RESEARCH AREAS

Biomolecular & Biomedical Engineering

Biomolecular and Biomedical Engineering applies chemical engineering principles to biological systems with the goal of improving medical treatments and human health. Our research ranges from single molecule biophysics, stem cell biology and polymer science to pre-clinical applications, tissue engineering, 3-dimensional cell culture and regenerative medicine. Applications include advanced biomaterials for drug delivery; control of cell growth and differentiation; stimuli-responsive biodegradable and biostable polymers; novel integrated single molecule functional imaging tools; and techniques that address basic questions about physical, chemical, mechanical and electronic properties of biological materials.

Bioprocess Engineering

Bioprocess Engineering combines biotechnology and engineering for the manufacturing of materials from renewable feedstocks. This field includes fundamental biomolecular research on proteins, enzymes and microbes, as well as work on biosensors, bioseparations and bioreactors. Applications include food processing and preservation; pharmaceutical, nutraceutical and sweetener production; air and wastewater treatment; bio-based structural motifs for supramolecular architectures; microfluidics for bioreactors and DNA chips; bioenergy; and applications in the pulp and paper industry. There are natural links to biomedical applications, such as drug metabolism, tissue engineering and bio-based therapeutic treatments.

Chemical & Materials Process Engineering

Chemical and Materials Process Engineering applies knowledge of inorganic and aqueous chemistry in the processing of natural and recycled resources to produce valuable materials, reduce waste and create new, more efficient processes for the industries that are the lifeblood of our economy. Products include metals, alloys, smart materials, ceramics, paper, clean energy, clean water and air, industrial gases, new health products, fortified foods, nutraceuticals and the chemicals of everyday use. Specific research areas include recovery of strategic, and critical elements by hydrometallurgy; nano-crystalline metals; amorphous metal glasses and atomic cluster catalysts; high surface area carbon powders; nickel and diamond coated ceramics; improved resources recovery; acidic gases capture from industrial processes; fuel cells; process water recovery and purification, as well as energy capture from high temperature kilns in the pulp and paper industry.

Environmental Science & Engineering

Environmental Science and Engineering is the application of sound science and engineering principles to the development of sustainable industrial processes and ecosystems. The research covers all aspects of environmental science and engineering from understanding the behavior of pollutants in natural environments to creating new waste treatment technologies and developing green technologies. Research includes the use of bacteria to remediate groundwater polluted with industrial solvents; evaluation of the sources of air pollution and their public health impacts; and the development of artificial wetlands for water treatment.

Informatics

Informatics is the science of information processing and the engineering of information systems, typically powerful, computer-based mathematical methods to turn data into comprehensive, predictive models. Informatics tools are very broadly applicable and are heavily used in molecular and synthetic biology, in the financial industry and in process control in complex technical systems like refineries and paper mills.

Pulp & Paper

The application of science and engineering principles to the pulp and paper industry has long been a vital part of our Department's research, coordinated through the Pulp & Paper Centre. Research is multidisciplinary with extensive linkages to the industry and other research organizations nationally and internationally. Research areas include applied chemistry (organic, inorganic), chemical and energy recovery, sustainable energy, high temperature processes, fluid mechanics, heat transfer, process control, materials science, paper science, surface science, printing and converting, coating and calendering, microbiology, microscopy, environmental engineering, and bioprocess engineering.

Surface and Interface Engineering

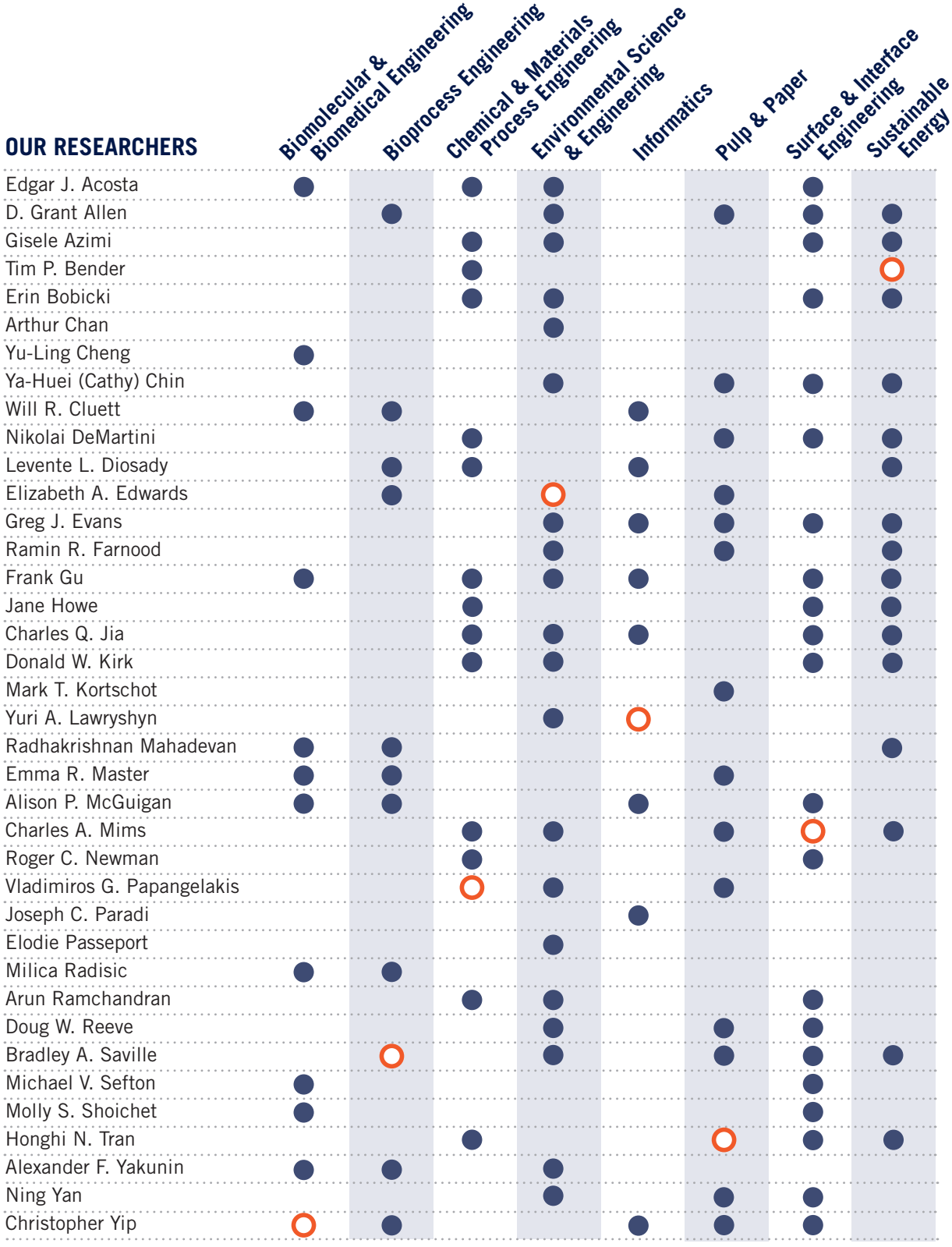
Surfaces and interfacial properties control the performance of materials in many diverse research areas in our department and beyond, including medicine, electronics, fuel cells and advanced energy research, composites, catalysis, geology, forestry and paper products and environmental science and technology. Our department is home to two advanced facilities for the study of surface and interfacial chemistry that together represent a world-leading environment for the study of surfaces and interfaces: Surface Interface Ontario and the Ontario Centre for the Characterization of Advanced Materials (OCCAM). These provide core experimental capabilities including mass/electron spectroscopy and electron microscopy.
Visit www.si-ontario.utoronto.ca and www.occam.utoronto.ca.

Sustainable Energy

Sustainable Energy research develops technologies that reduce our reliance on fossil fuels and reduce greenhouse gas emissions. The focus is on biomass-based fuels, fuel cells, energy recovery, thermal-hydraulics, nuclear energy, efficient use of fossil fuels and the environmental impact of energy production. Applications include the commercial production of biodiesel from edible oilseeds, soybean oil or algae; hydrogen production for fuel cells; production of biogas through the biological treatment of effluents; organic solar cells; catalytic liquefaction; gasification of waste biomass; and increased energy efficiency in a wide range of industries for improved competitiveness.

RESEARCH MATRIX

The high degree of collaboration among our faculty members and the multi-disciplinary nature of much of their work are reflected in the research matrix below, which lists researchers in each research area.



Edgar J. Acosta | edgar.acosta@utoronto.ca

Complex fluids research: surfactant and block copolymer micelles, microemulsions, emulsions, monolayers and liquid crystals. Surfactant-based processes: remediation of oil spills, colloid-enhanced ultrafiltration, admicellar chromatography, suspension - emulsion and microemulsion polymerization, froth flotation processes (paper de-inking, mineral separations and water decontamination), aqueous solvents for vegetable oil extraction. Formulation Engineering: molecular structure - physicochemical properties - formulation performance relationships in applications such as: delivery of drugs, cosmetics and food additives, coatings, paints and inks, detergency and general surface cleaners, water-based solvent replacements of organic degreasers (including dry cleaning systems).

D. Grant Allen | dgrant.allen@utoronto.ca

Bioprocess engineering and its environmental applications. Biological Waste Treatment: performance and design of biological treatment for toxicity reduction in pulp mill effluents, biological treatment of chlorinated organic compounds, biofiltration of air pollutants. Bioconversion of waste water and waste solids into value added fuels, chemicals and materials. Microalgae production from carbon dioxide, sunlight and wastewater for production of biofuels and biochemicals. Biofilm formation and adhesion. Microbiology and floc formation in waste treatment systems and the development of techniques of monitoring microbial communities.

Gisele Azimi | g.azimi@utoronto.ca

Extraction, processing, and recycling of strategic materials, mainly rare-earth elements; Electrochemistry: high-temperature electrolysis; Hydrometallurgy: High-pressure acid leaching, solvent extraction; Supercritical water desulphurization; Multi-resolution modelling and experimental investigation of electrolyte systems: thermodynamics, chemical modelling, and process simulation; Inorganic materials (metal- and ceramic-based) design and (nano) fabrication.

Tim P. Bender | tim.bender@utoronto.ca

Organic Photovoltaic Devices including design, synthesis and crystal engineering of light harvesting organic materials, hole- and electron-transporting organic materials and polymers, chemical process engineering, design of experiments, parallel chemistry, molecular modeling.

Erin Bobicki | erin.bobicki@utoronto.ca

Reduction of water and energy use in mineral processing; processing of low-grade ores; surface and colloid chemistry; interfacial phenomena; slurry rheology in flotation and comminution; comminution energy reduction; coarse particle flotation; microwave properties of minerals; microwave pre-treatment for improved processability; saline and recycle water use in processing; tailings re-processing; tailings and wastewater treatment; holistic strategies for increasing the sustainability of mining and mineral processing operations.

Arthur Chan | arthurwh.chan@utoronto.ca

Analytical techniques for resolving complex organic mixtures, atmospheric chemistry, particulate matter and human health, organic aerosols.

Yu-Ling Cheng | yuling.cheng@utoronto.ca

Global engineering, appropriate technologies, global health, off-grid sanitation, integrated innovation, drug delivery, diffusion and transport in polymeric and physiologic systems.

Ya-Huei (Cathy) Chin | cathy.chin@utoronto.ca

Applications of multidisciplinary research strategy (kinetic and isotopic techniques, spectroscopy and theoretical modeling) to address challenges in energy and environment. Design catalytic processes and develop microchemical reactor technology to intensify chemical conversion. Specific topics include renewable energy, hydrocarbon fuel processing, natural gas conversion, solar fuel production, exhaust emission control, fine chemical production and nanostructured materials.

Will R. Cluett | will.cluett@utoronto.ca

System identification, control and design. Systems biology.

Nikolai DeMartini | nikolai.demartini@utoronto.ca

The role and fate of inorganics in the industrial processing of woody biomass with an emphasis on energy efficiency and emissions. Scaling in spent liquor evaporators and trace metals in alkaline solutions in pulp and paper. Forms and release of inorganics during thermal conversion processes.

Levente L. Diosady | l.diosady@utoronto.ca

Food Engineering - the application of chemical engineering principles to processing agricultural products for recovery of food, nutraceuticals and biofuels based on modern membrane separation technologies. Micronutrient fortification of food for disease prevention in the Developing World. Drug delivery.

Elizabeth A. Edwards | elizabeth.edwards@utoronto.ca

Biodegradation and bioremediation of groundwater pollutants such as aromatic hydrocarbons and chlorinated solvents. Industrial wastewater treatment with a focus on anaerobic digestion. Kinetics and biochemical pathways of microbial degradative reactions. Identification of microbial species capable of anaerobic biodegradation. Molecular biology and metagenomics in environmental microbiology.

Greg J. Evans | greg.evans@utoronto.ca

Air pollution impacts on health and climate, advanced instrumentation and inexpensive chemical sensors, data mining for pollutant source identification, toxicity and biomarkers, engineering education research.

Ramin Farnood | ramin.farnood@utoronto.ca

Biomaterials, bioenergy, and environmental engineering, in particular: novel bio-based products, thermochemical biomass conversion, advanced treatment technologies for wastewater reuse applications, inkjet micro-fabrication of intelligent devices, micro-structure characterization of complex materials.

Frank Gu | f.gu@utoronto.ca

An interdisciplinary research group that combines functional polymers and metal oxide materials to solve problems in health, environmental protection, and industrial applications. Engineering of mucoadhesive nanocarriers for drug delivery applications. Biosensors for pathogen sensing. Sustainable platform for the treatment of organic and inorganic compounds in industrial wastewater. Manipulation of nano-scaled reactors for soil treatment and remediation.

Jane Howe | jane.howe@utoronto.ca

Prior to joining U of T in 2019, Professor Howe worked as a Senior Applications Scientist with Hitachi High-Technologies group in US and Canada for the past five years. Her current research interest is in situ and correlative microscopy techniques.

Charles Q. Jia | cq.jia@utoronto.ca

Nanoporous carbons for air and water purification and capacitive electrical energy storage; nanoporous carbon synthesis from biomass and industrial waste; industrial waste valorization; environmental and industrial applications of inorganic sulphur chemistry; simulation of environmental fate, transport and impact of pollutants.

Donald W. Kirk | don.kirk@utoronto.ca

Electrochemical engineering, design, modelling, reaction kinetic studies, pollution control, metal dissolution and organic electrosynthesis, environmental studies (recovery and recycling).

Mark T. Kortschot | mark.kortschot@utoronto.ca

Composite science and reinforced polymers: Structure/property relationships for non-metallic materials; studies of delamination in carbon fiber reinforced epoxy; manufacture and properties of wood fiber reinforced thermoplastics, manufacture and properties of engineered wood building products. Engineering design: Creative Product Design with an emphasis on novelty and materials selection and the resultant intellectual property issues.

Yuri A. Lawryshyn | yuri.lawryshyn@utoronto.ca

Applying Information Technology with analytical and numerical methods to solve complex, but practical, problems. Research areas: real options analysis, business process optimization, financial engineering, asset management in the municipal environmental sector and environmental research.

Radhakrishnan Mahadevan | krishna.mahadevan@utoronto.ca

Systems biology, synthetic biology, metabolic engineering, metabolic modeling and model-based design, metabolic networks, gene regulatory networks, bioprocess optimization & control, dynamic control of metabolism, bioremediation, biomedical systems, human metabolism, whole-body modeling, pharmacokinetic and pharmacodynamic modeling, personalized nutrition and medicine.

Emma R. Master | emma.master@utoronto.ca

Discovery, design and production of enzymes and non-catalytic proteins that can be used to synthesize new bio-based materials and high-value chemicals from renewable plant sources.

Alison P. McGuigan | alison.mcguigan@utoronto.ca

Tissue engineering, microfabrication, disease modeling, systems biology, 2D and 3D cell organization and self-assembly, cell migration, tissue patterning and boundaries, modelling tissue organization mechanisms, in vitro drug screening tools.

Charles A. Mims | charles.mims@utoronto.ca

Heterogeneous reactions, materials processing and advanced materials characterization with focus on mechanisms of energy related catalytic reactions, including isotope tracing and surface analytic techniques. Directs CFI-funded Ontario Centre for Characterization of Advanced Materials (OCCAM), with wide impact in R&D (www.si-ontario.utoronto.ca/).

Roger C. Newman | roger.newman@utoronto.ca

Corrosion and protection of metals, stress corrosion cracking, metallic nanomaterials, sensors, coatings, membranes, nuclear power systems and waste management, oil and gas production and refining, pulp and paper.

Vladimiros Papangelakis | vladimiros.papangelakis@utoronto.ca

Aqueous process engineering; hydrometallurgy; bio-hydrometallurgy; process modelling; electrolyte solution chemistry; recycling of inorganic wastes; environmental remediation from mining and metallurgical activities; process water recovery, recycling and purification; extractive metallurgy of nickel, gold and rare earth metals.

Joseph C. Paradi | paradi@mie.utoronto.ca

Production, internal economy, financial models, risk, branch operations technology and performance evaluation in the Financial Services Industry. Productivity, efficiency and effectiveness in the services industries are the major focus. Most research involves real-life situations where new approaches and science is needed.

Elodie Passeport | elodie.passeport@utoronto.ca

Fate and removal of contaminants from the environment in natural and engineered aquatic ecosystems. Development of sampling techniques that enable concentration and stable isotope analysis of chemicals that pose a threat to human and ecosystem health. Design of novel water treatment systems that mimic natural environments (e.g., constructed wetlands) to improve their natural ability at reducing pollution. Methods are multi-disciplinary and involve tools from reactor engineering, mass transfer, hydrology, environmental sciences, microbiology, chemistry, and analytical chemistry.

Milica Radisic | m.radisic@utoronto.ca

Tissue engineering, bioreactors, biophysical modulation of engineered tissues, patterned cell co-culture (2D and 3D), Modeling of transport processes relevant to tissue engineering.

Arun Ramchandran | arun.ramchandran@utoronto.ca

Comprehension and prediction of macroscale properties of a suspension (mixture of particles and liquids) through the study of microscale/nanoscale interactions and properties. Oil extraction, fabric softener design, mass transfer in flowing blood, motion of biological particles in vascular networks, and polymer blending.

Doug W. Reeve | doug.reeve@utoronto.ca

Engineer leadership in the workplace. Evidence-based leadership curriculum for engineering students.

Bradley A. Saville | bradley.saville@utoronto.ca

Applications of enzymes, biofuels and bioenergy, enzyme inactivation, inhibition and regulation of enzyme activity, drug distribution and elimination.

Michael V. Sefton | michael.sefton@utoronto.ca

Tissue engineering, cardiovascular biomaterials, medical implants, cell transplantation, gene delivery systems.

Molly S. Shoichet | molly.shoichet@utoronto.ca

Polymeric drug delivery and tissue engineering for traumatic injury to the central nervous system or cancer. Focus on stem cell guidance within defined 3-D matrices; injectable hydrogels for cell and biomolecule delivery; polymeric nanoparticles for targeted delivery.

Honghi N. Tran | honghi.tran@utoronto.ca

Energy and chemical recovery efficiencies in the kraft pulping process; control of deposit formation and high temperature corrosion in industrial boilers and rotary kilns; utilization of biosludge; thermal conversion of biomass to fuel; combustion behaviours of solid biofuel mixtures.

Alexander F. Yakunin | a.iakounine@utoronto.ca

Enzyme discovery, enzymatic screening of purified proteins and metagenomic gene libraries, biochemical and structural studies of unknown proteins and novel enzymes, CRISPR-associated nucleases, novel enzymes and biosynthetic pathways for applications in biocatalysis and CO_2 fixation.

Ning Yan | ning.yan@utoronto.ca

Lignocellulosic biomaterials science and engineering; synthesis, modifications, and applications of bio-based polymers, resins, polyols, adhesives, foams, composites and coatings; bio-based advanced functional materials, sensors, and devices; forest and agriculture residue utilization and conversion to value-added products; nanocellulose, lignin, and wood extractives valorization to green chemicals and functional materials.

Christopher Yip | christopher.yip@utoronto.ca

Molecular self-assembly: Protein-ligand and biomolecular complexes and elucidation of the mechanisms associated with their formation. Molecular and biomolecular crystals and their properties. Biomolecular and ligand-receptor interaction forces. Application of scanning probe microscopy to the characterization of biomolecular processes and structures. Novel protein complexes at interfaces. Molecular modeling of biomolecular complexes. Synthesis and characterization of molecular solids. Structure-property relationships in supramolecular assemblies. Advanced imaging including combinatorial super-resolution microscopies and spectroscopies.

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