



CBB

FIRST EDITION | 2016

IMPACT REPORT

THE CENTRE FOR BIOENGINEERING AND BIOTECHNOLOGY

Positioned at the cross-roads of physics, chemistry, biology, engineering and medicine, biotechnology and bioengineering hold dramatic promise for improving quality of human health, environment, and bio-industries.



UNIVERSITY OF
WATERLOO



welcome to the future

The Centre for Bioengineering and Biotechnology (CBB) provides interdisciplinary leadership in the fields of biotechnology and biomedical engineering.

CBB brings together faculty members from all faculties on campus who have an interest in exploring how human health can be improved through technology. The common thread among our researchers is a passion for understanding how synergy of life science and engineering can improve our lives and society.

CBB is deliberately broad in its scope and in its mandate. CBB's founding philosophy was grounded on a recognition that solutions to the toughest problems involve the most innovative people and integration of a wide variety of perspectives. One way to think out of the box is to have people who look at boxes in really different ways. For this reason, CBB encourages and actively supports networking and academic events that will continually broaden our outlook and perspectives.

Partnerships are essential to the CBB mission and we take our national and international partnerships very seriously. We work to establish strong relationships with companies but also with healthcare industries, government at all levels and other institutions. CBB strongly encourages student engagement,

and encourages students to become members of CBB. CBB also pursues strategic partnerships with international partners who can complement our work.

CBB hosts focus days with companies, networking events, academic seminars, research translation workshops and student events. We support researchers in grant applications and seek out new opportunities for our members. Further, CBB's rich network enables us to connect our members with the right people internally and externally.

The next decade promises to be a revolutionary time for health technology. New sensor technologies are enabling wearable technologies and the collection of information that was not available before. With this new information, customized treatments and preventions, personalized healthcare is becoming possible and affordable. Just as the Internet revolutionized how we work and communicate, new biotechnologies and biomedical devices have the potential to dramatically change how we live.

– **CATHERINE BURNS**, PhD, Director, Centre for Bioengineering and Biotechnology



“the next decade promises
to be a revolutionary time
for health technology.”

vision and mission

“With a focus on industry partnerships and cross-disciplinary research excellence, the Centre for Bioengineering and Biotechnology (CBB) embodies and advances Waterloo’s research strategy of changing lives and the world we live in through high-impact, highly-relevant transformational research. A deep and varied expertise at the CBB will further bioengineering and biotechnology, set standards for research partnerships at Waterloo, and improve quality of life and human health around the world.”

– **D. GEORGE DIXON**, PhD, Vice-President, University Research, University of Waterloo

VISION AND MISSION

CBB's vision is to be a world leader in bioengineering and biotechnology. Its mission is to facilitate strategic multidisciplinary and transdisciplinary research that applies technology to life sciences, human health, the environment and industrial challenges. It is collaborative in its approach to building strong local, national and international partnerships with industry, healthcare organizations, other academic institutions and government.

1. **Pursue** leading edge research
2. **Create** effective multi-disciplinary partnerships
3. **Strengthen** the University of Waterloo's reputation for its innovations in biotechnology and bioengineering



"The Waterloo-Toronto corridor is fast becoming a robust hub for technology startups and over the past four years, CBB has played an influential role in fast-tracking university innovations in bioengineering and biotechnology towards key industry players."

– **KARIM S. KARIM**, Associate Director
Faculty of Engineering
Center for Bioengineering and Biotechnology



"CBB is responsive to the needs of its members. It fosters the formation of interdisciplinary teams, and has fast become an integral part of the Waterloo innovation ecosystem."

– **TREVOR C. CHARLES**, Associate Director
Faculty of Science
Center for Bioengineering and Biotechnology

facts and figures

CBB is growing fast. Established in 2011, it is already one of the largest research centres in membership at Waterloo. It has attracted some of Waterloo's most recognized and highly respected researchers across the campus.



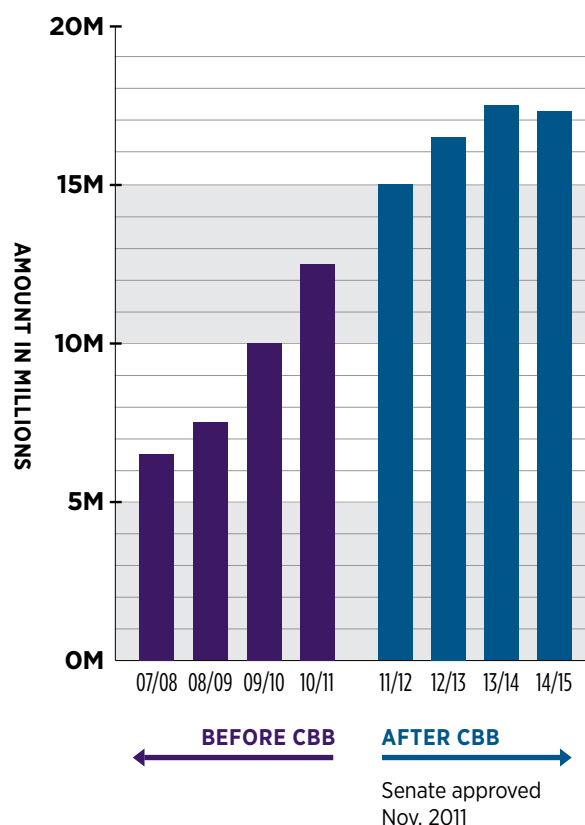
THE FIRST 4 YEARS ...

- » 71% increase in faculty membership base
- » 17 seminars and lectures
- » 5 distinguished lectures
- » 2 academic-industry networking forums
- » 2 conferences
- » 3 workshops
- » 2 international research partnership collaborations
- » 106+ networking activities/events

CBB's influence on grants received within the biotechnology/bioengineering/biomedical areas:

- » 9% influence across 4 faculties
- » 16% influence in Science and Engineering faculties

OVERALL FUNDING FOR ALL FACULTIES



“CBB connects me to the research that facilitates innovations.”

– JASON DOWD, PhD, Director, Product Development, Biopharmaceutical Division, Apotex Inc.

research impact

CBB has a substantial and significant faculty and student membership spanning across multiple Faculties to address major research challenges.

“CBB is on the forefront of cross-cutting research in areas of major international strategic importance.

This research will impact the Canadian economy with the generation of valuable IPs, patents and HQP trainees for the growing interconnections of human wellness and the health ecosystem.”

– **MURRAY MOO-YOUNG**, PhD, PEng, FAIMBE, FRSC,
Distinguished Professor Emeritus, University of Waterloo

priority areas (2)

BIOMATERIALS AND BIOMANUFACTURING INNOVATIONS

- » Biopharmaceutical and high-value bioproducts
- » Biomass and environmental bioremediation
- » Bionano-derivatives for functional materials

BIOMEDICAL SYSTEMS AND DEVICE TECHNOLOGIES

- » Biomedical imaging and biosensor technologies
- » High-throughput systems and microfluidics
- » Mobile health and health informatics
- » Electromagnetic and photonic treatment technologies

multidisciplinary research groups (6)

BIOMEDICAL ENGINEERING

75 CBB faculty members

- » systems and applications
- » drug delivery systems
- » diagnostic and lab-on-a-chip devices
- » genetic engineering
- » protein engineering
- » biomechanics, mechatronics, assistive devices
- » optics, spectroscopy, microscopy
- » microfluidics and nanofluidics

BIOPROCESSING AND FOOD TECHNOLOGY

16 CBB faculty members

- » pathogen detection
- » disinfection and sterilization technologies
- » food production and processing
- » food safety
- » packaging
- » baking process
- » separation and filtration bioprocessing
- » protein and pharmaceutical products
- » waste utilization
- » fermentation technology

ENVIRONMENTAL TECHNOLOGY

40 CBB faculty members

- » environmental monitoring
- » bioremediation
- » water and wastewater treatment
- » filtration processes
- » air pollution control
- » biofuels

HEALTHCARE SYSTEMS

30 CBB faculty members

- » drug delivery systems
- » health informatics management
- » analytics
- » workflow systems
- » clinical diagnostic systems
- » interface design

IMAGING

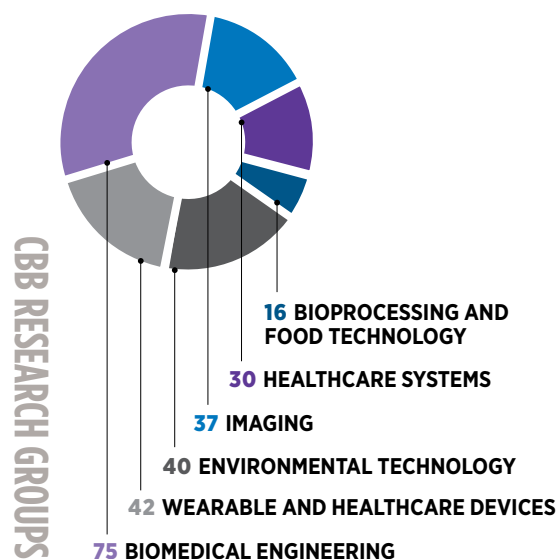
37 CBB faculty members

- » biomedical and scientific image classification, analysis, and processing
- » large area digital medical imaging
- » diagnostics (skin cancer imaging, diabetes, Alzheimer's, glaucoma, blindness and retinal diseases)
- » ophthalmic instrumentation, sensors, technologies, and hardware design (MRI, CT, ultrasound)
- » 3D imaging sensors and measurements

WEARABLE AND HEALTHCARE DEVICES

42 CBB faculty members

- » wearable sensors (fitness, continuous health monitoring, fall prevention, Alzheimer's)
- » diagnostics (skin cancer, infection testing, drinking water, lab-on-a-chip)
- » monitoring (corneal and coronary, heart rhythm, sleep)
- » smart technology for medical implants
- » human-robot interaction
- » assistive devices





scientific outreach

“CBB is an excellent research centre that ties together Waterloo’s diverse strengths in biotechnology and offers a great platform for building collaborations.”

– BRIAN FOODY, MME, President and CEO, Iogen Corporation

special events

DISTINGUISHED LECTURES (5)

Visionary and Innovation Lectures:

- » “The Next 3 Billion” Suneet Singh Tuli, BAsC, CEO, Datawind Inc., November 11, 2014
- » “Tackling Grand Challenges in Global Health and Development” Peter Singer, PhD, CEO, Grand Challenges Canada, October 5, 2015
- » “Accelerating Academic Research into Commercial Impact” Charles L. Cooney, PhD, Professor, Chemical Engineering and Faculty Director Emeritus, Deshpande Center for Technological Innovation, MIT, November 6, 2015
- » “A Wide-Angle View of Vaccine R&D and Manufacturing” Donald F. Gerson, PhD, Co-Founder and CEO, PnuVax Inc., March 27, 2015
- » “Biosensors and nanomaterials: a scientist’s journey from fundamental science to creating value to society” Cynthia Goh, PhD, Director, Impact Centre and Professor, Department of Chemistry, University of Toronto, September 30, 2015

ACADEMIC — INDUSTRY NETWORKING FORUMS (2)

- » “Devices and Sensors Academic Industry Forum”, University of Waterloo — Ontario Centres of Excellence, June 18, 2014
- » “Biomaterial & Biomanufacturing Academic Industry Forum”, University of Waterloo — Ontario Centres of Excellence, January 19, 2016

CBB WORKSHOPS (3)

- » “CIHR Info Session on open program changes and grant writing tips” Leslie Copp, University of Waterloo, January 8, 2014
- » “CBB Workshop: How to Start a Spinoff Company: Some Key Steps and Who Can Help” Benton Leong, Investor; Member, Selection Committee, Golden Triangle Angelnet, December 11, 2015
- » “Mitacs Programs and Funding Opportunities” Shaylene Nancekivell, Business Development Specialist, Waterloo Mitacs, April 7, 2016

CONFERENCES (2)

- » Biophysical Society of Canada Conference, University of Waterloo, June 17-19, 2015
- » Waterloo Region MED TECH 2016 Conference, Grand River Hospital Freeport Campus, May 25, 2016

GUEST LECTURES/SEMINARS (17)

National Biotechnology Week Celebration Events (4)

- » “Ontario Life Sciences Sector — Challenges and Opportunities” Jason Field, PhD, Executive Director, Life Sciences Ontario, September 19-20, 2013
- » “Biofuels and Waste Treatment” and “Biotechnology: Innovations in Imaging” Panel Discussion and Presentations, September 29-October 1, 2014
- » “Fermentology: Innocente Brewery. From Academic to Fermentologist” Steve Innocente, PhD, Head Brewer and Owner, Innocente Brewing Company, November 6, 2015
- » “CBB Panel Discussion: Engaging Hospitals in Research Projects” June 17, 2016

Biomedical Discussion Group Lectures (13)

- » “Translational studies of sodium nitrite supplementation to reverse arterial aging” and “Healthy ways to delay vascular aging” Douglas R. Seals, PhD, Department of Integrative Physiology, University of Colorado, September 11, 2013
- » “Bio-MEMS Seminar: “High-Throughput Analysis of Protein-Protein Interactions Using Droplet-based Microfluidics” Soo-Ik Chang, PhD, Professor of Biochemistry, Chungbuk National, October 24, 2013
- » “Seeing cells in the living eye: Pushing the limits of high-resolution retinal imaging” Jennifer Hunter, PhD, Assistant Professor, Departments of Ophthalmology, Biomedical Engineering, and Center for Visual Science, University of Rochester,” October 24, 2013
- » “Heart Wall Myofibers are Arranged in Minimal Surfaces” Kaleem Siddiqi, PhD, Professor and William Dawson Scholar, School of Computer Science, McGill University, October 25, 2013
- » “FDA’s role in regulating medical devices: premarket and scientific research programs” Yuan Fang, PhD, Regulatory Scientist, U.S. Food and Drug Administration (FDA), September 10, 2014

- » “Imaging Lipids in the Vulnerable Brain” Shawn Whitehead, PhD, Assistant Professor, Depts. Anatomy and Cell Biology; Clinical Neurological Sciences, Western University, November 27, 2014
- » “Exercise Training in Adverse Cardiac Remodeling” Dirk J. Duncker, PhD, Professor of Experimental Cardiology, Erasmus University, The Netherlands, April 2, 2015
- » “Persuasive Health Technology to Improve Health and Wellbeing” Olga Kulyk, PhD, Assistant Professor, Persuasive Health Technology Lab, Center for eHealth, University of Twente, Enschede, The Netherlands, May 27, 2015
- » “Zebra Mussel-inspired Electrically Conductive Polymer Nanofiber” Boxin Zhao, PhD, and Wei Zhang, Department of Chemical Engineering, University of Waterloo, June 11, 2015
- » “Mussel Power: Defining the Essentials for Translation to Technology” J. Herbert Waite, PhD, Professor of Biochemistry, Departments of Molecular Cell and Developmental Biology and Chemistry & Biochemistry, University of California, Santa Barbara (UCSB), August 13, 2015
- » “A tissue mechanist found in translation” Thomas Willett, PhD, Assistant Professor, Systems Design Engineering, University of Waterloo, November 19, 2015
- » “Ultrasound imaging innovations for live monitoring of complex flow dynamics” Alfred Yu, PhD, Associate Professor, Electrical and Computer Engineering, University of Waterloo, October 29, 2015
- » “Nanostructured based Lab-on-chips for optical and electrical detection” Sara Mahshid, Postdoc, Leslie Dan Faculty of Pharmacy, University of Toronto, April 14, 2016

STUDENT GROUPS (3)

CBB provides in-kind and seed funding support to student groups on campus for their operations and outreach activities.

- » Engineers in Medicine
- » uwdNA
- » International Genetically Engineered Machine (iGEM)

“IFPT and CBB have many common interests and have effectively collaborated in the development of research projects for the food industry. We value the support received from CBB and look forward to strengthening our collaboration as we work together on developing and implementing new technologies for the industry.”

– **LUIS GARCIA**, MSc, Chair, Institute of Food Processing Technology and Trades and Apprenticeship (Millwright), Conestoga College

research chairs and awards

“Our company came to the CBB looking for new medical imaging ideas and has partnered with researchers to commercialize new technologies for the x-ray imaging field. We believe the CBB creates a valuable ecosystem in which industry and academic researchers can collaborate to bring new ideas to market and we look forward to the continued collaboration programs.”

– **GEORGE PINHO**, PhD, MBA, President, Christie Medical Holdings, Inc.

prestigious awards and recognition

CANADA RESEARCH CHAIRS (9)

» **CLARK DICKERSON, PhD, Kinesiology;**

Shoulder Mechanics

Understanding the mechanics of the human shoulder. His research will improve our understanding of the fundamental causes of shoulder damage and prompt changes to our workplaces and daily lives that will protect shoulders and improve the lives of Canadians.

» **BRIAN DIXON, PhD, Biology; Fish and Environmental Immunology**

Understanding fish immunology and applying it to environmental problems such as climate change. His research will lead to increased knowledge and policies to preserve fisheries, threatened cold water species and aquaculture stocks.

» **FRANK GU, PhD, Chemical Engineering; Advanced Targeted Delivery Systems**

Reducing eye injections by using nanoparticles. His research will lead to new ways to treat eye diseases.

» **MING LI, PhD, Computer Science; Bioinformatics**

Predicting protein structures. This research will make genome mapping, homology searches and determining protein structures more efficient by developing tools in bioinformatics.

» **JOHN MCPHEE, PhD, Systems Design Engineering; Biomechatronic System Dynamics**

System Dynamics: From Cars to Humans. His research will result in innovative mechatronic and biomechanical systems that will improve the performance of elderly, athletes and persons with disabilities.

» **CAROLYN REN, PhD, Mechanical and Mechatronics Engineering; Lab-on-a-Chip Technology**

A laboratory in the palm of your hand. This research will lead to hand-held devices for point-of-care diagnosis; reducing the costs with health care and environmental protection.

» **ALEXANDER WONG, PhD, Systems Design Engineering; Medical Imaging Systems**

Imaging technologies to detect cancer. His research will lead to the development of new medical imaging and analysis technologies for early detection of cancer.

» **JOHN YEOW, PhD, Systems Design Engineering; Micro and Nanodevices**

Treating diseases with micro and nanotechnologies. This research will lead to development of new medical instruments and devices for early diagnosis and therapy of diseases.

» **JUSTIN WAN, PhD, Cheriton School of Computer Science; Scientific Computing**

Visualizing the Ailing Brain and Body. His research is aimed at improving simulation techniques in computer-aided surgery and enhancing results in medical imaging diagnostics in order to lead to better patient outcomes and savings to the health-care systems.

NSERC INDUSTRIAL RESEARCH CHAIRS (3)

» **PETER HUCK, PhD, Civil and Environmental Engineering; Water Treatment**

Investigating the presence of known and emerging chemical and microbial contaminants in source waters; and the evolving technologies for the removal of these contaminants.

» **JOHN MCPHEE, PhD, Systems Design Engineering; Mathematics-Based Modelling and Design**

In collaboration with Maplesoft and Toyota they are investigating ways to develop math-based models and computer simulations, with a focus on automotive applications such as vehicle dynamics, powertrains and hybrid electric vehicles.

» **SAFIEDDIN SAFAVI-NAEINI, Electrical and Computer Engineering; In Intelligent Integrated Radio/Antenna Systems and Novel Electromagnetic Media Technologies**

In collaboration with BlackBerry to investigate the next generation of sensor networks, miniaturizing, human body interactions and computational designs and methodologies.

UNIVERSITY RESEARCH CHAIRS (7)

» **PU CHEN, PhD, Professor, Chemical Engineering**

» **JAMES FORREST, PhD, Professor, Physics and Astronomy**

» **LYNDON JONES, PhD, Professor; Director, Centre for Contact Lens Research, Optometry and Vision Science**

» **BILL MCILROY, PhD, Professor, Department Chair, Kinesiology**

» **MICHAEL K.C. TAM, PhD, Professor, Chemical Engineering**

» **EHSAN TOYSERKANI, PhD, Professor, Mechanical and Mechatronics Engineering**

» **NORMAN ZHOU, PhD, Professor, Mechanical and Mechatronics Engineering**

ROYAL SOCIETY OF CANADA FELLOWS (3)

FRSC is the highest accolade for a Canadian scholar.

» **MING LI, PhD, Professor, Computer Science**

» **MURRAY MOO-YOUNG, PhD, Distinguished Professor Emeritus, Chemical Engineering**

» **JOHN THOMPSON, PhD, Distinguished Professor Emeritus, Biology**

INTERNATIONAL RESEARCH PARTNERSHIPS (2)

» **University of Twente, The Netherlands, "Data Driven Persuasive Technology", 2015**

Combining CBB's strengths in health, engineering, and computer science, with University of Twente's expertise in social sciences, this will be one of the largest international teams assembled to work together in data-driven persuasive technology, with over 20 researchers involved in the collaboration. The first workshop was held at the University of Twente in June 2016 and a second workshop in November 2016 at the University of Waterloo.

» **Sorbonne Universités, France, "Trans-disciplinary Innovation in Health Engineering", 2016**

This partnership seeks to enable concrete scientific collaborations, academic exchanges and innovation actions between the two partners in the area of Innovative Health Engineering Technologies. The first workshop with over 25 researchers participating was held at the University of Waterloo in May 2016 with a second workshop in October 2016 at the Sorbonne Universités.

boards, committees and staff

“GE Healthcare Life Science is a strong supporter of CBB. As an Industry Advisory Board member, I’ve seen first-hand the high quality of innovations emerging from this multidisciplinary approach. I’ve seen how CBB innovators are gearing their research to solve current issues and bottlenecks in my industry. This is exactly the type of approach we need in universities.”

– **FIONA FITZGERALD**, BSc (Hons),
National Zone Leader, Life Science, GE Healthcare Canada

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- » **Andriy Lomako**, Director of Business Development, Teledyne DALSA
- » **Tyler Whale**, PhD, President, Ontario Agri-Food Technologies
- » **Aldo Badano**, PhD, Acting Deputy Director, FDA (past member)
- » **George Pinho**, PhD, MBA, President, Christie Medical Holdings, Inc. (past member)

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- » **Gary Higgs**, MSc, Integrated CIO, Grand River Hospital/ St. Mary's Hospital
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- » **Chekema Prince**, PhD, Project Manager
- » **Krystina Bednarowski**, Administrative Assistant

“The Centre for Bioengineering and Biotechnology has created a great forum for interaction between academic scientists and industry. CBB provides a significant benefit to the Canadian biotechnology industry by supporting research, contributing to the development of scientific talent, and enhancing the reputation of Canada in the international biotechnology arena.”

– **TONY D'AMORE**, PhD, MBA, VP, Product R&D — Global, Sanofi Pasteur

CBB members

“CBB is on the leading edge of research and innovation that cut across traditional disciplines. With its focus on multidisciplinary research, CBB is building a strong, strategic, international footprint in the globally important areas of bioengineering and biotechnology.”

– **JOHN THOMPSON**, PhD, FRSC, Associate Vice-President, University Research, University of Waterloo

150 UWATERLOO FACULTY MEMBERS

- » **Eihab Abdel-Rahman**, Systems Design Engineering
- » **Stacey Acker**, Kinesiology
- » **Adil Al-Mayah**, Civil and Environmental Engineering
- » **Bill Anderson**, Chemical Engineering
- » **Jose (Frank) Arocha**, School of Public Health & Health Systems
- » **Marc Aucoin**, Chemical Engineering
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- » **Mike Beazely**, School of Pharmacy
- » **Philip Beesley**, Architecture
- » **Kostadinka Bizheva**, Physics and Astronomy
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- » **Niels Bols**, Biology
- » **Slim Boumaiza**, Electrical and Computer Engineering
- » **Wayne Brodland**, Civil and Environmental Engineering
- » **Hector Budman**, Chemical Engineering
- » **Catherine Burns**, Systems Design Engineering
- » **Melanie Campbell**, Physics and Astronomy
- » **Shi Cao**, Systems Design Engineering
- » **Naveen Chandrashekar**, Mechanical and Mechatronics Engineering
- » **Trevor Charles**, Biology
- » **Helen Chen**, School of Public Health & Health Systems
- » **Jeff Chen**, Physics and Astronomy
- » **Pu Chen**, Chemical Engineering
- » **Perry Chou**, Chemical Engineering
- » **David Clausi**, Systems Design Engineering
- » **Donald Cowan**, Cheriton School of Computer Science
- » **Eric Croiset**, Chemical Engineering
- » **Bo Cui**, Electrical and Computer Engineering
- » **Mohamed Oussama Damen**, Electrical and Computer Engineering
- » **Clark Dickerson**, Kinesiology
- » **Brian Dixon**, Biology
- » **George Dixon**, Biology

- » **Andrew Doxey**, Biology
- » **Bernard Duncker**, Biology
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- » **Behrad Khamesee**, Mechanical and Mechatronics Engineering
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- » **Brendan McConkey**, Biology
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- » **Kumaraswamy Ponnambalam**, Systems Design Engineering
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- » **Omar Ramahi**, Electrical and Computer Engineering
- » **Bruce Reed**, Biology
- » **Carolyn Ren**, Mechanical and Mechatronics Engineering

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- » **Armaghan Salehian**, Mechanical and Mechatronics Engineering
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- » **Neil Thomson**, Civil and Environmental Engineering
- » **John Thompson**, Biology
- » **Hamid Tizhoosh**, Systems Design Engineering
- » **Ehsan Toyserkani**, Mechanical and Mechatronics Engineering
- » **James Tung**, Mechanical and Mechatronics Engineering
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- » **Thomas Willett**, Systems Design Engineering
- » **Alex Wong**, Systems Design Engineering
- » **Andrew K.C. Wong**, Systems Design Engineering
- » **John Yeow**, Systems Design Engineering
- » **David Yevick**, Physics and Astronomy
- » **Alfred Yu**, Electrical and Computer Engineering
- » **Boxin Zhao**, Chemical Engineering
- » **Norman Zhou**, Mechanical and Mechatronics Engineering





pathway to innovation

“Biotechnology and medical devices is the third largest industrial category in the region, and one of the fastest growing. Researchers at the Centre for Bioengineering and Biotechnology are exploring advances in pharmaceutical delivery systems, biofuels, and new biomaterials. One of the strengths of the Waterloo area is its high volume of patents, rivaling California and Massachusetts in number.

CBB fosters innovative thinking among its members by supporting a culture of partnership and collaboration. One of the mandates behind the Centre is to break through traditional academic silos by encouraging interaction between researchers in different departments, in different disciplines, and with different perspectives.

CBB hosts regular networking sessions, inspirational speakers, and small informal group interactions to encourage creative thinking and mentoring. This concept of CBB as a large extended family pays dividends in enhanced research productivity.”

– **CATHERINE BURNS**, PhD, Director, Centre for Bioengineering and Biotechnology
Ref: “Pathway to Innovation,” *Industrial Biotechnology* 9 (5), 258-259 (2013).



**CENTRE FOR BIOENGINEERING AND BIOTECHNOLOGY (CBB)
UNIVERSITY OF WATERLOO**

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