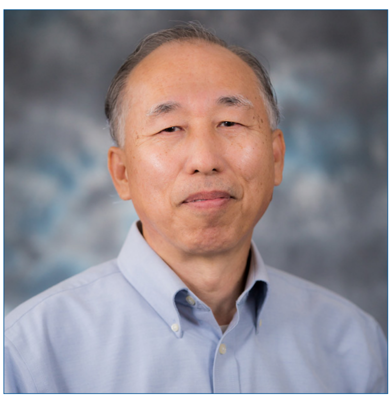
ELECTROCHEMICAL ENGINEERING

The research performed in this group represents applications of electrochemical engineering to systems of practical importance. In recent work, electrokinetic phenomena were exploited to enhance continuous separation of water from dilute suspensions of clay associated with phosphate mining operations. The technology developed in this project is intended to greatly reduce the environmental impact of mining operations. Our group recently patented a sensor, based on indirect impedance measurements, that can detect corrosion of post-tensioned tendons in segmentally constructed bridges.

ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY

Electrochemical impedance spectroscopy is an experimental technique in which sinusoidal modulation of an input signal is used to obtain the transfer function for an electrochemical system. In its usual application, the modulated input is potential, the measured response is current, and the transfer function is represented as an impedance. The impedance is obtained at different modulation frequencies, thus invoking the term spectroscopy. Through use of system-specific models, the impedance response can be interpreted in terms of kinetic and transport parameters. Through an international collaboration with scientists and engineers from France, Italy, and the United States, work is underway to improve the understanding of how impedance can be interpreted to gain insight into the physics and chemistry of such diverse systems as batteries, fuel cells, corroding metals, and human skin.

Current projects include a modelling and experimental study of the impedance of enzyme-based sensors for biological systems, use of impedance spectroscopy to explore the failure mechanisms for quantum-dot light-emitting diodes, and fundamental studies designed to enhance interpretation of impedance spectra. For example, in collaboration with French and Italian colleagues, our group developed a novel method to extract physically meaningful information from impedance data affected by frequency dispersion, a problem that had been unresolved since it was identified in the 1940s. Our power-law model, first published in 2010, has proven useful for oxides on metals, for human skin, and for water uptake in coatings. It is Now implemented in industry to assess the quality of raw materials for electrochemical fabrication lines. Our new understanding of the influence of electrode geometry on impedance response gives developers of impedance-based sensors guidelines for electrode size and shape.



FAN REN, DISTINGUISHED PROFESSOR

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HEALTH SENSORS

We aim to develop a highly sensitive and low-cost heart attack sensor technology, which can be implemented in a wireless-capable, real-time and handheld sensor for personal and medical usages. Acute myocardial infraction (AMI) causes one of the highest mortality rates worldwide. The existing methods employed by first responders, hospitals and clinics are time consuming and require trained personnel to perform tests. The challenge is to develop a real-time, accurate, handheld and low cost heart attack sensor for both personal and medical applications. AlGaN/GaN high electron mobility transistor (HEMT) based wide-energy bandgap semiconductor sensors amplify tiny changes of the surface charges from 10_5 to 10_6 times larger (50-60 dB higher) than those results from simple conductive or resistive measurements for the conventional conductive or resistive based sensors.

WIDE ENERGY-BANDGAP DEVICES

β-phase of Gallium Oxide is a very promising monoclinic semiconductor with relevant applications for power electronics and also for solar blind photodetectors. β-Ga_2O_3 based devices are predicted to have a Baliga figure-of-merit at least 4 times higher than either SiC or GaN, as reflected in the higher breakdown field and lower on-state resistance. Several types of transistors, including MOSFETs and MESFETs, as well as power Schottky diodes and solar blind UV detectors have also been reported. Our group holds the records of highest forward current as well as highest reverse breakdown voltage. We are studying the effects of total dose proton, electron, gamma ray and neutron fluxes on Ga_2O_3, which has exceptionally high breakdown fields and great promise for high power, high temperature electronics.

CERAMIC COATINGS

Ceramic prostheses are important components of restorative dentistry because of their unrivalled aesthetics and biocompatibility. However, ceramic veneers are susceptible to chipping failures intraorally, compromising the integrity of the prostheses. The resulting roughened surfaces can lead to increased plaque accumulation and the replacement of these prostheses. The long-term goal of this research is to develop fracture-resistant and chemically stable (durable) dental ceramics for prostheses by applying protective coatings. The overall objective is to critically evaluate the corrosion resistance and the strength of these dental ceramic coatings as a function of a simulated environment with constant changes in pH and intermittent abrasion.

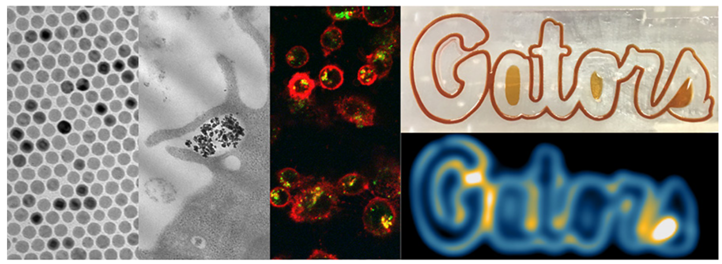
CARLOS RINALDI, DEPARTMENT CHAIR AND DEAN'S LEADERSHIP PROFESSOR

Ph.D., 2002, Massachusetts Institute of Technology **carlos.rinaldi@ufl.edu**

MY GROUP STUDIES THE BEHAVIOR AND BIOMEDICAL APPLICATIONS OF MAGNETIC NANOPARTICLES. The response of magnetic nanoparticles to applied magnetic fields enables a broad range of biomedical applications, such as imaging agents for magnetic resonance and magnetic particle imaging, biosensors, targeted delivery and triggered release of drugs, magnetomechanical actuation of cell response, and nanoscale thermal therapy. We combine expertise in synthesis and surface modification of magnetic nanoparticles; physical, chemical, and magnetic characterization; and modelling to answer fundamental and applied questions regarding the behavior of magnetic nanoparticles, understand their interaction with biological entities, and advance their biomedical applications. We are actively investigating novel methods of synthesizing nanoparticles with tailored magnetic properties, evaluating nanoparticle stability and mobility in biological environments, and advancing applications of magnetic nanoparticles in cancer therapy and magnetic particle imaging.

MAGNETIC PARTICLE IMAGING

Magnetic particle imaging (MPI) is a new biomedical imaging modality that enables unambiguous, tomographic, and quantitative evaluation of the distribution of magnetic nanoparticles in living subjects. My group is engineering biocompatible nanoparticle tracers for MPI that offer unprecedented resolution and sensitivity and can be used to track cells or image the distribution of biomarkers in pre-clinical models of cancer, arthritis, and diabetes. We are also engineering the surface of these tracers for labelling cells of the innate and adaptive immune system to enable sensitive and quantitative tracking of their biodistribution. We collaborate with clinicians and other scientists to evaluate the application of MPI for tracking adoptive cell transfer immunotherapies.



WHITNEY STOPPEL, ASSISTANT PROFESSOR

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Our research team is focused on the design and optimization of natural biomaterials for a variety of clinical applications. Experimental research explores the mechanical and transport properties of elastic and viscoelastic materials, aiming to determine a predictive set of material characteristics that have a known function in the body. We aim to harness the power of the immune system to alter the way that these materials integrate following implantation, providing a new strategy for classifying materials for clinical applications.

MATERIAL DESIGN AND IN VITRO CHARACTERIZATION

Natural materials and polymer composites derived from biopolymers such as silk fibroin, alginate, or decellularized extracellular matrix can be combined to form a variety of material shapes, architectures and mechanical properties. In turn, the format for the biomaterial can have a significant impact on cellular function and biological processes. We determine specific material properties and compositions that consistently alter or direct cell function through time-dependent analysis of cell-material interactions. These materials have applications in soft tissue repair and as in vitro platforms for understanding disease progression.

QUANTIFYING BIOMATERIAL PERFORMANCE IN VIVO

Understanding complex interactions between the immune system, local stromal cell populations, and implanted biomaterials necessitates spatiotemporal analysis of biomaterial degradation and histogenesis. We quantify how biomaterial composition and structure alter the rate of degradation and the composition and strength of new tissue that replaces the material. On-going efforts aim to understand how secondary diseases, biological sex, and age influence the kinetics of degradation and tissue formation.

SPYROS SVORONOS, HARRY AND BERTHA BERNSTEIN PROFESSOR AND UNDERGRADUATE PROGRAM COORDINATOR

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BIOFUEL PRODUCTION FROM SALINE CYANOBACTERIA

Although microalgae provide excellent means of capturing sunlight and atmospheric carbon dioxide, impediments to their widespread utilization are the inability to grow algae in a sustainable manner without large inputs of freshwater and nutrients—and to economically separate valuable products. Our research aims to establish a path for the economic production of a biofuel (methane) and an extracellular bioproduct. It utilizes a remarkable cyanobacterium that eliminates the need for fresh water inputs or external addition of nitrogenous nutrients and avoids expensive purification methods for product recovery. The project is in collaboration with Professor Pratap Pullammanappallil of the UF Agricultural and Biological Engineering Department and Professor Edward J. Phlips of the UF School of Forest Resources and Conservation.

YIIDER TSENG, ASSOCIATE PROFESSOR AND MASTERS PROGRAM COORDINATOR

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MY LAB FOCUSES ON COMBINING NEW ENGINEERING PRINCIPLES WITH ADVANCED LIFE SCIENCE METHODS for the purpose of developing a systematic, quantitative and integrative way to understand fundamental biological phenomena at the molecular and cellular levels. My research has implications on tissue engineering, wound repairs, microorganism invasions and disease states, such as cancer metastasis.

MY RESEARCH LABORATORY develops high-throughput/high-content methods to establish more sophisticated cell dynamic models. After identifying the key correlation among different subcellular activities, an integrative cell activity model can be established and the spatiotemporal connections between the subcellular activities can guide us to understand the comprehensive molecular mechanisms.

SERGEY VASENKOV, PROFESSOR

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MY RESEARCH PROGRAM FOCUSES ON DEVELOPING FUNDAMENTAL UNDERSTANDING OF TRANSPORT of molecules and ions in porous membranes, sorbents, catalysts and related materials on a broad range of microscopic length scales between around 100 nm and tens of microns. Such materials usually exhibit complex and, in some cases, even hierarchical structure that results in different transport properties on different microscopic length scales. Understanding the complexity of microscale transport in these materials on a fundamental level is required for optimizing their performance in separations and catalysis. For such studies, we develop and apply nuclear magnetic resonance (NMR) techniques that benefit from combining advantages of high magnetic field and high magnetic field gradients.

MICROSCOPIC GAS TRANSPORT IN GAS-SEPARATION MEMBRANES AND CATALYSTS

An application of a unique diffusion NMR technique, pulsed field gradient (PFG) NMR at high magnetic field and large magnetic field gradients resulted in the first direct measurements of microscale transport of gas molecules in mixed matrix membranes (MMMs) and carbon molecular sieve (CMS) membranes as well as in aerogel and nanoporous gold catalysts. In particular, for MMMs, which are formed by dispersing fillers, such as metal-organic frameworks (MOFs) in polymeric matrices, it was possible to resolve diffusion inside MOF particles from diffusion in the polymer phase between the particles. My group has proposed and validated experimentally an analytical expression for the long-range diffusivity in MMMs.

SINGLE-FILE DIFFUSION OF GAS MIXTURES

Diffusion in one-dimensional channels so narrow that they forbid mutual passage of molecules is referred to as single-file diffusion. My group was the first to report an experimental observation of single-file diffusion of molecular mixtures, an important result for applications in separations and catalysis. The relationship between the transport rates of mixtures and the corresponding pure components was found to be qualitatively different under the single-file conditions in comparison to normal diffusion. A model-based explanation of this difference was proposed.

JASON WEAVER, EXXON MOBIL GATOR ALUMNI PROFESSOR

Ph.D., 1998, Stanford University weaver@che.ufl.edu

OUR RESEARCH FOCUSES ON ADVANCING THE MOLECULAR-LEVEL understanding of surface chemical reactions that are important in applications of heterogeneous catalysis. My students and I investigate chemical reactions on solid surfaces using a wide array of analysis methods based on ultrahigh vacuum (UHV) surface chemistry and physics, including methods that provide information about surface reaction kinetics, adsorbed intermediates, atomic scale surface structure and the chemical states of adsorbed molecules and atoms of the solid. We make rigorous comparisons between our experimental data and predictions of molecular simulations, and find that this approach is a powerful way in which to identify elementary steps in surface reaction networks. We also investigate the catalytic behavior of well-defined surfaces using in situ synchrotron-based techniques to enable comparisons between the results of our model UHV studies and the behavior of working catalysts.

GROWTH AND SURFACE CHEMISTRY OF OXIDE THIN FILMS

We are investigating the growth and chemical properties of oxide thin films that develop on the surfaces of late transition metals during oxidation catalysis. This work is motivated by findings that metal oxide layers form on metallic catalysts in oxygen-rich environments, and that such oxide layers can play a decisive role in determining catalytic performance. In our research, we produce oxide thin films for characterization in UHV by oxidizing metallic surfaces using atomic oxygen beams or through controlled exposure to O2 in an isolated reaction cell. This approach allows us to investigate oxide films under well-controlled conditions, and gain insights about the growth and surface chemical properties of oxides that are central to several catalytic applications, such as the catalytic combustion of natural gas, exhaust gas remediation in automobiles and selective oxidation processes. Key topics of focus include the oxidation mechanisms of late transition-metal surfaces and the chemistry of small molecules on metal oxide surfaces, particularly the oxidation of light alkanes. Our work continues to advance the molecular-level understanding of catalytic reaction mechanisms on late transition-metal oxides.

CATALYSIS ON MULTIFUNCTIONAL SURFACES

We are also studying oxidation chemistry on mixed-metal oxides and metal-oxide nanostructures. These types of materials feature different types of surface domains separated by interfacial regions at which the constituents make atomic contact. Such multifunctional surfaces can exhibit unique catalytic properties as a result of cooperativity among the coexisting surface domains as well as distinct chemical properties of the interfacial regions. Our main goals are to determine how coexisting sites and domains influence catalytic reaction processes and develop structure-reactivity relationships that may be used to design multifunctional surfaces that promote selective oxidation catalysis. We are particularly interested in understanding how to modify these surfaces to achieve high selectivity and activity for converting light alkanes to value-added products such as olefins and organic oxygenates.

KIRK J. ZIEGLER, DOW CHEMICAL COMPANY FOUNDATION PROFESSOR AND ASSOCIATE CHAIR FOR GRADUATE STUDIES

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NEARLY ALL NANOMATERIAL APPLICATIONS REQUIRE an interface with other materials, including, for example, polymers in composites, electrodes in devices, pharmaceuticals in drug delivery, body fluids and cells in bioimaging and biosensors, or analytes in chemical sensors. Our group focuses on developing a fundamental understanding of interfaces in nanoscale systems, which can have far-reaching implications to various fields of nanotechnology. The goal is to manipulate interfaces to dictate the nanostructures that are fabricated and to control reactions and transport at the surface of the nanostructures. Once these interfaces can be controlled and manipulated, it is possible to fabricate nanomaterials with novel functionality, improving their integration and performance in several applications.

MANIPULATING INTERFACES

The ultimate objective is to create new functionality by manipulating the interface. The manipulation of nanoscale interfaces can alter the wettability, interaction of nanomaterials with matrices, and their stability to environmental effects. We aim to control these interfaces to alter the dispersion and sensing properties of the nanoparticles. These factors also limit the organization and dimensions of nanostructures that are fabricated. For example, we have exploited the natural sensing capabilities of single walled carbon nanotubes (SWCNTs) to help us characterize the localized environment surrounding them. The ability to characterize the surface of SWCNTs has enabled the development of processes to alter the surfactant structure surrounding the nanotube, providing more stable suspensions, better fluorescence intensities, selective adsorption onto surfaces, and reduced toxicity.

CONTROLLING REACTIONS AND TRANSPORT AT SURFACES

Nanotechnology offers significant promise to improving the performance of solar cells, batteries, and supercapacitors because of the large surface area and unique properties of nanomaterials. However, designing these devices requires exceptional control of the chemical and electronic processes that occur at interfaces. Since many of the atoms in nanostructures exist on the surface, their reaction and transport properties depend strongly on the interface. Our group develops processes that control reactions and transport at the surface to synthesize porous materials suitable for gas phase separations. These nanomaterial interfaces can also be used to help control biological function or accessibility, enhance the collection of photons, improve charge transport, yield better heat transfer, and generate more plasma.

STEPS TO APPLY

NEW STUDENTS FOR ALL GRADUATE PROGRAMS ARE ADMITTED ONLY IN THE FALL SEMESTER. THE DEADLINE FOR APPLICATIONS TO THE PH.D. AND M.S. PROGRAMS ARE DECEMBER 5. LATE APPLICATIONS MAY BE ACCEPTED IF OPPORTUNITIES ARE AVAILABLE.

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- Arrange to have official transcripts sent to the UF Office of Admissions from each postsecondary institution attended. International applicants must submit official copies in their native language and in English.

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-Julie F. Jameson

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