The Department of Chemical and Biomolecular Engineering offers courses of study leading to B.E., M.E., M.S., and Ph.D. degrees. Our program leading to the bachelor of engineering degree is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, phone (410) 347-7700.
Undergraduate

Chemical engineering is unique among the engineering disciplines in that it is based on the molecular sciences of chemistry and biology as well as physics, mathematics and computation. From its early foundation in petrochemical and bulk chemical processing, chemical engineering has expanded to play key roles in the development and production of pharmaceuticals and biomaterials, specialty polymers and high-strength composites, semiconductors and microelectronic devices, fine chemicals and nanomaterials, and so forth. Indeed, chemical engineering is essential for the operation of contemporary society. The solutions to many of the problems facing society today—energy, the environment, sustainable processes and development of high-performance materials—will involve chemical engineers. Future opportunities in the field are very bright.

The Vanderbilt undergraduate program in chemical engineering prepares students to contribute to these critical technologies. It is the department’s mission to educate those who will advance the knowledge base in chemical engineering, to conduct both basic and applied research in chemical engineering, to become practicing chemical engineers, and to be leaders in the chemical and process industries, academia and government. Graduates find meaningful careers in industry, in government laboratories and as private consultants. Some continue their education through graduate studies in chemical engineering, medicine, business or law.

Contact
Director of Undergraduate Studies
Kenneth Debelak
Email: kenneth.a.debelak@vanderbilt.edu
Phone: (615) 322-2088

Graduate

Graduate work in chemical and biomolecular engineering provides an opportunity for study and research at the cutting edge—to contribute to shaping a new model of what chemical engineers do. All faculty members are active in research and direction of graduate student projects. The department’s research focus areas can be broadly defined as materials, bioengineering and energy and are synchronized with institutional strengths and areas of national and regional need. In their research endeavors, faculty pursue novel applications of chemical engineering principles, both in their own research and as part of interdisciplinary teams. Interdisciplinary research is important at Vanderbilt and can lead to “game-changing” new ideas and discoveries. Faculty collaborate outside the school with faculty in the natural sciences and medicine and through research initiatives such as the Vanderbilt Institute of Nanoscale Science and Engineering (VINSE), the Vanderbilt Institute for Integrative Bioengineering Research and Education (VIIBRE) and the Vanderbilt Institute of Chemical Biology (VICB).

Graduate students are provided with strong support throughout their Ph.D. program and are offered opportunities for professional development through future faculty programs, conferences and internships as well as an active Chemical Engineering Graduate Student Association (ChEGSA). Thesis research gives unparalleled experience in problem solving, the key to challenging research assignments in industry and admission to a global community of scholars.

Contact
Director of Graduate Recruiting
Bridget Rogers
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Director of Graduate Studies
Clare McCabe
Email: c.mccabe@vanderbilt.edu
Phone: (615) 322-6853
The research theme in our lab hinges on the question: How does size reduction to the nanoscale alter material properties, including photonic, electronic, electrochemical and catalytic behavior? Understanding these fundamental properties at the nanoscale has important technological implications, from chemical sensing to energy conversion and storage to biomedicine. Our research efforts are focused on interdisciplinary nanoscience, with the convergence of multiple disciplines: engineering, material science, chemistry, physics and bioengineering. We combine both wet-chemistry and nanofabrication techniques to engineer plasmonic nanostructures, utilize “smart” bioconjugation techniques to design biologically active beacons and employ cutting-edge tools such as molecular spectroscopy, ultrafast optics, electrochemistry and super-resolution imaging to characterize the nanostructures. The ultimate goal of our research program is to utilize these materials to solve important global challenges—energy and sustainability and human health.

Rizia Bardhan
Assistant Professor of Chemical and Biomolecular Engineering

The foundation of our research group is based on understanding the fundamentals of plasmonics and nanophotonics and applying these fundamental concepts toward biomedical and energy applications. We design optically active metal and metal-oxide nanostructures with unique photonic characteristics driven by their geometry, dimensions and composition. We then engineer assemblies of these metal and metal-oxide nanostructures in functional architectures for real-time biosensing in cellular media for detecting pathogens and biomolecular analytes, for theranostics that combine targeting, imaging and therapy within a single nanoentity for disease detection and treatment, for plasmon-enhanced energy conversion processes—including photoelectrochemistry for water splitting into hydrogen—and CO2-to-fuel conversion and plasmon-mediated heterogeneous catalysis. We also have active collaborations with other faculty members at Vanderbilt to design and study phase transformations in batteries and supercapacitors at the nanoscale.

https://my.vanderbilt.edu/bardhanlab
Understanding collective phenomena is the ultimate goal of our research group, using a combination of theory and computational tools. For example, we perform computational simulations of fluids and interfaces by computing the motions of the constituent atoms and molecules. We simulate tumors by computing the motion and dynamics of individual cancer cells, their interactions with each other and their environment. In order to do this, we use a hierarchy of computational tools, from individual workstations to local and national parallel computing facilities and, in some cases, the largest computers in the world. We work closely with experimentalists, particularly those who can perform molecular and atomic level probes of structure and dynamics at the nanoscale, using methods such as X-ray scattering and neutron scattering techniques. The computational tools we develop and apply in our laboratory will evolve into the design tools for new technologies in the future, such as next-generation batteries and energy storage devices. Our group consists of both graduate students and postdoctoral researchers, with typically each student paired with a postdoctoral researcher to work on a specific project.

http://huggins.vuse.vanderbilt.edu
How cellular subsystems function together and are coordinated and controlled is not fully understood. We have explored particular biochemical and genetic networks, such as nitrogen metabolism and nitrogen catabolite repression, but we are rarely interested in specifics. We are generally interested in abstract notions of dynamics and control. For instance, we have explored how structure theorems are encoded in evolutionarily persistent networks. Our efforts in this direction with populations of microorganisms has revealed the importance of the cell cycle. We have shown that in order to accurately decipher experimental data from microbial populations, we must first understand and accurately model growth and division.

Microbes talk to each other, and this act often results in coordinated behavior. We are currently exploring how cell cycle-dependent, quorum sensing-type feedback influences population structure. We and countless others have observed that microbial population structure changes in response to environmental parameters, but no bifurcation theory, nor a framework for one, currently exists. Developing such a theory for cultures, colonies and biofilms is currently our central objective. There are a wide variety of applications for such a theory from basic biology to biofuels.

engineering.vanderbilt.edu/bio/kenneth-debelak

Kenneth Debelak
Associate Professor of Chemical and Biomolecular Engineering
Director of Undergraduate Studies
We are exploring two main areas of research: scaffolds and drug delivery systems for tissue regeneration and regulation of cell fate by the extracellular matrix. A specific area of interest is the design of injectable and settable grafts for bone defects that are challenging to heal, such as open fractures contaminated by infection, fractures at weight-bearing sites and mandibular continuity defects. Other current projects aim to understand how the bone microenvironment controls the progression of cancer-induced bone disease. We use 3-D printing technology to design scaffolds for investigating the effects of the biological and physical properties of the microenvironment on tumor cell fate. All projects are multidisciplinary, and students have extensive opportunities to collaborate with life scientists in the Vanderbilt University Medical Center and U.S. Army Institute of Surgical Research. Our lab space houses equipment for polymer synthesis and characterization, cell culture and histology. We also have access to equipment and facilities in the Vanderbilt University Medical Center, and we collaborate with corporate partners to translate new therapies into the clinic.

Scott Guelcher
Associate Professor of Chemical and Biomolecular Engineering
Associate Professor of Biomedical Engineering

Restoration of form and function to tissue defects caused by trauma or disease is a critical goal of regenerative medicine. However, currently available therapies often are insufficient for healing large tissue defects. We are creating injectable scaffolds and drug delivery systems for healing of bone and cutaneous defects. Current research interests include weight-bearing bone grafts, dual-purpose bone and skin grafts for healing of infected wounds, and carriers for drugs, proteins, and nucleic acids. We are also interested in applying tissue-engineered systems to understanding how the tumor microenvironment regulates cancer progression. Using scaffolds prepared by 3-D printing techniques culture in a perfused bioreactor, we are investigating how the properties of the microenvironment regulate cell fate in metastatic bone disease. A long-term goal of this work is to develop an in vitro 3-D model for testing therapeutics for cancer-induced bone disease.

http://research.vuse.vanderbilt.edu/guelcher_research/index
G. Kane Jennings  
Professor of Chemical and Biomolecular Engineering  
Chair of Chemical and Biomolecular Engineering

My research efforts are aimed at the molecular design and fabrication of new surfaces and materials that mimic, replicate or employ highly functional biological systems. We use the methods of self-assembly as well as surface-initiated polymerizations (grafting from) to modify surfaces with molecular or (bio) macromolecular films for applications in solar energy conversion, responsive coatings, superhydrophobic surfaces, nanoscale lubrication and self-aware materials. In this research, I employ graduate and undergraduate students to train a cadre of talented young minds in the molecular and interfacial aspects of biohybrid, bio-inspired and bioreplica materials.

http://engineering.vanderbilt.edu/chbe/FacultyResearch/kane-jennings.php

Organic coatings on metal surfaces are used extensively in materials processing as solar energy-conversion films, responsive interfaces, lubricating surfaces and robust protective coatings. Our research utilizes a molecular-level, biologically inspired approach to design and assemble tailor-made, ultrathin organic films on metal and semiconductor surfaces to impact the processing of advanced materials. For example, we assemble photosynthetic proteins into well-defined monolayer and multilayer films to convert incoming light to electrochemical energy. As highlights, we have prepared photosynthetic protein films on p-doped silicon to achieve photocurrents that greatly exceed those of uncoated silicon. We have also developed strategies for interfacing these proteins with graphene for the potential design of all-carbon solar cells. In the area of coatings, we have recently developed a method to replicate microstructured surfaces, including those of superhydrophobic plant leaves, to provide bioreplica coatings for targeted applications. The key innovation here is that we can combine nature-engineered topography with innovative polymeric materials that can greatly surpass the limited performance of hydrocarbons in nature.
The relationships between the chemical structure at a surface and the properties that result from this interface underlie both the systems we explore and the goals of our projects. At a fundamental level, we explore surface reactivity and two-dimensional structure-property relationships using molecular systems that we design and develop to undergo self-assembling coating processes. These often molecular and sometimes polymeric films are developed for use within systems such as porous silicon waveguides, magnetically responsive nanoparticles, microfluidic and microelectrode devices and photolithographically patterned surfaces. Through interdisciplinary collaborations with various groups at Vanderbilt, we apply these coatings to a range of systems. These include porous silicon waveguides with controllable optical properties whereby the coatings provide chemical and biochemical sensing possibilities for these structures. We use another class of coatings to enhance the imaging of biological tissue samples by mass spectroscopy, where the coatings simplify required processing steps and offer possibilities for imaging at higher resolutions. We continue to develop approaches for generating nonfouling surfaces, for uses in microfluidics and separations and future applications in biomedical devices. Many of these projects span the areas of materials science and molecular biology. The research at the interface between these areas is our focus on surface engineering.

Paul Laibinis
Professor of Chemical and Biomolecular Engineering
Co-Director of Nanoscience and Nanotechnology Minor

Our work focuses on the integration of fabricated nonbiological systems with biological materials. In these systems, interfaces and a control over their surface chemistry play a large role in defining their performance. We routinely design and apply thin organic coatings, often having nanometer- or molecular-scale dimensions, as a way to control the properties of a surface. Using methods of spontaneous and directed assembly, we design systems that can self-assemble into controlled structures with defined properties. Examples include the use of interfaces with grafted DNA chains for sensing applications, nonfouling coatings for controlling adsorption and improving separations methods, nanoparticles for enhancing transport within microfluidic chambers, and patterned surfaces for directing crystal growth for tissue imaging applications. We employ a variety of electrochemical, optical and analytical methods through the design and use of these systems. Students in this research develop an understanding of the connections between molecular-scale interfacial engineering and system development.

engineering.vanderbilt.edu/chbe/FacultyResearch/paul-laibinis.php
Molecular Biophysics

Matthew Lang
Associate Professor of Chemical and Biomolecular Engineering
Associate Professor of Molecular Physiology and Biophysics
Visiting Scientist, Massachusetts Institute of Technology, Department of Mechanical Engineering

The general goal of our research program is to probe the inner workings of nature’s molecular and cellular machinery. Building from a molecular perspective, we employ a measure-make-model approach, including single-molecule biophysics measurements with optical tweezers, single-molecule fluorescence spectroscopy, functional mutations and simulations. Our projects include the study of biological motors, in particular ClpXP motor machinery, which destroys proteins tagged for removal from cells harnessing energy from ATP; kinesin motors, which move on microtubules and are critical components of spindle assembly and dynamics; and cellulases, which degrade cellulose for biofuel production; the study of cellular machinery, specifically mechanoimmunology of antigen recognition and signaling of the T-cell receptor; and structure, function and nanomaterial applications of amyloid-based fibers. We collaborate with several groups that specialize in the biology and theory relating to the above projects. Our lab has advanced a number of optical and technical methods for single-molecule biophysics, including combined trapping and single-molecule fluorescence. Our long-range goals include laying the foundation for forward engineering with physical biological parts through understanding of nature’s fascinating machinery and identifying strategies for fighting disease.

www.vanderbilt.edu/langlab

Our lab explores the machinery of molecular and cellular systems. We have a number of specialized, home-built microscopes adapted with single-molecule biophysics methods that combine optical tweezers and single-molecule fluorescence spectroscopy. These instruments allow us to physically probe a structure using nanometer position sensing and piconewton force resolution while observing that structure with the ability to visualize fluorescence from a single molecule. The lab maintains dedicated microscopy rooms for low-noise measurement adjacent to a wet lab appropriate for assay preparation. Our facilities are custom designed and located in a newly renovated space ideal for single-molecule biophysics measurement. Working in the lab provides a broad training environment that includes exposure to advanced measurement and experimentation, optics and modern methods in molecular biology. Training in the lab is extended through interactions with expert biology and theory groups who collaborate with our lab. We are developing a number of single-molecule and single-cell assays for probing molecular and cellular machinery and adapting these methods to forward engineer new synthetic systems with physical-biological parts.
The ability to separate and purify gases and liquids is important in our society. Carbon dioxide needs to be captured and concentrated for sequestration. Toxic chemicals are present in the air we breathe and in the water we drink. Adsorbents are nanoporous materials with very large surface areas, and they are used in a wide variety of purification and separation processes. My research group focuses on both experimental and computational work related to adsorption. We have facilities for adsorbent synthesis, and we have a wide range of tools for adsorbent characterization. Standard bench-top instruments are available for porosimetry, spectroscopy, etc. Major commitments to experimental work are in the areas of adsorption equilibrium measurement, for which we have several gravimetric, volumetric and chromatographic systems, and for measuring mass transfer rates. In this last area, we have truly unique capabilities with apparatuses that use frequency response methods to perturb pressures, concentrations and volumes. Our research includes theoretical components involving thermodynamics and transport phenomena. Our computational research unites the theoretical and experimental components through simulation of molecular and macroscopic models.

Adsorption processes are important in purifying air and water and in separating a variety of mixtures. My research group investigates phenomena important in gas-phase adsorption. Recently, we have been focusing on the creation of novel adsorbent materials for removal of carbon dioxide and toxic chemicals from air. We measure pure component and mixture adsorption equilibria for a variety of applications. We have constructed several novel apparatuses for the measurement of mass transfer rates in nanoporous adsorbents, including the determination of the types of mass transfer resistances present. On the computational side, we have been performing molecular simulations to predict adsorption equilibria. We also simulate gas-phase adsorption processes including pressure-swing adsorption, temperature-swing adsorption, adsorption compression and adsorption cooling. In recent years, our research has been funded by NASA, the U.S. Army and the Department of Energy.

http://engineering.vanderbilt.edu/chbe/FacultyResearch/douglas-levan.php
Clare McCabe
Professor of Chemical and Biomolecular Engineering
Director of Graduate Studies
Professor of Chemistry

With today’s advances in computational power and evolving architectures such as graphical processing units—the video cards in computers and game consoles—the future of computational research has never been brighter. The complexity, in both size and detail, of the systems we can now study, compared to even 10 years ago, means computational studies can make a real impact and drive experimental research. In our work, we use molecular simulation to elucidate the structure of lipid bilayers through self-assembly studies in an effort to understand the barrier function of skin, to understand nanoscale lubrication and develop enhanced lubrication schemes for devices, as well as determine the mechanism by which enzymes depolymerize cellulose. We also work in the area of molecular theory to develop accurate tools to predict the thermodynamics of separation processes relevant to the chemical industry, with particular emphasis on green solvents and carbon capture.

https://my.vanderbilt.edu/mums/

Our research group aims to solve outstanding problems in energy, the environment, biology and medicine. The common thread in our approach to these diverse research areas is our use of molecular-based computational methods, which include molecular simulation (both Monte Carlo and molecular dynamics), quantum chemistry, and molecular theory, to elucidate the molecular-level behavior responsible for observed macroscopic properties. Molecular-level understanding provides a rational basis for prediction, design and optimization of new physical and biological systems. Much of our research is computationally intensive in nature. Thus, in addition to our own dedicated computational cluster, we use computational facilities at the National Center for Computational Sciences at Oak Ridge National Laboratory, the National Energy Research Scientific Computing Center at Lawrence Berkeley National Laboratory, and the Advanced Computing Center for Research and Education at Vanderbilt. We collaborate closely with experimentalists at Vanderbilt as well as groups at other universities and national laboratories in the United States and abroad to validate and enhance our work.
New and innovative membrane and electrode morphologies are being designed and created to address deficiencies in existing materials. Thus, multiple-polymer electrospinning is being used to fabricate polymeric-proton exchange membranes for hydrogen/air fuel cells, hydrogen/bromine regenerative fuel cells and water electrolyzers, where the final membranes exhibit better high-temperature and low-humidity ion conductivity, improved mechanical properties, low water swelling and better long-term durability. Gradient through-plane nanofiber structures and uniaxial stretching of fluorinated ionomers are two approaches being explored to improve the methanol barrier properties of proton-conducting membranes for direct liquid methanol fuel cells. Similarly, mechanically resilient and highly conductive, nanofiber-composite, anion-exchange membranes are being fabricated for use in alkaline fuel cells via polymer electrospinning. Electrospun, Pt-based, nanofiber electrode mats for hydrogen/air fuel cells are being developed with low Pt loading, high-power output and excellent long-term durability. Oxygen transport and the kinetics of oxygen reduction in such electrodes are being studied using AC impedance, cyclic voltammetry and Tafel-slope polarization experiments.

Peter Pintauro
H. Eugene McBrayer Professor of Chemical Engineering
Professor of Chemical and Biomolecular Engineering

The polymeric ion-exchange membrane in a fuel cell or battery performs three roles: It physically separates the positive and negative electrodes, it prevents mixing of fuel and oxidant and it provides a conduit for ion movement between the electrodes. Ion-exchange membranes are also used in a variety of water cleanup and industrial electrochemical syntheses and separation processes. There is a need for new fabrication strategies and new nano-morphologies for high performance cation-exchange, anion-exchange and bipolar membranes. My research group is addressing this need by designing, creating and evaluating membranes for fuel cells, batteries, electrodialysis separations and membrane-based, salt-splitting processes. Two membrane fabrication schemes are currently being pursued: nanofiber electrospinning of composite membranes as an alternative approach to polymer blending and the use of block copolymers and uniaxial polymer film stretching to improve the mechanical and/or transport properties of membranes. A second research thrust area in my group involves the development of polymer/particle electrospinning techniques to fabricate high surface area, inexpensive and durable nanofiber mat electrodes for fuel cells and batteries. For a hydrogen/air fuel cell, the emphasis is on lowering the precious metal catalyst loading of the oxygen reduction cathode. For lithium battery applications, the emphasis is on high areal capacity electrodes with high capacity retention at high charge/discharge rates. Graduate students in my lab receive training in the fields of polymer chemistry, membrane science, electrochemistry, chemical engineering and polymer fiber electrospinning.

electrochemical.engineering.vanderbilt.edu/bio/peter-pintauro
Our research focuses on using surfaces, interfaces, films and powders to engineer materials and microstructures for technically important applications such as microelectronics, catalysis, ultra-high temperature environments, radiation detection and energy. The Rogers group creates materials and structures using thin film processing techniques as well as combustion synthesis. We characterize our materials using a myriad of techniques including spectroscopic ellipsometry, ion beam backscattering spectrometry, electron spectroscopy and X-ray diffraction. We use the characterization results as feedback into process optimization. Having a complete knowledge of a material's chemical and physical properties also helps us to understand why certain materials work well in a particular application but not in others. This understanding enables us to engineer materials with desired properties for optimal performance in the targeted application.

http://engineering.vanderbilt.edu/chbe/FacultyResearch/bridget-rogers.php

The theme of our research is “From Atoms to Applications.” It includes making the materials, characterizing their properties and testing them in the targeted applications. Our laboratory facilities include processing and characterization equipment. We have a chemical vapor deposition (CVD) reactor to form thin, solid films on substrates. We have the ability to characterize our materials using electron, ion, X-ray and optical probes. Our X-ray photoelectron spectrometer supports the research projects of many investigators across the Vanderbilt campus. We also have Auger electron spectrometers that are optimized for depth-profiling materials to give compositional information through the depth of a material. We also have a spectroscopic ellipsometer with optical components mounted on the CVD reactor for in situ analysis and another set of optical components mounted on an ex situ stage. We are in charge of the ion beam backscattering beamline and end station of the campus Pelletron ion accelerator. Our group uses the processing capabilities in the Vanderbilt Institute of Nanoscale Science and Engineering core facilities and characterization instruments found in labs across Vanderbilt and Oak Ridge National Labs’ user facilities.
In the Laboratory for Immunomodulatory Biomaterials, we are currently focused on developing novel polymeric nanoparticles for the coordinated intracellular delivery of protein, nucleic acid and small-molecule cargo for applications in cancer immunotherapy, infectious disease vaccines and autoimmune disorders. We utilize advanced reversible addition-fragmentation chain transfer (RAFT) polymerization technologies to create precisely controlled drug carriers that deliver cargo in response to environmental cues. We are using these carrier platforms to target the extensive network of cytosolic immunoregulatory machinery as well as for the delivery of small-molecule immunomodulatory compounds for which there are currently few translatable carrier technologies. Our 1,200-square-foot laboratory is well equipped for performing organic synthesis, polymer synthesis and characterization, nanoparticle formulation, bioconjugation, cell culture and cell and molecular biology. Additionally, we have access to state-of-the-art equipment for nanoparticle characterization, imaging facilities and advanced tools for characterizing immune responses. Our projects are highly interdisciplinary and team-oriented, often spanning materials synthesis to evaluation in preclinical animal models, and provide extensive opportunities for working with clinical and basic science collaborators.

**John Wilson**
Assistant Professor of Chemical and Biomolecular Engineering

The immune system underlies the pathophysiology of nearly every disease and strategies that modulate immunity hold enormous, yet unmet, clinical potential. Our laboratory works at the interface of materials science and immunobiology to innovate new solutions for immune-based therapies. We are guided by the principle that the immune system must dictate therapeutic design requirements, and we turn to nature for inspiration to engineer highly modular and tunable materials to accommodate these criteria. Our multidisciplinary approach brings together expertise in nanotechnology, advanced polymerization techniques, cellular engineering and drug delivery to create molecularly engineered materials that specifically target and tightly regulate the delivery of immunomodulatory compounds to the organs, cells and/or intracellular pathways of the immune system. Additionally, through innovation in materials design, synthesis and formulation, our research is leading to novel drug delivery platforms with diverse potential applications.

http://engineering.vanderbilt.edu/bio/john-wilson
Jamey Young  
Assistant Professor of Chemical and Biomolecular Engineering  
Assistant Professor of Molecular Physiology and Biophysics

The overarching theme of my research program is to apply engineering approaches to quantitatively analyze and redirect cellular metabolism. My lab is currently applying metabolic flux analysis and metabolomic profiling to investigate a variety of cell and animal models of relevance to human disease, including cancer and type 2 diabetes. Through this work, we are elucidating the molecular alterations that contribute to these diseases and developing novel strategies to target these processes therapeutically.

I am also interested in enhancing biological production of fuels and chemicals. This work involves engineering mammalian cells to eliminate byproduct formation and resist toxicity in industrial bioreactors. My lab is collaborating with biologists to enhance the efficiency of photosynthetic carbon fixation in plants and cyanobacteria, which is a key step toward solving food, energy and environmental challenges of the future.

www.vanderbilt.edu/younglab

Living cells rely on metabolic reaction networks to break down nutrients and synthesize complex biomolecules. My lab is applying a combination of experimental and computational approaches to understand these processes and how they can be redirected to fight disease or to produce valuable biological products. We use isotope tracers, gas and liquid chromatography, mass spectrometry, microscopy, expression analysis and various other biochemical and molecular biology techniques to assess metabolic phenotypes in both cultured cells and plant or animal tissues. We combine these experimental measurements with computational models of metabolic reaction networks, which enables us to extract detailed information about the flow of material and energy within these networks and to understand how they are regulated. We are collaborating with cancer biologists, physiologists and endocrinologists to apply these approaches to cell and animal models that mimic human disease states. Furthermore, we are working with biologists to engineer transgenic plants and transgenic lines of animal or bacteria cells that exhibit enhanced productivities in agricultural or industrial applications.
Our graduate students have access to world-class research facilities through Vanderbilt’s many centers and institutes (http://research.vanderbilt.edu/centers-institutes). As an example, the Vanderbilt Institute for Nanoscale Science and Engineering provides cutting-edge facilities to support collaboration in materials science for 46 faculty, including 12 from the Department of Chemical and Biomolecular Engineering, and hundreds of students from 10 academic departments.

Created by an initial $16.4 million investment by the university, VINSE offers the types of electron microscopies and materials fabrication facilities that are too large and expensive to be confined within a professor’s laboratory. The proximity of these tools enables our research groups to rapidly obtain the answers to their questions and consistently stand among the world leaders in interdisciplinary materials.

Vanderbilt has a compact campus that fosters interdisciplinary collaboration via the close proximity of all engineering departments to those of the sciences and medicine. Chemical and biomolecular engineering graduate students in the area of bioengineering often collaborate with and work alongside medical researchers in our highly ranked medical center. The crossbreeding of intellectual strengths from engineers to medical researchers and physicians aids the translational impact of our research toward new products and discoveries.

Vanderbilt has recently opened the new Multiscale Modeling and Simulation facility, which enables our students to perform computational modeling from the very large to the very small scales. The groups of Peter Cummings, the director of MuMS, and Clare McCabe focus on molecular modeling and simulation and actively collaborate with other engineers through MuMS, as well as scientists and engineers from the world-renowned Institute for Software Integrated Systems at Vanderbilt.

CAREER PROSPECTS

The world-class training and intimate mentoring that you will obtain while earning your Ph.D. in chemical and biomolecular engineering from Vanderbilt will position you for a highly rewarding career.

Our graduates consistently win out in competitive job offers from industry, academia and government. Examples of where our recent alumni are working include:

- Agilyx
- BASF
- Baxter Healthcare
- Baylor College of Medicine
- Boeing
- Brewer Science
- Chevron
- Dow-Corning
- DuPont
- Eli Lilly
- Exxon-Mobil
- Fluor
- General Mills
- Georgia Institute of Technology
- Intel
- Merck
- National Renewable Energy Research Laboratory
- Nestle-Purina
- NextGxDx
- Pacific Northwest National Laboratory
- Pepsi
- Procter & Gamble
- Schlumberger
- University of Kentucky
- University of Texas Southwestern Medical Center
Undergraduate

Admission to the undergraduate school is managed by the Office of Undergraduate Admissions. Prospective students are encouraged to investigate the university by visiting the campus. Admissions staff are available to answer questions, arrange campus tours, provide additional information about degree programs and link visitors with appropriate campus offices and members of the university community.

Contact
Office of Undergraduate Admissions
Vanderbilt University
2305 West End Avenue
Nashville, TN 37203-1727 U.S.A.
Phone: (615) 322-2561 or (800) 288-0432
Website: admissions.vanderbilt.edu

Dates to Remember
November 1: Application deadline for Early Decision I
December 15: Early Decision I notification
January 1: Application deadline for Early Decision II and Regular Decision and earliest deadline to submit the Free Application for Federal Student Aid (FAFSA) to processors
April 1: Admissions decisions available
May 1: Deadline for matriculation deposit

Graduate

To apply for admission to the graduate program in chemical and biomolecular engineering, you must first meet the general requirements of admission by the Vanderbilt University Graduate School. Application for admission may be made through the Graduate School website at: www.vanderbilt.edu/gradschool

The Graduate School Catalog may be viewed at: www.vanderbilt.edu/catalogs

Contact
Engineering Graduate Programs
ATTN: Chemical and Biomolecular Engineering
Vanderbilt University
411 Kirkland Hall
Nashville, TN 37240 U.S.A.
Phone: (615) 322-2441
Website: vanderbilt.edu/gradschool

Dates to Remember
January 15: Application deadline for fall admissions
December 15–January 31: Faculty review of applications
December 20–March 31: Fall admissions offers made
April 15: Deadline to accept admission
Undergraduate

Vanderbilt is committed to enrolling talented, motivated students from diverse backgrounds. More than 60 percent of Vanderbilt students receive some type of aid. The university offers a full range of merit-based scholarships, need-based financial assistance and financing/payments options to families of all income levels. More information can be found at www.vanderbilt.edu/financialaid.

Expanded Aid Program

Beginning in the fall of 2009, need-based financial aid packages for all undergraduate students no longer include need-based loans. This latest initiative does not involve the use of income bands or “cut-offs” to pre-determine levels of eligibility and applies to all undergraduate students with demonstrated financial need who are U.S. citizens or eligible non-citizens. The end result is that, in addition to a realistic academic year earnings expectation, all need-based aid packages now include scholarships and/or grants (gift assistance) in place of need-based loans that would have previously been offered to meet demonstrated need.

Graduate

Graduate students in the Department of Chemical and Biomolecular Engineering seeking the Ph.D. degree receive a competitive stipend, full tuition waiver and health insurance. Typically, students are first supported on a teaching assistantship and then a research assistantship once a thesis advisor has been identified. Students on a teaching assistantship assist the faculty with undergraduate courses, typically by grading assignments and holding office hours. Opportunities to teach are available for those that wish to gain such experience.

Both teaching and research assistantships can be supplemented by any one of the following university fellowships, which are awarded through a competitive process to highly qualified applicants:

- University Graduate Fellowships
  $10,000/year for up to 5 years

- Provost’s Graduate Fellowships
  $10,000/year for up to 5 years

- Harold Stirling Vanderbilt Graduate Scholarships
  $6,000/year for up to 5 years

- School of Engineering IBM Fellowships
  $4,000/year for up to 4 years plus an award of $1,000 for professional development

In order to be considered for these fellowships, an applicant's file must be complete by January 15. Prospective applicants are also urged to apply for external fellowships or grants from national, international, industrial or foundation sources.
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<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Research Interests</th>
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<tbody>
<tr>
<td>Rizia Bardhan</td>
<td>Assistant Professor of Chemical and Biomolecular Engineering</td>
<td>Plasmonics and nanophotonics, nanomedicine and nanobiosensing, nanomaterials for energy conversion and storage</td>
</tr>
<tr>
<td>Peter Cummings</td>
<td>John R. Hall Professor of Chemical Engineering</td>
<td>Statistical mechanics, molecular simulation, computational materials science, computational and theoretical nanoscience and computational biology</td>
</tr>
<tr>
<td>Kenneth Debelak</td>
<td>Associate Professor of Chemical and Biomolecular Engineering</td>
<td>Automotive catalyst coating, plant-wide modeling, simulation and control.</td>
</tr>
<tr>
<td>Russell F. Dunn</td>
<td>Professor of the Practice of Chemical and Biomolecular Engineering</td>
<td>Process integration, plant-wide design and optimization strategies, polymer product characterization and failure analysis, chemical product and process safety</td>
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<tr>
<td>Todd Giorgio</td>
<td>Associate Professor of Chemical and Biomolecular Engineering</td>
<td>Biologically responsive nanomaterials, cancer immunology, drug and gene delivery, multifunctional inorganic nanostructures</td>
</tr>
<tr>
<td>Scott Guelcher</td>
<td>Associate Professor of Chemical and Biomolecular Engineering</td>
<td>Polymer science and engineering, biomaterials, drug delivery and tissue engineering, colloid and surface chemistry, electrophoretic deposition</td>
</tr>
<tr>
<td>Eva Harth</td>
<td>Associate Professor of Chemical and Biomolecular Engineering</td>
<td>Polymer and organic chemistry, nanomaterials, drug delivery and bioconjugates</td>
</tr>
<tr>
<td>G. Kane Jennings</td>
<td>Professor and Chair of Chemical and Biomolecular Engineering</td>
<td>Bio-inspired materials, biohybrid solar energy conversion, organic thin films, surface science, tribology, superhydrophobic surfaces</td>
</tr>
<tr>
<td>David Kosson</td>
<td>Professor of Chemical Engineering</td>
<td>Chemical and nuclear environmental engineering, contaminant mass transfer, environmental remediation and waste management</td>
</tr>
<tr>
<td>Paul Laibinis</td>
<td>Professor of Chemical and Biomolecular Engineering</td>
<td>Self-assembly, organic thin films, chemical and biochemical sensors, surface modification, interfacial phenomena, directed adsorption and biomolecules at surfaces</td>
</tr>
<tr>
<td>Matthew Lang</td>
<td>Associate Professor of Chemical and Biomolecular Engineering</td>
<td>Molecular and cellular machines, biological motors and single molecule biophysics</td>
</tr>
<tr>
<td>Douglas LeVan</td>
<td>J. Lawrence Wilson Professor of Engineering</td>
<td>Air purification, gas separation, novel nanoporous adsorbents, adsorption equilibria, mass transfer in adsorbents and adsorption cycles</td>
</tr>
</tbody>
</table>
Clare McCabe
Professor of Chemical and Biomolecular Engineering
Director of Graduate Studies
Research Interests: Molecular modeling of fluids and materials, bioenergy processes, biological self-assembly, molecular rheology and tribology, molecular theory, phase equilibria

Peter Pintauro
H. Eugene McBrayer Professor of Chemical Engineering
Professor of Chemical and Biomolecular Engineering
Research Interests: Electrochemical engineering, membrane science, fabrication and characterization of polymeric ion-exchange membranes for fuel cell applications, membrane transport modeling and organic electrochemical synthesis

Bridget Rogers
Associate Professor of Chemical and Biomolecular Engineering
Director of Graduate Recruiting
Research Interests: Processing, characterizing, and utilizing films, coatings and powders for applications in microelectronics, aerospace, defense and energy

Sandra Rosenthal
Professor of Chemical and Biomolecular Engineering
Research Interests: Synthesis, characterization, surface modification, and ultrafast carrier dynamics of semiconductor nanocrystals for applications in biological imaging, photovoltaics and solid-state lighting

Julie Sharp
Professor of the Practice of Chemical and Biomolecular Engineering
Research Interests: Job search communication, learning styles and integrating communication in engineering courses

John Wilson
Assistant Professor of Chemical and Biomolecular Engineering
Research Interests: Drug delivery, biomaterials, polymer science and engineering, colloid and surface science, nanotechnology, immunotherapy, vaccines and cell-based therapeutics

Jamey Young
Assistant Professor of Chemical and Biomolecular Engineering
Assistant Professor of Molecular Physiology and Biophysics
Research Interests: Metabolic engineering; systems biology; diabetes, obesity, metabolic disorders; tumor metabolism; cell culture engineering and enhancing photosynthesis
Vanderbilt

Cornelius Vanderbilt had a vision of a place that would “contribute to strengthening the ties that should exist between all sections of our common country” when he gave a million dollars to create a university in 1873. Today, that vision has been realized in Vanderbilt, an internationally recognized research university in Nashville, Tenn., with strong partnerships among its 10 schools, neighboring institutions and the community.

Vanderbilt offers undergraduate programs in the liberal arts and sciences, engineering, music, education and human development, as well as a full range of graduate and professional degrees. The combination of cutting-edge research, liberal arts education, nationally recognized schools of law, business and divinity, the nation’s top ranked graduate school of education, and a distinguished medical center creates an invigorating atmosphere where students tailor their education to meet their goals and researchers collaborate to address the complex questions affecting our health, culture and society.

An independent, privately supported university, Vanderbilt is the largest private employer in Middle Tennessee and the second largest private employer based in the state.

Nashville

Vanderbilt’s hometown of Nashville is a vibrant, engaging city known proudly as “Music City U.S.A.” The university’s students, faculty, staff and visitors frequently cite Nashville as one of the perks of Vanderbilt, with its 330-acre campus located a little more than a mile from downtown. Named America’s friendliest city, Nashville is a metropolitan place that exudes all of the charm and hospitality one expects from a Southern capital.

The city was settled in 1779 and permanently became the state capital in 1843. The city proper is 533 square miles with a population of more than 600,000. Major industries include tourism, printing and publishing, technology, manufacturing, music production, higher education, finance, insurance, automobile production and health care management. Nashville has been named one of the 15 best U.S. cities for work and family by Fortune magazine, was ranked as the No. 1 most popular U.S. city for corporate relocations by Expansion Management magazine, and was named by Forbes magazine as one of the 25 cities most likely to have the country’s highest job growth over the coming five years.
Architect’s rendering of the new Engineering and Science building, currently under construction.
Department of Chemical and Biomolecular Engineering
PMB 351604
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