UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report on

BioZone

Centre for Applied Bioscience and Bioengineering

Summer 2013

Report on BioZone
July 2013

An electronic copy of this report is available through www.biozone.utoronto.ca.

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Director's Message

Elizabeth Edwards
Professor and Director

Welcome to BioZone, a Centre for Applied Bioscience and Bioengineering at the University of Toronto.

With the bulk of major construction, laboratory moves, and equipment purchases and installations behind us, BioZone is now fully operational. It is exciting to see so many faces busily coming and going and greeting you in the hall. I am so gratified to see everyone working together to make the little day-to-day events meaningful, to lend a helping hand, contribute to equipment maintenance and method development, and share in varied discussions to imagine a better way – in research and in life.

There have been many achievements over the past year or so, big and small. Of note is the vast array of equipment that we now command, from microbalances to large bioreactors, from elaborate mass spectrometers to workhorse centrifuges, from cold rooms to calorimeters. To steal a phrase from the latest Dan Brown novel *Inferno*: "Cerca Trova — Seek and you will find". We are not limited by equipment, but only by our ideas and imagination. Do not be shy to seek out help and advice and explore the equipment and resources at your disposition.

Equipment only facilitates implementation of ideas. It is clear that ideas are proliferating, and hard work is being rewarded with new funding and initiatives, bringing fresh talent to BioZone. Last year we also welcomed many visitors from outside Toronto to BioZone, some to observe, others to carry out research. Visitors came from the Netherlands, Saudi Arabia, France, China and Guadeloupe, among others, and we sent students to Finland, Germany and the United States Exchanges are a very helpful way to leverage knowledge effectively, and we are actively expanding such opportunities in Brazil and Europe.

Whether a permanent resident of BioZone or a visitor, I urge you to soak up all that you can while you are here, explore your surroundings, learn about the equipment, approaches and people around you and contribute your passion.

Elizabeth A. Edwards

Elizabeth Edwards, Director

Vision & Mission

BioZone's vision is to be a multidisciplinary and internationally recognized centre for bioengineering research, technology transfer, outreach and training focused on urgent societal needs in sustainable energy, the environment and human health.

A particular strength will be our ability to effectively translate the most appropriate and up-to-date molecular and cellular discoveries and tools into industrial practice.

BioZone's mission is to:

- attract the best and brightest minds from a diverse range of fields, including chemical and process engineering, microbiology, genomics, biochemistry, medicine, computer science, economics and public policy
- create a focal point for collaborative applied and environmental bioengineering research leading to the development of innovative new technologies that address urgent challenges and foster the long-term sustainability of our planet and its inhabitants
- provide state-of-the-art facilities and exciting opportunities for research
- provide students with the knowledge and ability to debate public policies and influence political decisions that affect the environment and health, based on sound scientific principles
- foster innovation, creativity, and imagination
- encourage leadership and excellence, humility and collegiality
- have a lasting and positive impact on our environment and society
- have fun

Executive Summary

BioZone's second official year as an Extra-Departmental Unit and research centre in the University of Toronto's Faculty of Applied Science and Engineering was marked by several important milestones that have expanded our capabilities and strengthened our ties with collaborators around the world. We are proud to report these exciting developments in this report describing achievements during the period of September 2011 to August 2012.

Summer 2012 marked the **completion of BioZone's extensive Phase II and III renovation and expansion**, which created 974 m^2 of new facilities, bringing our total contiguous, collaborative space in the Wallberg Building to 1,836 m^2. The facilities were designed to encourage cross-disciplinary collaboration and the easy exchange of ideas through shared lab spaces and facilities dedicated to specific areas of inquiry.

The expanded space has allowed Professor Savchenko and Professor Yakunin to move their world-renowned enzymology and proteomics research groups into the Wallberg Building, bringing with them expertise that is relevant to the work done by many of their colleagues in BioZone.

In addition, we are very excited that the newly created space includes a **new mass spectrometry facility**, managed by Dr. Andrei Starostine. This facility provides key analytical capabilities for the quantitative analysis of enzyme biocatalysts and cell metabolites, a common requirement in bioengineering applications from medicine, health and food to bioproducts, environment and energy.

During the 2011 - 2012 year, our nine core professors continued their history of successful grant applications in support of their innovative research. A number of grants received are furthering our goal of creating **strong international collaborations and exchanges** by providing support for the establishment of new relationships with collaborators in the bioremediation sector in Brazil and the forestry sector in Scandinavia.

In our second year, BioZone received over $4.7M in cash funding, as well as valuable generous in-kind contributions from our many collaborators. Over 27% of the cash funding came from outside of Canada. Significant funding was obtained from organizations uncommon to engineering programs, such as Genome Canada.

During the 2011 - 2012 year, **BioZone was home to 84 students** at all levels. Sixteen graduate students convocated, three postdoctoral fellows completed their terms and forty-two peer-reviewed papers were published. Our partners in industry, government and at other institutions near and far provided tremendous support, and helped transition our work to practice. BioZone hosted 7 external speakers as well as groups of visiting scholars and students from the Netherlands, China and Saudi Arabia.

Now that the most recent expansion of our facilities is complete, we look forward to exciting research in the coming year as we continue to tackle challenging real-world problems and pursue research excellence of the highest calibre.

Executive Committee Report

BioZone continues to achieve research excellence through a culture of collaboration and sharing. The Centre's ability to provide an outstanding learning and research environment for technological innovation in energy, environment and health is reflected in our researchers' many prestigious grants and projects. Although it is still a young centre, BioZone is becoming known nationally and internationally for its high calibre of research and the breadth of opportunities enjoyed by its team members. This report, assembled by BioZone's Executive Committee (see the *"Leadership"* section, pg. 8), highlights our achievements during the September 2011 - August 2012 reporting period, unless otherwise indicated.

Research Funding

BioZone researchers worked on 27 funded research projects in 2011-2012, many of which involved collaborations between multiple research groups, domestic and international. Fig. 1 shows the total research cash funding to the core BioZone principal investigators (PIs) since BioZone's inception.

In 2010-2011, the majority of funding for the multi-year BEEM, Centre for Structural Genomics and Infectious Diseases, and BioZone Phase II projects was released. A significant portion of these funds has been carried forward to 2011-2012 and beyond to maintain BioZone's high research productivity. Total project values for major research initiatives are often significantly higher than the cash awards as they include leveraged contributions from other institutions and private sector partners. Major awards held in 2011-2012 resulting in over $700K cash to U of T during this interval included:

BEEM: Bioproducts and Enzymes from Environmental Metagenomes (Edwards, Mahadevan, Master, Savchenko, Saville, Yakunin and 9 collaborators)

Contributions:

Genome Canada (2009-2013): $5M

Ontario Ministry of Research and Innovation: $3.3M

EU-funded MAMBA project, Geosyntec Consultants, Tembec Inc., US DoD, and others: $3.4M

Midwest Center for Structural Genomics, also known as Protein Structure Initiative III (Savchenko and international collaborators)

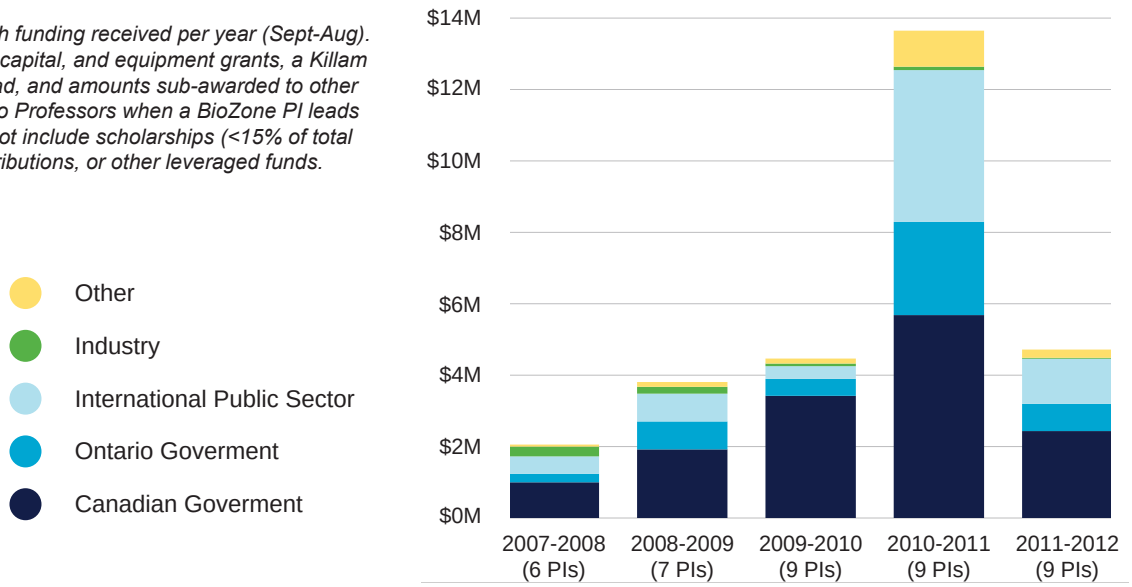
Contributions:

Argonne National Laboratory (2012): $708K

A new large project led by Professor Master in collaboration with Professors Saville, Savchenko, Yakunin, and 7 researchers at other institutions began recently. *Forest FAB: Applied Genomics for Functionalized Fibre and Biochemicals* will bring $2.1M in cash from the Ontario government via an ORF-RE award and an additional $4.2M in cash and in-kind contributions from institutional and private sector partners. Professor Master's FiDiPro Fellowship, valued at over $1M over 4 years, is also ongoing until December 2014.

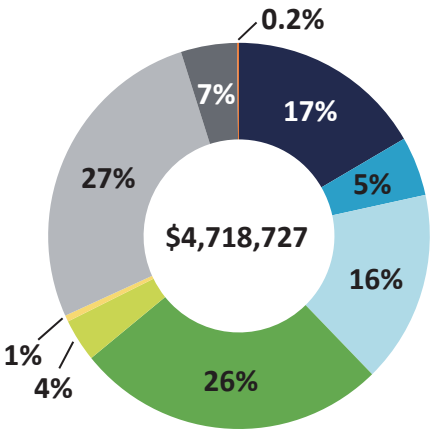
Cash funding for BioZone research in 2011-2012 came from a mix of domestic and international sources (Fig. 2). International research grants provided 27% of total cash funding to BioZone in 2011-2012. Several proposals with new private sector collaborators were accepted shortly after the reporting period, thus higher industry contributions are expected in 2012-2013. BioZone gratefully acknowledges support from the wide range of public, nonprofit, and private sector partners listed on the inside back cover of this report, whose contributions have included personnel time, expertise, samples, equipment and research funding.

Fig 1. BioZone cash funding received per year (Sept-Aug). Includes operating, capital, and equipment grants, a Killam Fellowship, overhead, and amounts sub-awarded to other University of Toronto Professors when a BioZone PI leads the project. Does not include scholarships (<15% of total funds), in-kind contributions, or other leveraged funds.



	Canadian Government	Ontario Government	International Public Sector	Industry	Other	Total
2007 / 2008	$999,848	$238,144	$486,799	$275,899	$57,065	**$2,057,754**
2008 / 2009	$1,921,299	$784,218	$778,088	$190,568	$135,512	**$3,809,685**
2009 / 2010	$3,420,240	$474,808	$354,655	$75,000	$140,715	**$4,465,418**
2010 / 2011	$5,681,149	$2,611,153	$4,251,247	$93,155	$1,009,180	**$13,645,884**
2011 / 2012	$2,433,673	$760,775	$1,267,228	$25,000	$232,051	**$4,718,727**

Fig 2. Sources of cash funding to BioZone Professors between September 1, 2011 and August 31, 2012. Inclusions and exclusions are listed in the caption for Fig. 1.



Source	2011-2012 funding
NSERC	$783,858
CFI	$234,748
MEDI / MRI	$760,775
Genome Canada	$1,245,067
Other Canadian Government	$170,000
Industry	$25,000
International Public Sector	$1,267,228
Nonprofit Organizations	$224,251
Other	$7,800
Total	**$4,718,727**

State-of-the-Art Facilities

In summer 2012, we completed the second phase of extensive renovations and expansion of research facilities in the Wallberg Building begun in 2010. Named *BioZone Phase II*, this $6M project created 851 m^2 (NASM) of new or renovated space, including a 270 m^2 (NASM) rooftop addition to the building (Fig. 3). A third phase (*BioZone Phase III*) provided funding to renovate an additional 123 m^2 (NASM), bringing BioZone's facilities to a total of over 1,800 m^2 (NASM). For more detail, please see our *2012 Report on BioZone*, available through our website (www.biozone.utoronto.ca).

The new spaces allowed Professors Savchenko and Yakunin to move their world-leading protein production and characterization facilties from the Best Building into the Wallberg Building in September 2012. This has created a truly unique research environment and we are already benefitting from new synergies created by the consolidation of our space. Renovations also provided much-needed space for staff, additional researchers, and equipment benefiting all of the Professors' groups.

Fig 3. (top right) Early stage of expansion of the fourth floor of the Wallberg Building, showing rough framing for the new facilities; (right) the new Chemical & Biomolecular Lab in the newly constructed space on the fourth floor.

Fig 4. One of several new instruments in the new Mass Spectrometry Facility.

Among the new facilities is a new mass spectrometry laboratory opened in May 2012 and managed by Dr. Andrei Starostine. The lab includes a gas chromatography-mass spectrometer and two liquid chromatography-mass spectrometers for metabolomics and proteomics measurements. A fourth mass spectrometry system will be acquired within the next year. This facility is open to users within and outside of BioZone and is is already attracting users from various Departments in the Faculty of Applied Science and Engineering. For a detailed description of its capabilities, please see "Mass Spectrometry Facility" on pg. 11.

Other shared facilities created during these renovations include a high-throughput sterilization and glasswashing facility (WB19) and the Jan Walter Szymaszek videoconference room (WB407).

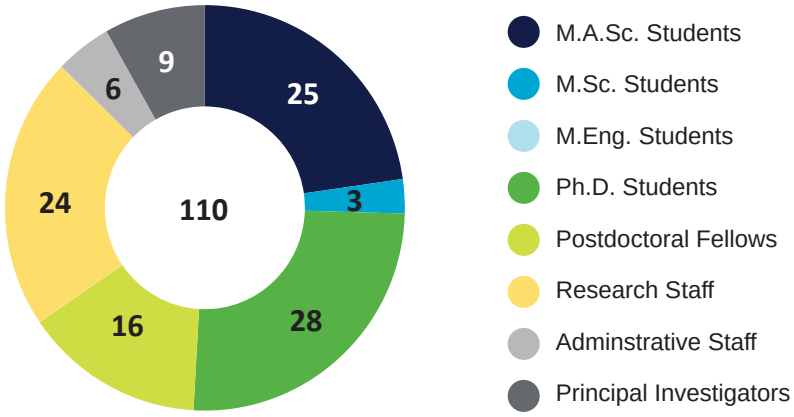


Fig 5. Headcount of BioZone personnel by category on Aug 31, 2012.

BioZone Team Members

Recruiting Top Talent

BioZone is home to a very diverse and gifted pool of students, researchers, staff and PIs from a wide range of disciplines. Since the centre's inception, we have attracted personnel and trainees from approximately 30 countries on 5 continents.

In the reporting period, BioZone was home to over 100 graduate students, postdoctoral fellows, staff and PIs (Fig. 5). In addition, 18 undergraduate students and one high school student completed summer internships in BioZone's laboratories.

To further our goal of attracting and supporting high calibre graduate students, we awarded the inaugural BioZone Graduate Scholarships in 2011. These scholarships are made possible by the generous philanthropic support from a Chemical Engineering alumnus, Tai-Wing Ng. Award criteria include academic and research excellence, financial need, and service to BioZone. Scholarships will be awarded annually, with four awarded this year.

BioZone Alumni

In 2011-2012, a total of 16 graduate degrees were awarded to students in BioZone (9 M.A.Sc., 2 M.Eng., 1 M.Sc., and 4 Ph.D.), and 10 undergraduate student theses were supervised by our PIs. In addition, 3 postdoctoral fellows completed their fellowships and 18 undergraduate students completed summer placements in our labs.

Since the inception of BioZone in 2007, a total of 62 graduate degrees have been awarded to students in BioZone, and 14 postdoctoral fellows have completed their fellowships. Alumni from BioZone have gone on to professional and academic positions in Canada and abroad. Fig. 6 shows the breakdown by sector for the 2011 - 2012 graduates.

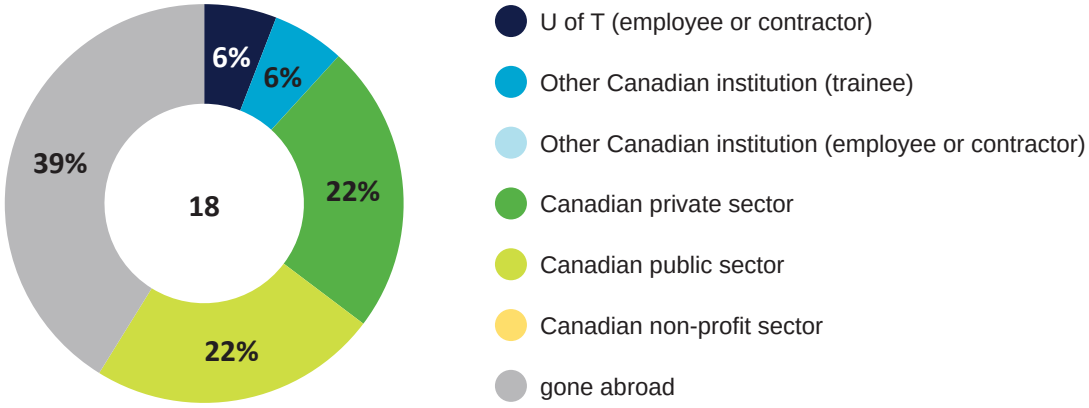


Fig 6. Breakdown of industry sectors reached by BioZone alumni, including former graduate students, postdoctoral fellows, research associates and technicians. Graph based on information for 18 BioZone members who became alumni during the Sep 2011 - Aug 2012 reporting period and whose current positions are known.

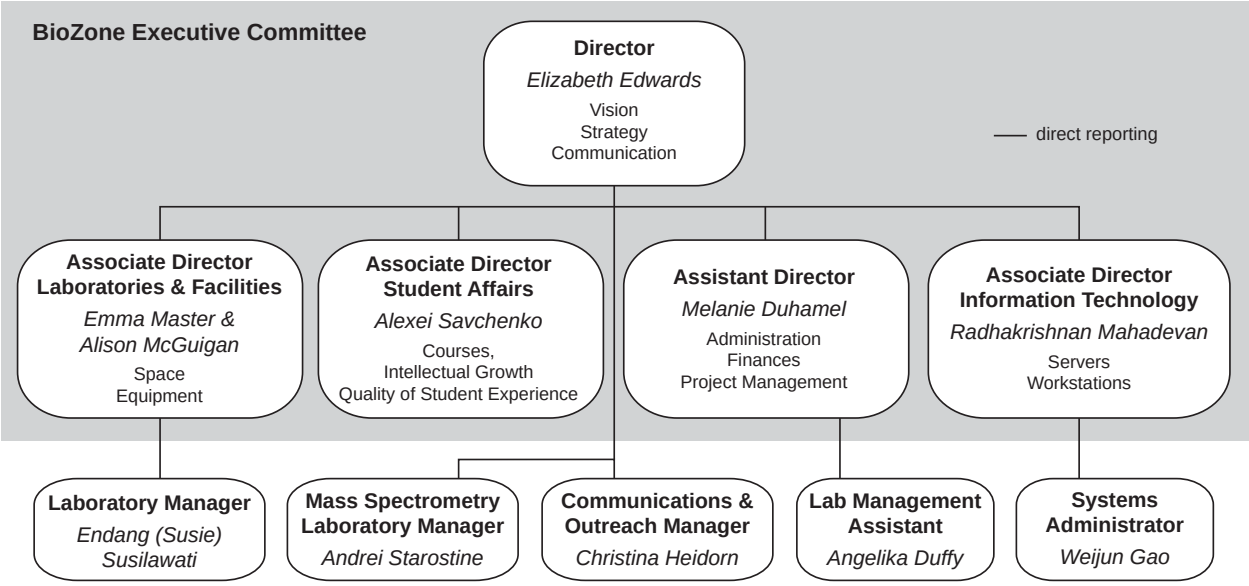


Fig 7. Overview of BioZone's leadership showing Executive Committee and Administrative and Management Staff.

Leadership

In January 2011, Professor Elizabeth Edwards was appointed as BioZone's founding Director for a term ending in June 2014. BioZone's Director is appointed by and reports to the Dean of the University of Toronto's Faculty of Applied Science and Engineering.

BioZone's strategic direction and day-to-day operations are overseen by the Centre's Executive Committee (ECOMM), consisting of the Director, three Associate Directors and the Assistant Director, each with separate portfolios (Fig. 7). Membership in the Executive Committee rotates among BioZone professors. The position of Associate Director for Laboratories and Facilities is currently shared between Professors McGuigan and Master because Professor Master's FiDiPro Fellowship requires her to spend extended periods overseas.

The ECOMM meets regularly to review new opportunities, provide an organizational framework for students and researchers, and oversee lab and computational resources. To ensure that strategic planning addresses the evolving day-to-day needs of our students and research personnel, the committee also works closely with BioZone staff, as shown in the chart. Staff hold regular meetings with student user committees to discuss current needs as they arise and bring them to the attention of the ECOMM for action.

The ECOMM also receives guidance from our Commercialization Committee on matters related to technology transfer and industry relations (see pg. 10).

The BioZone Experience

BioZone provides its members with a diverse, relevant and multidisciplinary learning experience. This is manifested through coursework, teaching, and research, as well as through a variety of events. This year, we launched an internal Wiki to facilitate communication of upcoming events and to act as a repository for orientation information, laboratory protocols, equipment lists and other relevant information.

Innovation in Education

One of BioZone's long-term goals is to streamline and focus graduate courses in the emerging areas of bioengineering and bioscience to be as relevant as possible to our students. Currently we offer courses that introduce microbial ecology and bioenergetics (JCC1313: *Environmental Microbiology* – Edwards/Master), and build on these concepts with genomics and proteomics (CHE1135: *Advances in Bioengineering* - Savchenko/Yakunin). In 2012, two additional courses, *Modeling Optimization of Chemical and Biological Networks* (CHE1125; Mahadevan) and *Liquid Biofuels* (CHE 1123; Saville) complemented existing courses.

As new equipment comes online, we will develop training targeting applications of specific techniques, such as novel uses of mass spectrometry and bioreactor design and operation. Training on the use of syringes, chromatographs, DNA extraction, PCR and specialized software are already offered on an on-demand basis. Such training has been provided to groups of 4-12 students by Line Lomheim and has attracted students from collaborators' labs outside of BioZone.

In collaboration with the Dept. of Chemical Engineering and Applied Chemistry, we are revamping the Unit Operations Laboratory in the Wallberg Building. This two-story lab forms a core part of the undergraduate teaching facilities and we have added an 80 L fermenter and clarifier to be incorporated into undergraduate and graduate courses and research activities in Fall 2013.

Pooling resources within BioZone has allowed us to hire permanent and dedicated research staff to work alongside students and postdocs, providing continuity and consistency in training. This is especially important for high precision complex equipment and allows our students to gain valuable, high-calibre training. In addition, all BioZone students rotate on a monthly basis through a lab duty roster and are responsible for the maintenance of specific instruments and training of new recruits.

We encourage the passion that researchers bring to their work by providing exposure to real-world applications of bioengineering. To that end, we make use of plant tours at our collaborators' facilities or at local plants (see *Events* section on pg. 41).

To further our students' non-technical professional development and encourage their engagement in outreach, policy and other public discourse, BioZone is creating a series of workshops on visual and public communication of science and engineering that will help them to communicate effectively with lay audiences. In spring of 2012, Communications and Outreach Manager Christina Heidorn held initial workshops on the use of Adobe Illustrator for creating attractive figures, which were attended by over 40 graduate students, postdoctoral fellows, staff and faculty. In the coming year, we will expand on this by offering workshops and short courses on distilling your message, basic elements of design and audience engagement.

International Exchanges

This year we continued to build on the many international collaborations previously established by our researchers. New opportunities are being developed through grants from FAPESP (part of a program to initiate collaboration between Ontario and São Paulo, Brazil) and FiDiPro (Finland) that support joint research projects between PIs in BioZone and abroad.

As in previous years, in the 2011 - 2012 BioZone hosted a number of international visitors:

- a visiting scholar from the University of Delaware for a 2-month stay
- visiting researchers from Glasgow University
- a visiting student from ENSIACET in France
- a postdoctoral fellow from Germany who spent two years of his Marie Curie Fellowship in BioZone developing molecular biological tools and conducting metabolomics experiments
- a postdoctoral fellow from Japan who learned techniques to characterize wood degradation by white-rot fungi
- a postdoctoral fellow from Guadeloupe who learned anaerobic microcosm preparation and helped expand BioZone's bioremediation research to banana plantations in the Caribbean
- a group of 12 PhD students and professors from Wageningen University in the Netherlands for a 1-day visit
- a delegation of professors from Tianjin University of Commerce in China
- a contingent of 16 prospective students from Saudi Arabia

During this time, BioZone sent:

- a PhD student to Finland to develop novel protein separation techniques
- a PhD student to Woods Hole Oceanographic Institution for a 2-month stay, where he was a teaching assistant for a course
- Professor Elizabeth Edwards to São Paolo as part of a grant to develop collaborations with Brazilian researchers
- Professor Emma Master to Finland for extended stays as part of her FiDiPro Fellowship

Research Accomplishments

Awards

The high calibre of work done by BioZone students and post-doctoral fellows was recognized with 35 awards in 2011-2012, including 21 scholarships:

Colin Hahnemann Bayley Fellowship in Chemical Engineering
Evald Torokvei Scholarship for Community Involvement
Frank Howard Guest Bursary for Academic Standing
Irving O. Shoichet Graduate Scholarship
Mitacs Elevate Postdoctoral Fellowship
Norman Stuart Robertson Fellowship
NSERC Canada Graduate Scholarship (4)
NSERC Postgraduate Scholarship
NSERC Vanier Canada Graduate Scholarship
Ontario Graduate Scholarship (3)
Queen Elizabeth II Graduate Scholarship in Science and Technology
William J. Dowkes Graduate Bursary

See *"Grants, Awards & Scholarships"* on pg. 39 for details.

Publications

Our team published 42 peer-reviewed articles in international journals, one of which (Facchini *et al.*) was a cover story in Trends in Biotechnology. Our students and researchers also made over 90 oral and poster presentations at over 45 mostly international conferences and institutions. For a full list of all publications and presentations, including student theses, please see the *"Publications"* section on pg. 32.

Technology Transfer

Our goal is to provide benefits to society and the environment through the development of technology that addresses important problems. To help achieve this goal, the real-world application of technologies developed in our labs is guided by a Commercialization Committee (CCOM) including external private sector, policy and academic advisors.

The CCOM meets with BioZone's leadership three times a year and helps us to strengthen ties with industry, government, and other potential end users of the knowledge, tools, and technologies developed in our labs. The CCOM also assists with identifying and acting on commercialization opportunities, as well as large-scale funding opportunities in the public and private sectors.

As of August 2012, the Commercialization Committee's members were:

- Dr. Aled Edwards, Chair, Director of the Structural Genomics Consortium
- Tom Rand, Director of MaRS Cleantech & VCi Green Funds
- Rhonda Tannenbaum, VP Business Development, Ontario Genomics Institute
- Dr. Peter Azmi, Business Development Officer, Innovations and Partnerships Office
- Prof. Bradley Saville
- Prof. Elizabeth Edwards

Between September 2011 and August 2012, BioZone researchers filed one intellectual property disclosures with the University and one full U.S. patent.

We have longstanding, strong research partnerships with several corporations (see "Collaborators" on pg. 31 of the *2012 Report on BioZone*) and are actively seeking new partners for collaborative research.

In addition, many of our alumni still maintain close ties to our research, providing another conduit for technology transfer through their careers and other endeavours.

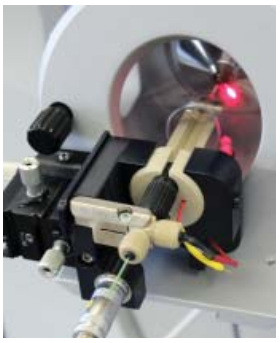
Building Momentum

Our productivity in terms of high impact publications and presentations, international collaborations continues to be high. Research is humming along, buoyed by our new facilities and equipment, which are readily accessible and fully supported with high calibre training.

Current efforts are focussed on growing relationships with existing and new collaborators at all levels, from visiting researchers to industrial partners. Inquiries are welcome from all. Please drop by for a visit any time!

Mass Spectrometry Facility

An exciting recent development in BioZone is the establishment of a state-of-the-art bioanalytical and mass spectrometry facility open to users from various disciplines within and outside of BioZone.



The Bioanalytical and Mass Spectrometry facility expands the centre's analytical capabilities for **metabolomics and proteomics measurements**, and includes HPLC, UPLC, GC, nanoLC and nanoUPLC systems equipped with UV and mass spectrum detectors.

Q-Exactive high resolution – Dionex 3000 UPLC: specialized for the separation of small molecules and metabolomics analysis. This instrument provides dedicated purification methods for different sample quantities and optimizes them for the highest recovery, purity, throughput and productivity. It is suitable for separation and quantification of small molecules and complex mixtures, and is especially good for the effective ionization of non-polar compounds. High sensitivity, resolution and accuracy ensures high-throughput analysis at lower levels of detection for peptides, organic acids, lipids, oil and wide range of polar and non-polar compounds.

LTQ-nanoLC: the benchmark linear ion trap mass spectrometer coupled with the nano-LC for reliable protein sequencing, peptide mapping, and complex protein mixture analysis. This system is useful for samples in high salt buffers. A Dynamic NanoElectrospray ion source delivers attomolar sensitivity.

Q-Exactive high resolution/LTQ – nanoUPLC: specialized for high-throughput analysis of complex proteins and peptide samples. This system provides stable, reproducible separations for protein sequencing, peptide/protein identification, phosphorylation analysis, biomarker discovery and more. It can be used for multi-dimensional separations as part of protein sequencing and affinity proteomics.

Accela UPLC-Exactive: the ultimate screening machine for confident identification and quantification of compounds in complex samples. This system delivers high resolution, accurate mass data and fast scanning capabilities.

Varian Saturn 2100D GC/MS: delivers high sensitivity and confidence for identifying drugs and small molecules in a range of samples such as toxins in water, leaves, oil, gasoline in debris, and pesticides in soil.

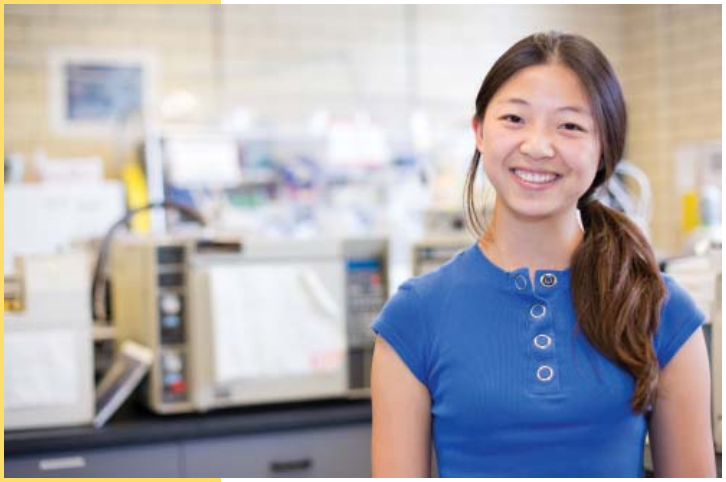
Andrei Starostine

Mass Spectrometry Laboratory Manager

Dr. Andrei Starostine specializes in protein identification, small molecule characterization and mass spectrometry of biological and organic compounds. His work focuses on applying mass spectrometry and chromatography methods, including multidimensional molecular identification, to the analysis of tissue cell components, metabolic pathways and toxic chemicals in the environment.

Dr. Starostine completed a M.Sc. in nuclear physics at the Moscow State Engineering Physics Institute at the National Research Nuclear University, and holds a Ph.D. in biophysics from the Institute of Chemical Physics of the Russian Academy of Sciences in Moscow. He has developed and patented an analytical method for the fluorescent determination of trace metal ions in the environment. As Biomolecular Lab Manager at the University of Toronto he provided analytical chemistry support and training to students and lab users. He has published over 30 papers.

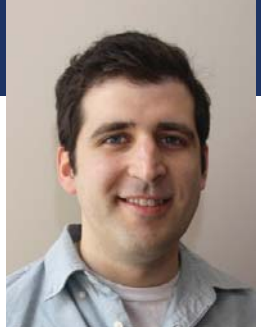
New Researchers



BioZone's strength resides in its people. The Centre is home to a talented group of over 100 highly qualified personnel and trainees who bring a wide range of expertise and experience to their work, and tackle challenging research goals in a supportive and collegial community.

The following pages include profiles of the most recent additions to the BioZone team who joined us during the reporting period.

For profiles of continuing BioZone researchers, please see our *2012 Report on BioZone*, available through our website.



Kevin Correia
M.A.Sc. Student

B.A.Sc., 2009 , University of Waterloo

Supervisor: Radhakrishnan Mahadevan

Engineering microorganisms towards lignocellulose-based biorefineries

Fossil fuels have enabled the world to experience an improved standard of living since the Industrial Revolution, but at a cost of rising CO_2 emissions threatening the world with global warming. *Saccharomyces cerevisiae*, or baker's yeast, has been important in reducing CO_2 emissions from fuels by ethanol fermentation, but further progress is needed.

1st generation ethanol technologies using sugarcane and corn have limitations, one of which is the choice of feedstock. The use of food for fuel, regardless of whether the feedstock could be used for human or animal consumption, is not without debate. Lignocellulose feedstocks, such as corn stover or wood, circumvent the food for fuel debate, but consist of many technical challenges. From a fermentation perspective, corn stover contains up to 30% xylose by weight and is not fermentable by wild-type *S. cerevisiae*. Attempts to genetically engineer *S. cerevisiae* for xylose fermentation have resulted in lower ethanol yields and undesirable xylitol production. *Scheffersomyces stipitis*, an organism that evolved digesting wood in beetle gut, is one of nature's most efficient xylose consumers. Its xylose metabolism and regulation is not well understood. **The focus of my research is to understand how *S. stipitis* is able to efficiently metabolize xylose using experimental data and mathematical computer models for metabolism.**

Another limitation in 1st generation ethanol is in the product itself. Ethanol is a weak substitute for gasoline. It sells for a lower price than gasoline, has a lower energy density than gasoline, and requires separate transportation infrastructure from gasoline. Organisms are being engineered to produce next generation biofuels, biochemical, and biopolymers. Ideally these products will have improved technical and economic performance that will allow lignocellulose-based products to compete with petroleum-based products. **The goal of my work is to engineer yeast to economically convert xylose into a value added product.**

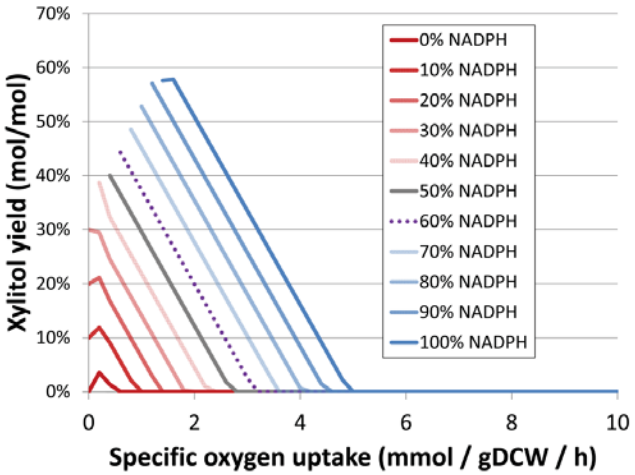


Fig. 1: Predicted xylitol production as a function of oxygen uptake in yeast.

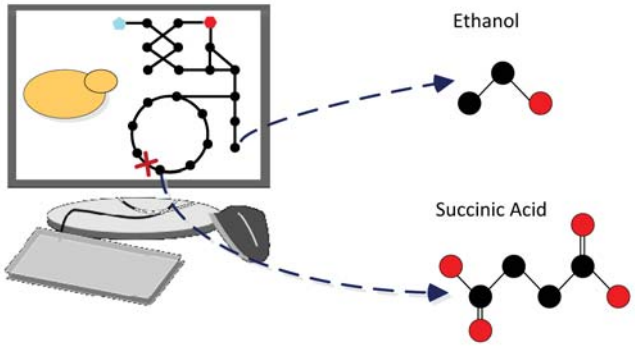


Fig. 2: Computer models can be used to identify genetic manipulations to overproduce desired biochemical.

Research Highlights

Correia, K., Mahadevan, R., Yang, L., Zhuang, K., and W.R. Cluett (2012). Model-based approaches for metabolic engineering. *SIMB Annual Meeting & Exhibition*, Washington, DC

Correia, K., Lee, H, and R. Mahadevan (2012). Model-based design for xylose metabolic strategies in *Scheffersomyces stipitis*. *NSERC Bioconversion Network*, Vancouver, BC

Veronica Dueik
Postdoctoral Fellow

Ph.D., 2011, Pontificia Universidad Católica de Chile
M.Sc., 2007, Universidad de Chile
B.A.Sc., 2005, Universidad de Chile

Supervisor: Levente Diosady

Research Highlights

Dueik, V. and P. Bouchon (2011). Development of healthy low-fat snacks: understanding the mechanisms of quality changes during atmospheric and vacuum frying. *Food Reviews International*, 27:408-432

Dueik, V. Moreno, M.C. and P. Bouchon (2012). Microstructural approach to understand oil absorption during vacuum and atmospheric frying. *Journal of Food Engineering*, 111:528-536

Food fortification and the development of novel delivery systems

One of the main research areas of the Food Engineering Group is dedicated to food fortification and the development of novel delivery systems for overcoming major micronutrient deficiencies.

Iron deficiency in the diet is the largest single source of disease in the world, affecting some 2 billion people. Food fortification, using the adequate vehicles, can lead to relatively rapid improvements in the micronutrient status of a population at a very reasonable cost. Based on this, currently I am working in the **fortification of tea leaves for overcoming iron deficiency**. Tea is a widely consumed beverage especially in India and Africa, so its consumption can be an opportunity to improve the iron status of large populations. The main challenge of this research is to create unnoticeable particles that stick to tea leaves and to avoid the interaction between tea polyphenols and iron, as it changes the colour of brewed tea and reduces the bioavailability of both compounds.

Another part of my research will be in cooperation with a major Chilean research project on the development of healthy food matrices. The final goal is to incorporate essential oils and polyphenols into formulated food matrices using microemulsions.

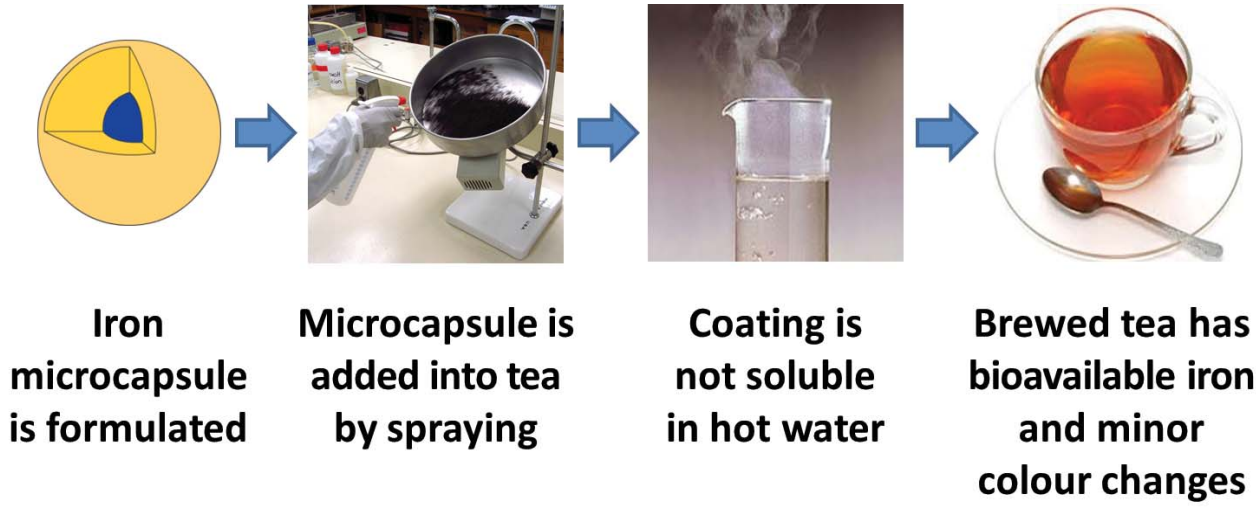


Fig. 1: Approach for overcoming the main challenges of this research (i) to attach unnoticeable iron microcapsules into tea leaves, and (ii) avoid iron-polyphenols interaction during tea brewing.ÿÿ

Adriana Gaona Gómez
Ph.D. Student

M.Sc Chemical Engineering, 2012,
Ryerson University
B.A.Sc Chemical Engineering, 2008,
Universidad del Valle

Supervisor: Bradley Saville
Co-Supervisor: Yuri Lawryshyn

Exploring the fluid behaviour in high-solids ligno-cellulosic enzymatic hydrolysis

Ethanol fuel obtained from cellulosic biomass feedstocks has the potential to reduce dependence on fossil fuel. An enzymatic hydrolysis process transforms the biomass into liquid slurry composed of five-carbon and six-carbon sugars, which is then fermented to obtain ethanol fuel. To increase the conversion of fermentable sugars, a high biomass loading in the enzymatic hydrolysis process is required. However, as the solids concentration is increased, the viscosity of the slurry increases, yielding inadequate mixing in the process. As a consequence, an **industrial scale-up of the process operating at high-solids loading is not yet economically viable**.

There has been increased interest to optimize the enzymatic hydrolysis process by studying the rheological properties of various cellulosic biomass feedstocks and conducting experiments in different bioreactor scales to analyze the slurry flow based on empirical correlations. In spite of these efforts, the rheological results are specific to the characteristics of the system studied and are difficult to implement to different systems.

This limitation can be overcome by employing computational fluid dynamics, in which the biomass slurry flow can be studied by tuning solids load, and bioreactor dimensions and parameters, such as type and number of impellers, as well as rotational speed. **I plan to develop a computational fluid dynamics model combined with experimental work to understand the biomass fluid behaviour at high-solids loadings.**

Ultimately, we expect that the results of this research will **shed light on the relationship between rheological behaviour of the lignocellulosic slurry and the reactor design parameters**, in order to promote mixing and optimize the hydrolysis process.

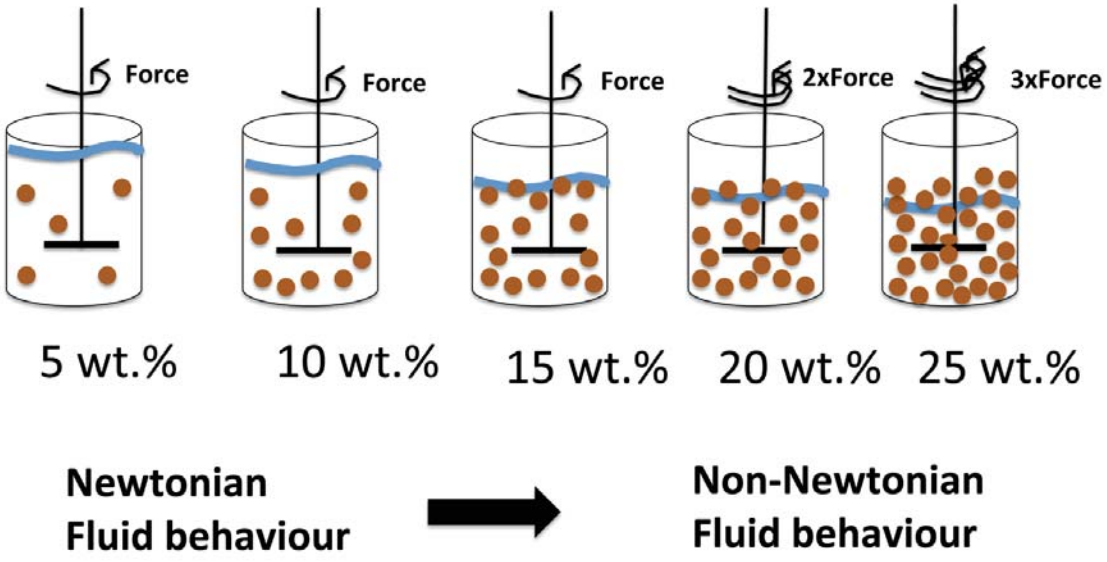


Fig. 1: Mixing Limitations Due to Solids Content

Research Highlights

Gaona Gomez, A. and Cheng, C-H. (2012). Modification of zeolite L (LTL) morphology using diols, $(OH)_2(CH_2)_{2n+2}O_n$ (n = 0, 1, and 2)". *Microporous and Mesoporous Materials*, 153: 227-235

Gaona Gomez, A., de Silveira, G., Doan, H. and Cheng, C-H. (2011). A facile method to tune zeolite L crystals with low aspect ratio. *Chemical Communications*, 47:5876-5878

Research Highlights

Cheng, W., Gerbrandt, K., Hsieh, Y., Kempthorne, H., Kim, P., and C. Tan (2012). Design of a carbonated yogurt beverage production plant in Canada. SNC Lavalin Plant Design Competition (invited speaker). *62nd Canadian Chemical Engineering Conference*, Vancouver, BC

Kelsey Gerbrandt

M.A.Sc. Student

B.A.Sc. Chemical and Biological Engineering, 2012 , University of British Columbia

Supervisor: Bradley Saville

Life cycle assessment of co-product options for cellulosic ethanol biorefineries

Global energy demand is on the rise, however as we are facing the realities of climate change there is growing pressure to reduce our carbon output. A significant portion of our carbon emissions are attributed to fossil fuels; this is a particular challenge for the transportation sector as we rely almost entirely on fuels such as gasoline to power our vehicles. My work revolves around cellulosic ethanol, a biofuel which has the potential to dramatically reduce carbon emissions compared to gasoline. Unfortunately, a lack of commercial viability has meant that there are few large scale cellulosic ethanol plants in operation. **I am working on incorporating co-product pathways, specifically xylitol, into cellulosic ethanol production.** Life cycle assessment is then used to evaluate different xylitol pathways based on various sustainability metrics such as energy use and greenhouse gas emissions. **The ultimate goal is to improve the environmental performance and commercial viability of cellulosic ethanol biorefineries to meet demand for low-carbon transportation fuels.**

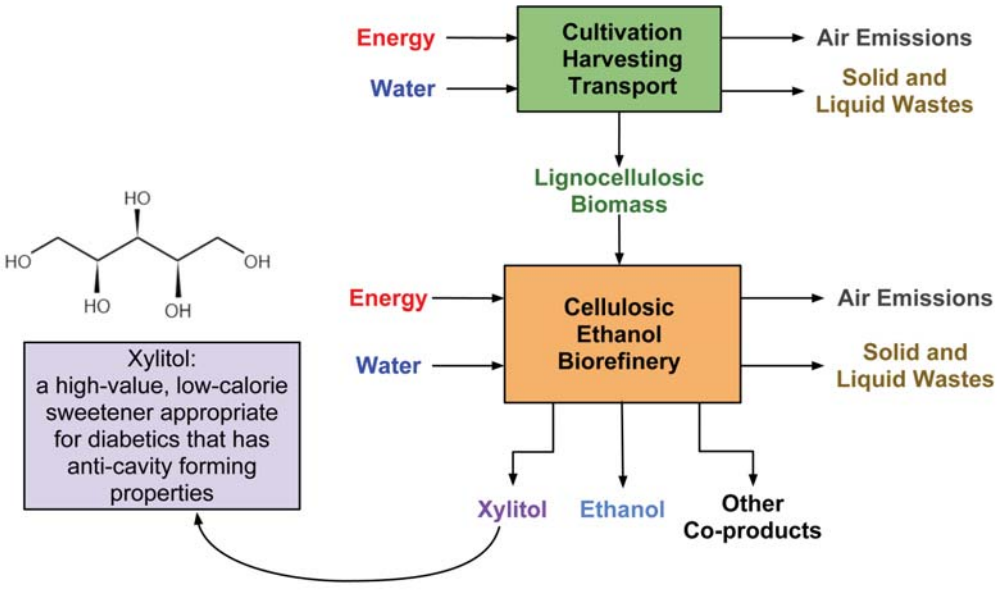


Fig. 1: Theoretical Well-to-Gate diagram of a cellulosic ethanol refinery with co-product xylitol.

Ph.D., 2009, Max Planck Institute of Bio-Inorganic Chemistry
M.Sc. Biotechnology, 2001, Guru Nanak Dev University
B.Sc. Industrial Microbiology, 1999, Guru Nanak Dev University

Amrit Kaur
Postdoctoral Fellow

Supervisor: Alexei Savchenko

Structural and functional characterization of extracellular enzymes from fungi involved in wood degradation

The focus of my research project is the functional and structural characterization of the extracellular lignocellulolytic enzymes from fungal genomes recently unveiled by the Genozymes Project (*http://www.fungalgenomics.ca*). These enzymes are needed for efficient use of plant biomass in industrial applications such as biofuels production and synthesis of value-added bioproducts. I am currently characterising the selected candidate enzymes produced using a secretory expression system in *Aspergillus niger* and over-expression system in *E. coli*. I am screening these candidate enzymes in functional assays measuring specific activity against a panel of substrates. In terms of structural characterisation we already determined initial crystallisation conditions for over 20 enzymes, which led to determination of 9 protein structures so far. Structurally characterised enzymes include representatives of GH12, GH10, GH93, GH105 and CE3 protein families according to CAZy nomenclature. The representatives of families CE16 and GH62 have been visualised for the first time. We are using obtained structural information to provide **molecular insights into catalytic activity of these enzymes as well as guidance for activity and substrate optimization required for use of these enzymes in industrial applications**.

Fig. 1: CE16 Esterase from Myriococcum thermophilum

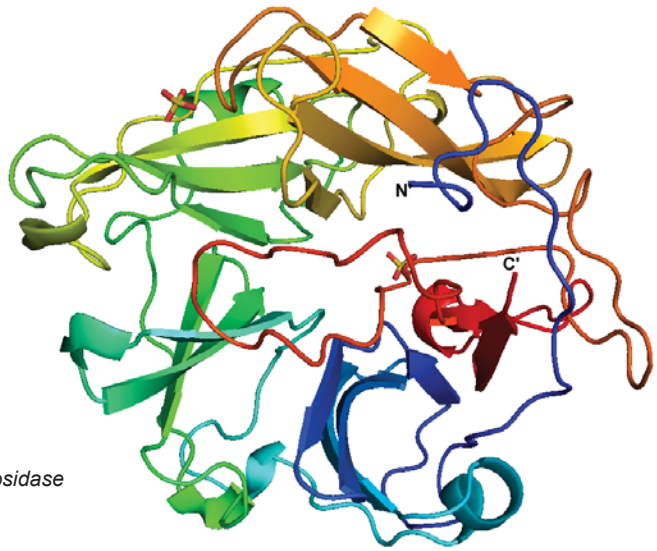


Fig. 2: GH62 α-L-arabinofuranosidase from Scytalidium thermophilum

Research Highlights

Kaur, A.P. *et al.* (2012). High throughput crystallization and characterization of extracellular fungal proteins involved in biodegradation of lignocellulose (poster). *Genozymes AGM 2012*, Montreal, QC

Ogata, H. *et al.* (2010). Purification, crystallization and preliminary X-ray analysis of the dissimilatory sulfite reductase from *Desulfovibrio vulgaris* Miyazaki F. *Acta Crystallogr. F Struct. Biol. Cryst. Commun.*, 66(11):1470-1472

Ogata, H., Goenka Agrawal, A., Kaur, A.P., Goddard, R., Gärtner, W. and W. Lubitz (2008). Purification, crystallization and preliminary X-ray analysis of adenylylsulfate reductase from *Desulfovibrio vulgaris* Miyazaki F. *Acta Crystallogr. F Struct. Biol. Cryst. Commun.*, 64(11):1010-1012

Khan, S., Nan, R, Gor, J., Mulloy, B. and S.J. Perkins (2012). Bivalent and co-operative binding of complement factor H to heparan sulphate and heparin. *Biochemical Journal*, 444:417-428

Khan, S., Rodriguez, E., Patel, R., Gor, J., Mulloy, B. and S.J. Perkins (2011). Solution structure of heparan sulphate differs from that of heparin: Implications for function. *Journal of Biological Chemistry*, 286: 24842-24854

Sanaullah Khan
Postdoctoral Fellow

Ph.D, 2011 1, Department of Structural & Molecular Biology, University College London, UK
M.Sc (Biochemistry), 2002, Department of Chemistry, Gomal University Pakistan
B.A.Sc, 2002, Gomal University Pakistan

Supervisor: Alexei Savchenko

Biochemical and biophysical characterisation of proteins related to bacterial pathogenicity

Bacterial pathogens are able to infect humans, animals and plants causing a serious global threat to health and agriculture. While ever-expanding sequencing initiatives provide the overall catalogue of genes in bacterial pathogens, allowing the identification of ones intimately involved in the pathogenesis process, **the specific functions of a significant number of pathogen-specific genes and their products remain unknown**. Characterisation of functions of these proteins is essential for advancing our understanding of bacterial pathogenesis and development of novel antibacterial therapies.

My research efforts focus on biochemical and biophysical characterisation of uncharacterised pathogenesis proteins from Gram-negative bacteria. In order to achieve my research goals, I apply a multidisciplinary approach, which combines experimental protein structure determination by X-ray crystallography with diverse biochemical and biophysical methodology such as analytical ultracentrifugation (Fig.1), isothermal titration calorimetry and site directed mutagenesis. I also intend to use X-ray solution scattering in cases where X-ray crystallography is not readily applicable.

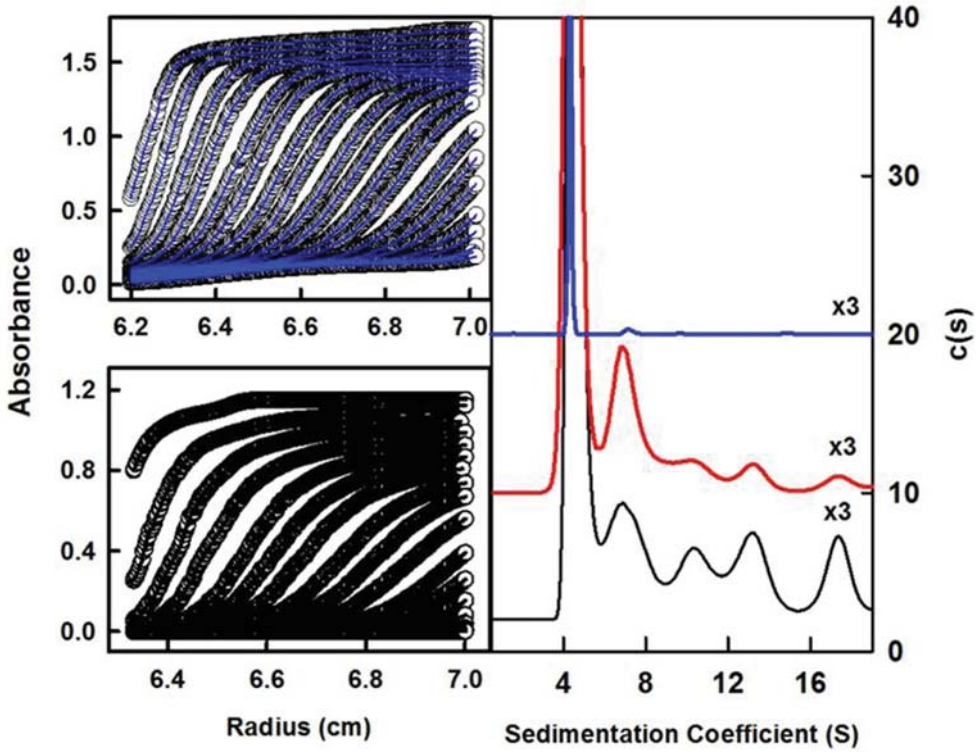


Fig. 1: Sedimentation velocity profile of target protein (black) and its complexes with lipids (red) and non-hydrolyzable ATP (blue).

Alan Lam
M.A.Sc. Student

B.A.Sc., 2010, University of Toronto

Supervisor: Bradley Saville
Co-Supervisor: Heather MacLean

Research Highlights

Lam, A. (2010). Mathematical modeling - peritoneal dialysis. 4th year thesis, *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto

Financial and environmental analysis of lignocellulosic butanol production

My project includes the Life Cycle Analysis (LCA) of butanol from lignocellulosic biomass, along with an economic analysis that demonstrates the viability of this renewable biofuel. **One innovative aspect of this research is the use of lignocellulosic biomass as the feedstock.** Traditionally, corn is the feedstock of choice in the industry. However, as a feed source, there are concerns about its use as a raw material in biofuels. Conversely, lignocellulosic biomass is abundant and inexpensive. Some examples of lignocellulosic biomass are corn stover and sugar cane bagasse.

Butanol is superior to ethanol in many respects, including lower vapor pressure, capacity to be transported via existing pipelines, and higher energy density. These qualities place butanol as a high potential alternative in the replacement of gasoline that powers everyday vehicles. **Aspen Plus is being used to simulate the manufacturing process from pre-treatment to product recovery.** Subsequently, a sensitivity analysis will be performed to identify key operating parameters. This information is for developing new processes and improving existing ones to achieve optimal operating conditions. **An LCA of the process will make it possible to compare promising biofuel with conventional gasoline and ethanol in terms of GHG emissions, energy use and profitability.**

Research Highlights

Lemak, S., Tchigvintsev, A., Petit, P., Flick, R., Singer, A.U., Brown, G., Evdokimova, E., *et al.* (2012). Structure and activity of the cold-active and anion-activated carboxyl esterase OLEI01171 from the oil-degrading marine bacterium *Oleispira antarctica*. *Biochemical Journal*, 445(2):193-203

Sofia Lemak
M.A.Sc. Student

B.M.Sc., 2011 1, University of Western Ontario

Supervisor: Alexander Yakunin

Biochemical analysis of CRISPR Cas4 nucleases

The Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and associated proteins (Cas) represent an adaptive microbial immune system found in most archaeal and many bacterial species. CRISPRs are transcribed and processed into short CRISPR RNAs that direct Cas proteins to degrade foreign nucleic acids including viruses and plasmids (Fig. 1). Studying this uniquely prokaryotic system which plays a role in DNA repair, transcriptional regulation, biofilm formation and bacterial swarming has already aided in bacterial strain typing, metagenome analysis and several areas of industry.

My main goal is to experimentally characterize the biochemical activity and molecular mechanism of the core CRISPR Cas4 proteins. These nucleases are predicted to be involved in the adaptation stage of immunity. This involves the integration of new spacer sequences into bacterial genomes, extending the immunity of the organism.

Determining the roles and mechanisms of Cas proteins will help to understand the functions of the system and its components, as well as help to formulate new hypotheses to further scientific knowledge and find novel industrial applications. **The potential specificity of Cas4 nucleases can be used along with other Cas proteins as cheaper, more exact and straightforward tools for genetic engineering.**

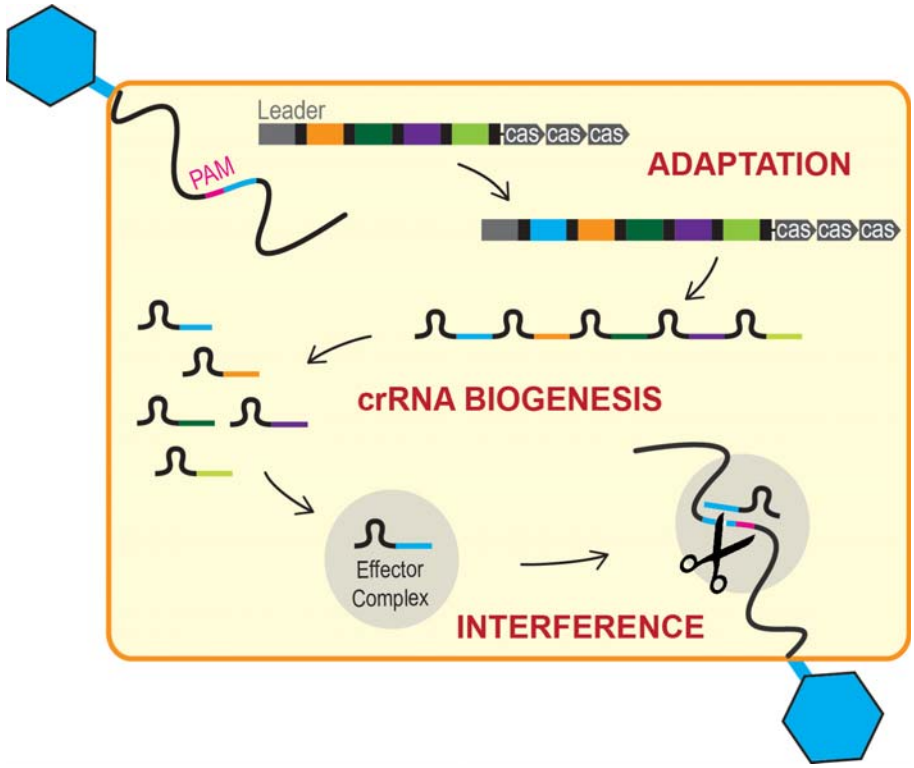


Fig. 1: Overview of the CRISPR -Cas invader defense pathway. (adapted from Terns, M.P., and R. M. Terns. 2011. Curr Opin Microbiol.)

Sarah McRae
Ph.D. Student

B.Sc. (hons), 2011, University of Auckland
B.Sc., 2010, University of Canterbury

Supervisor: Elizabeth Edwards

Interactions and communities involved in the anaerobic degradation of benzene

Benzene is a environmental pollutant of great concern as it is a known human carcinogen. It is released into groundwater as a result of petroleum leaks or spills relatively frequently, and is mobile in the environment due to its solubility in water. **While benzene degrades rapidly in aerobic environments, it is much slower to degrade in anaerobic environments, such as groundwater.**

Some bacteria are capable of anaerobic degradation of benzene to non-toxic compounds. This could provide an inexpensive, environmentally friendly method for benzene remediation. The bacteria involved work in communities with other members that may play different roles in helping or hindering the degradation of benzene. One group of bacteria that may assist benzene degradation under nitrate reducing conditions are anaerobic ammonium oxidizing bacteria (anammox). These bacteria oxidize ammonium with nitrite derived from the incomplete reduction of nitrate. Anammox are present in some of the cultures we have. They play an important role in nitrogen cycling, but are not well understood. **My research focuses on studying what community members are present during degradation under different conditions and examining the interactions and roles of the community members.**

This involves growing enrichment cultures under different conditions and monitoring degradation of benzene and production of end products. Quantitative PCR and other molecular techniques will be used to track the relative abundances of different community members. Microscopy techniques (FISH) will also be used to look at physical relationships of involved bacteria. The introduction of established benzene degrading communities to different bacteria may also increase degradation rates. **By elucidating the role of different bacteria in benzene degradation, new insight into the process of benzene degradation may be obtained, and the rate of degradation may be accelerated.**

Fig. 1: Anaerobic bottles of benzene degrading mixed culture combined with toluene degrading culture

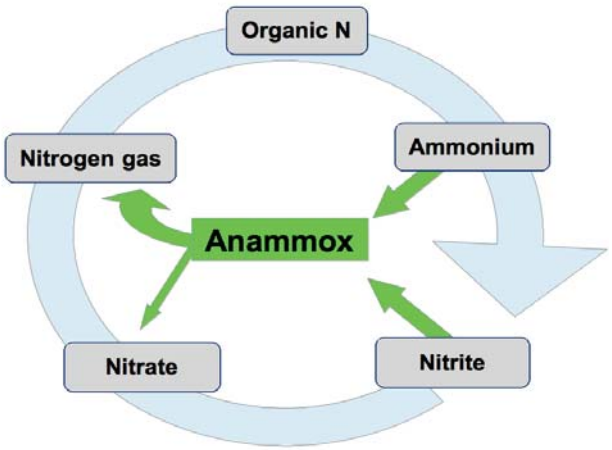


Fig. 2: Overview of the nitrogen cycle components, including the anammox process

Johnston, M.J.W., Nemr, K., and M.A. Hefford (2010). Influence of bovine serum albumin on thesecondary structure of interferon alpha 2b as determined by far UV circular dichroismspectropolarimetry. *Biologicals*, 38(2):314-320

Johnston, M.J.W., Nemr, K., and M.A. Hefford (2009). Influence of bovine serum albumin on thesecondary structure of interferon alpha 2b as determined by far UV circular dichroismspectropolarimetry. *Health Canada Science Forum 2009*, Ottawa, ON

Kayla Nemr
M.A.Sc. Student

B.A.Sc, 2012, University of Ottawa
B.Sc, 2012, University of Ottawa

Supervisor: Radhakrishnan Mahadevan

Enzyme discovery and its implementation into metabolic engineering strategies for the synthesis of value-added chemicals

Increase in global awareness about the environmental impact and unsustainability of petroleum-based chemicals has been the drive for research towards the discovery of cleaner and more sustainable processes. **Biocatalysis is a promising alternative to organic synthesis of many essential chemicals by using enzymes as the catalyst.** Microorganisms, which possess the necessary machinery to produce such enzymes, can act as the factory in which biomass-based feedstocks are converted into the desired chemicals. Unfortunately, many enzymes required to produce non-naturally occurring chemicals, which would otherwise be produced from petroleum-based sources, might not exist in industrially relevant microorganisms; therefore, the success of metabolic engineering strategies, which intend to modify the native metabolic pathways of microorganisms by deleting or adding genes for enzyme production, rely on screening for or engineering enzymes with the desired activity. As a result, the genes of the enzymes discovered can be introduced into the engineered bugs to produce the desired chemicals.

Some enzymes can elongate carbon chains thus producing useful chemicals or intermediate compounds that are usually composed of over four carbons. Such enzymes can sometimes accept a wide range of substrates, which gives them the potential to catalyze the formation of a variety of products. The challenge is to find the appropriate enzyme that has a high specificity towards the desired substrates and a high activity in order for the reaction to be efficient and industrially relevant. **My project involves screening a library of enzymes and identifying candidates that possess the desired functionality.** Site-directed mutagenesis might be a potential tool to further improve the activity of the identified candidates.

The ultimate goal is to introduce the discovered enzymes into engineered bugs to produce value-added chemicals from renewable feedstocks.

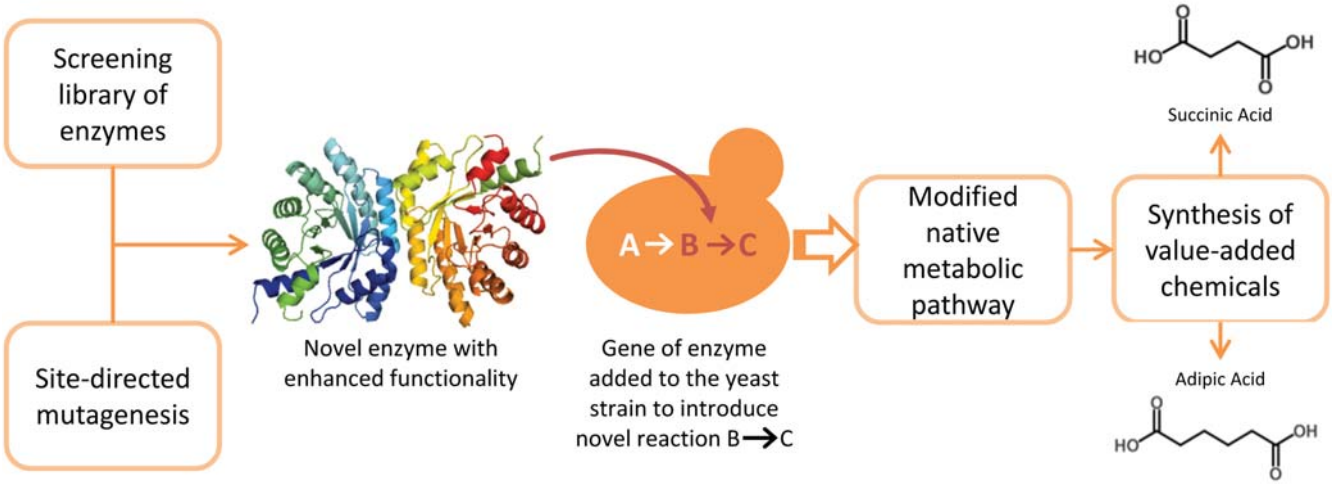


Fig. 1: Process summary for the synthesis of value-added chemicals using enzyme engineering and metabolic engineering strategies.

Kylie O'Donnell
M.Sc. Student

B.E.Sc., 2011, Western University

Supervisor: Emma Master

Assessing the potential of class II hydrophobins as an alternative to traditional surface modification techniques

Surface modification is a technique widely used to attract, repulse or retard the adhesion of molecules to a variety of natural or synthetic surfaces. Bacterial biofilm formation represents a major problem in environmental biology, medical fields, the food industry and biotechnology. Additionally, the design of bioactive surfaces is integral in enhancing cell adhesion to materials used as scaffolds in tissue engineering applications. Previous approaches of surface modification often employ the use of toxic compounds to change the biocompatibility and/or biofunctionality of a material. Drawbacks of this approach include low environmental sustainability of corresponding biotech applications, and reduced biocompatibility to cells in tissue engineering applications.

Accordingly, **the overall aim of my graduate thesis is to assess the potential of using class II hydrophobins as an alternative to traditional surface modification techniques.** Hydrophobins have been described as the most surface-active proteins known and represent non-immunogenic proteins with the capacity to change the property of surfaces via stable coatings of thin layers at interfaces. Hydrophobins are separated into two classes based on a variety of characteristics, including their propensity to create films on surfaces: class I hydrophobins tend to form films consisting of rodlets, whereas class II hydrophobins tend to form monolayers. Through protein engineering, it is possible to construct fusion proteins between hydrophobins and various fusion partners. I plan to address fundamental questions about the self-assembly of hydrophobins, including how to control self-assembly by varying environmental parameters such as surface chemistry and the presence of a fusion partner. Hydrophobins represent an attractive surface modification technology that can be paired with a variety of fusion partners to increase their versatility as surface modifiers. **The use of natural, non-toxic surface-active substances, such as hydrophobins, represent an alternative to toxic compounds to make surface coatings less hazardous to the environment, as well as increase biocompatibility.**

Research Highlights

Javaherian, S., O'Donnell. K.A., and A. P. McGuigan (2011). A fast and accessible methodology for micro-patterning cells on standard culture substrates using Parafilm™ inserts. *PLoS One*. 6(6): e20909

O'Donnell, K. and L. Briens (2011). Effect of moisture content on flowability properties of pharmaceutical powders. B.E.Sc thesis, *Dept. of Chemical Engineering*, Western University

Research Highlights

Puentes Jácome, L. (2012). An investigation on the influence of wettability on the recovery of entrapped LNAPLs via surfactant flushing. M.A.Sc. thesis, *Dept. of Civil and Env. Eng.*, Carleton University

Puentes Jácome, L. and P. Van Geel (2011). Influence of soil wettability on the recovery of residual LNAPLs via soil flushing. *GeoHydro*, Quebec, QC

Puentes Jácome, L.A. (2008). Biodegradation of phenols in a fixed-bed anaerobic bioreactor for the oil-industry wastewater from Payoa field-site. Undergraduate thesis, *Dept. of Env. Eng.*, Universidad Pontificia Bolivariana

Kopytko M. and L. Puentes Jacome (2008). Phenol biodegradation in fixed-bed anaerobic reactors with an adapted bacterial biofilm layer. *12th Conf. on Env. and Min. Proc.*, VSB Tecnological University, Czech Republic

Luz Puentes Jácome
Ph.D. Student

M.A.Sc., 2012, Carleton University
B.Eng., 2008, Universidad Pontificia Bolivariana

Supervisor: Elizabeth Edwards

Anaerobic biodegradation of polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls or PCBs are highly ubiquitous and persistent compounds in the environment. PCBs have been detected in surface waters, sediments, and soils; they bio-accumulate in higher organisms due to their high hydrophobicity. PCBs have been linked to long-term immune, neurological, and hormonal adverse effects in humans; some PCBs are also carcinogenic. Different bacteria have been shown to anaerobically biodegrade PCBs.

During my doctoral research, **I will study PCB anaerobic biodegradation using different mixed bacterial cultures that have been shown to reductively dechlorinate other chlorinated compounds, such as chlorinated ethenes and chlorobenzene.** Initially, we will employ a reference PCB compound (PCB 116 - 2,3,4,5,6 pentachlorobiphenyl) to monitor dechlorination and bacterial activity. The first stage of the project has entailed the development of an analytical protocol to quantify the concentration of PCB 116 and its dechlorination products using gas chromatography coupled to mass spectrometry (GC-MS). Dechlorination will be monitored in microcosm experiments to identify the cultures capable of PCB biodegradation.

In later stages of the investigation, we will focus on understanding the mechanisms involved in PCB dechlorination, the microbial community composition, as well as the enzymes that catalyze the dechlorination process. Also, we will explore alternatives to enhance bioremediation of soils and sediments and test them at field sites. **We want to contribute to the scientific understanding of anaerobic biodegradation of PCBs and help to translate this knowledge into practical field applications that will reduce the concentrations of PCBs in the environment.**

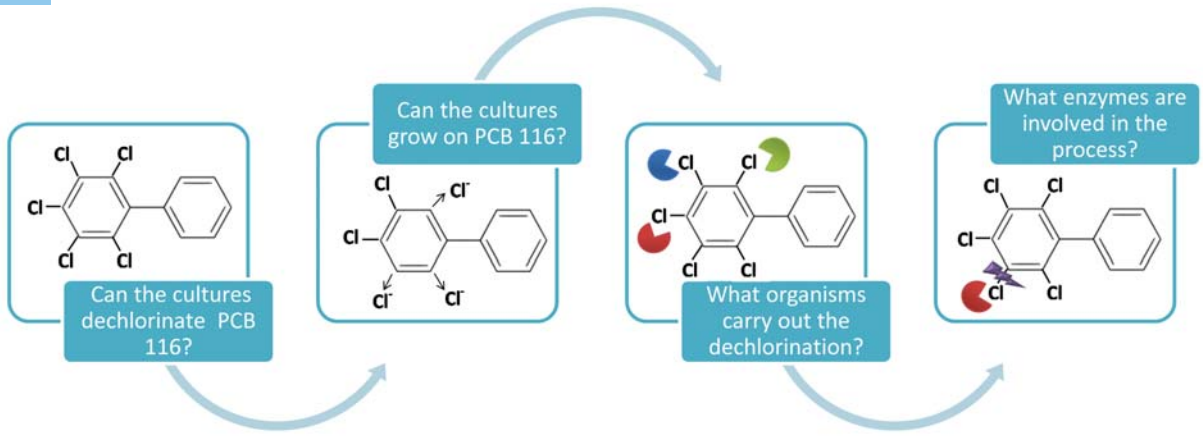


Fig. 1: Schematic representation of research questions.

Andrew Quaile
Postdoctoral Fellow

Ph.D., 2009 University of Liverpool
B.Sc. (Hons) Applied Biochemistry, 2005, University of Liverpool

Supervisor: Alexei Savchenko

Identifying host cell proteins targeted by pathogenic bacteria

The bacterial effectors are a group of proteins that are translocated by specialized bacterial machinery into their hosts. They are critical determinants of virulence thanks to their ability to induce, repress, hijack and subvert the cellular responses of the host to the invader. Discovering and understanding the Modus operandi of these proteins is often obfuscated by their low sequence similarity with functionally characterised proteins. Consequently the 3D structural data can provide the first insight into what these proteins do. However further understanding of their function requires identification of specific host proteins and processes targeted by these pathogenic factors.

To answer this challenge, I am taking advantage of the high quality, highly purified protein we are able to produce and use them as bait in search for their host cell interactors. **Using recently developed highly specific affinity tags and entirely gel-free complex purification methodology coupled with tandem mass spectrometry, I am able to identify not only the directly interacting partners, but also entire functional complexes without being limited by the availability of specific antibodies.** Once I identify and confirm interactions between bacterial pathogenic factors and host proteins we move into characterization of the cell processes and functions affected by bacterial infection. **This information is critical to our general understanding of bacterial pathogenesis as well for development of novel antimicrobial therapies.**

Research Highlights

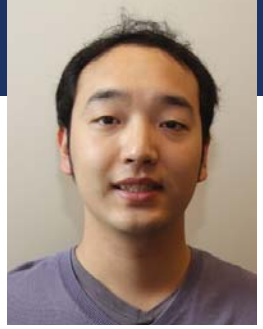
Wu, Y. Nelson, M.M. Quaile, A. Xia, D. Wastling, J.M., and A. Craig (2009). Identification of phosphorylated proteins in *Erythrocytes* infected by the human malaria parasite *Plasmodium falciparum*. *Malaria Journal*, 8:105

Quaile, A. (2009). Nitazoxanide and the thiazolides: drug targets and cellular responses. Ph.D. thesis. *Dept. Comparative Molecular Medicine*, University of Liverpool

Research Highlights

Malekian, M., Trieu, D., Owoc, J.S., Park, S.S., and C.J. Hunter (2010). Investigation of the intervertebral disc and fused joint dynamics through experimental modal analysis and the receptance coupling method. *Journal of Biomechanical Engineering*, 132(4):041004

Farshidi, R., Trieu, D., Park, S.S., and T. Freiheit (2010). Non-contact experimental modal analysis using air excitation and a microphone array. *Journal of Measurement*, 43(6):755-765



Dennis Trieu
M.A.Sc. Student

BSc., 2010, University of Calgary

Supervisor: Alison McGuigan
Co-Supervisor: Thomas Waddell

Functional tissue engineering of epithelium using airflow shear stress

There are currently no acceptable clinical treatments for reconstructing large segments of injured trachea. Decellularized tracheal allografts and tissue engineered scaffolds are used as an alternate treatment, but are not optimized to provide effective organ functionality. The function of the trachea is to protect the body from contaminants in the air by secreting mucous to absorb contaminants and clearing the mucous away via coordinated ciliary beating.

In-vivo airway epithelial cells are organized in a planar manner through planar cell polarity proteins in conjunction with an apical/basal manner. Air-liquid interface culture is a method of inducing apical/basal polarization in the *in-vitro* environment, but do not organize epithelium in a planar manner. **We aim to investigate the effects of airflow on planar polarization.**

We have created a unique fluidic flow system for inducing airflow on epithelial cells *in-vitro*. We will utilize the system to characterize the effects of long term airflow maturing epithelial cells. **This study will provide valuable information on strategies to generate functional epithelium and advance medical *in-vitro* testing technology.**

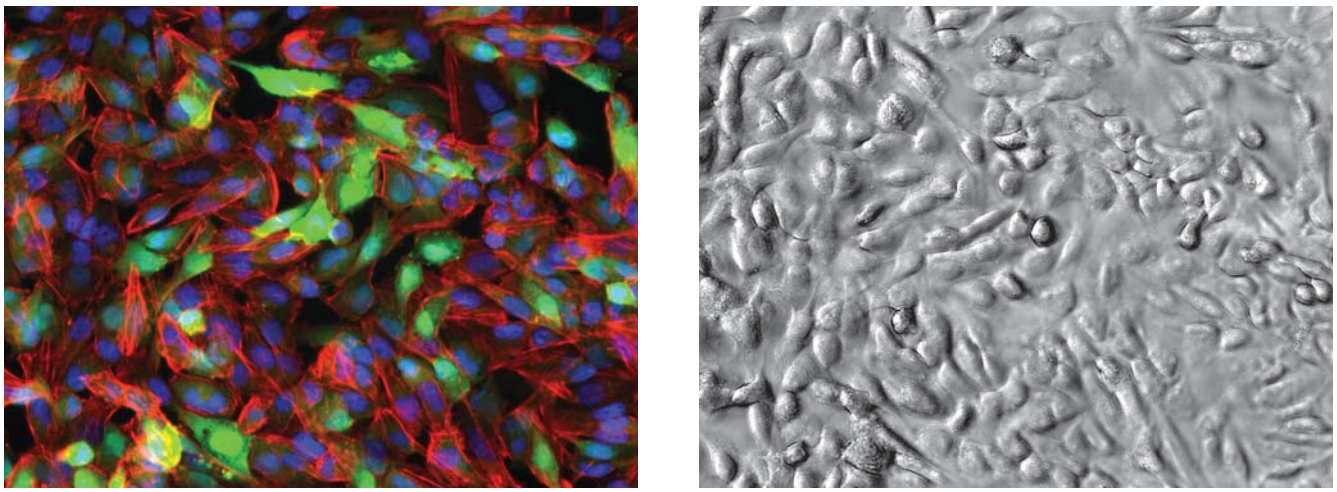
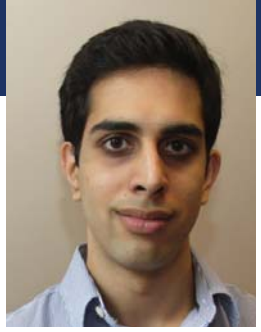


Fig. 1: A. Fluorescent, and B. Bright-field Micrograph of Green Fluorescent Transfected Epithelial Cells stained with Phalloidin and DAPI.



Naveen Venayak
M.A.Sc. Student

B.A.Sc. Chemical Engineering, 2012, University of Ottawa
B.Sc. Honours Science, 2012, University of Ottawa

Supervisor: Radhakrishnan Mahadevan

Metabolic engineering for improved high-value chemical production characteristics

The current use of oil reserves is unsustainable and has negative environmental impacts. The hydrocarbons found in oil are refined and predominantly used as fuels; however, they are also precursors of many essential, high-value compounds. Alternatives to produce these petrochemical-derived compounds are important to reduce our reliance on oil.

A promising alternative method to synthesize these petrochemical derived compounds is by harnessing microbial metabolism. There are many chemicals which have the potential to be produced biologically and the US Department of Energy has published a list of several candidates. **My project involves improving the productivity, titre or yield of valuable chemicals in model organisms such as *Escherichia coli* and *Saccharomyces cerevisiae*.**

This will be accomplished by implementing genetic engineering strategies based on recent developments in synthetic biology and metabolic modeling. A fundamental understanding of microbial metabolism, coupled with *in silico* modeling and optimization techniques, can be used to define potential metabolic engineering strategies which improve the production characteristics of high-value chemicals. These strategies can then be implemented and verified in model organisms using molecular biology techniques.

Commercially viable microbial strains to produce high-value petrochemicals will be important in the transition from the use of petrochemicals to renewable sources. Not only will my research improve upon the current method of producing these chemicals, it will also lead to a better understanding of microbial metabolism, which can open avenues to producing other important chemicals.

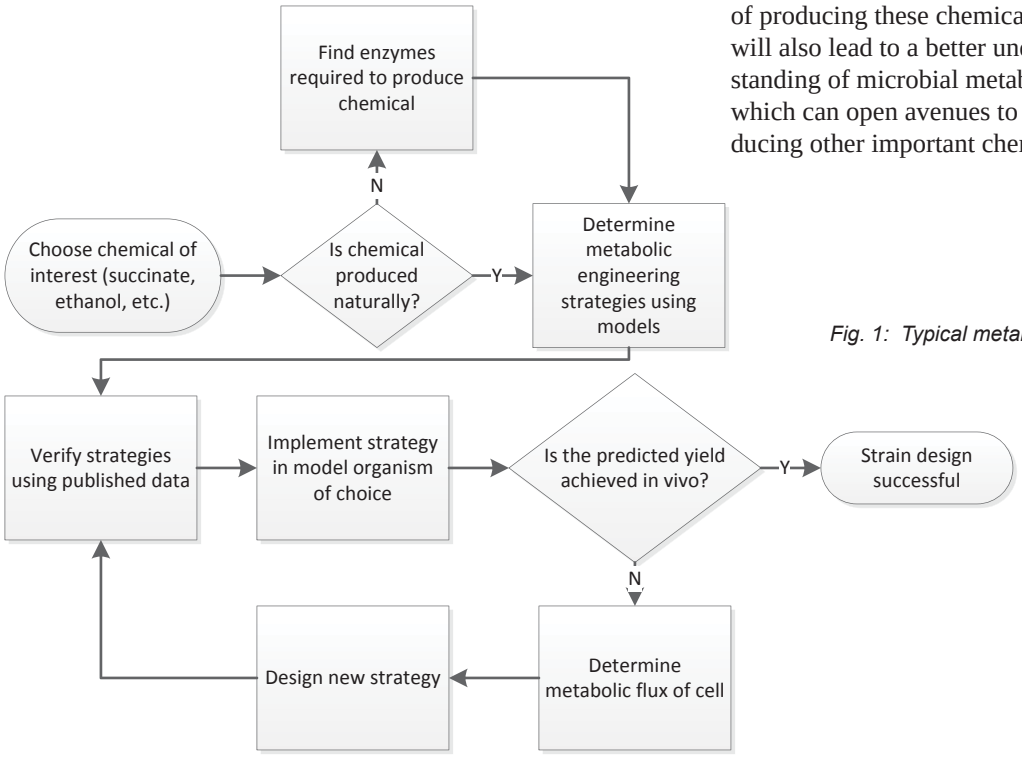


Fig. 1: Typical metabolic engineering workflow

Research Highlights

2012 Ontario Graduate Scholarship recipient

Venayak, N. (2012). Medium optimization for phytase production by recombinant pGAP *Pichia pastoris* grown on glucose. B.A.Sc. thesis, *Dept. of Chemical and Biological Engineering*, University of Ottawa

Venayak, N. (2011). The role of UCP3 in glutamine metabolism in mouse primary myotubes. B.Sc. thesis, *Dept. of Biochemistry, Microbiology and Immunology*, University of Ottawa

Research Highlights

Wang,W. Archbold, T. Kimber, M.S. Li, J. Lam, J.S. and M.Z. Fan (2012). The porcine gut microbial metagenomic library for mining novel cellulases established from growing pigs fed cellulose-supplemented high-fat diets. *Journal of Animal Science,* 90(Supplement 4): 400-402

Wang,W., Mazurkewich,S., Kimber, M.S. and S.Y.K Seah (2010). Structural and kinetic characterization of 4-hydroxy-4-methyl-2-oxoglutarate/4-carboxy-4-hydroxy-2-oxoadipate aldolase, a protocatechuate degradation enzyme evolutionarily convergent with the HpaI and DmpG pyruvate aldolases. *Journal of Biological Chemistry*, 285(47): 36608–36615

Weijun Wang
Research Associate

Ph.D., 1997, South China Agricultral University

Supervisor: Emma Master

Exploration of anaerobic microcosms that digest woody biomass, and discovery and design of accessory hemicellulase with enhanced activity on polymeric xylan

By using anearobic enrichment, metagenomic and metatranscriptomic techniques, this research aims **to identify the key microbial species and activities required to transform or detoxify wood-derived compounds**, such as crystalline cellulose, lignin and tannin, which are recalcitrant or inhibitory to bioconversion processes.

The discovery and design of accessory hemicellulases with enhanced activity on polymeric xylan will be beneficial for enzymatic production of high-value biochemicals and materials from lignocellulosic biomass.

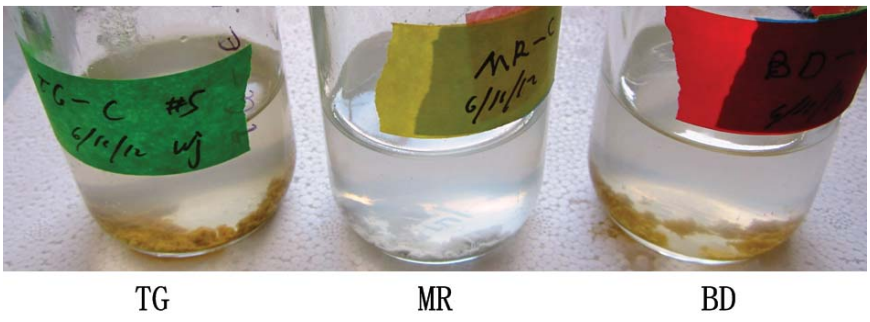


Fig. 1: Microcosms from Tembec granules (TG), moose rumen (MR) and beaver droppings (BD) enriched on microcrystalline cellulose (Avicel).

Ruoyu Yan
Ph.D. Student

M.Sc., 2011, Western University

Supervisor: Emma Master

Research Highlights

Yan,R. (2011). Expression of active xylanases in *N. benthamiana* for hemicellulose degradation. M.Sc. thesis, *Dept. of Biology*, Western University

Effect of xylan composition and branching on interaction with other lignocellulose components

My motivation is to improve application of xylan polymers from woody biomass by altering its branching chemistry. A fundamental research question of my thesis is to study how the structure of xylan affects its interaction with other lignocellulose components. Another research question is to study whether selective debranching of xylan can improve subsequent chemical derivatization of the biomolecules. Investigation of this question can provide us with information to **optimize recovery of high value components from lignocellulose and optimize synthesis of composite materials.**

For example, I will investigate the binding affinity between xylan and other plant polysaccharides before and after treatment with accessory hemicellulases. An underlying assumption of this study is that debranching will increase the association of xylan and other plant polysaccharides in composite materials.

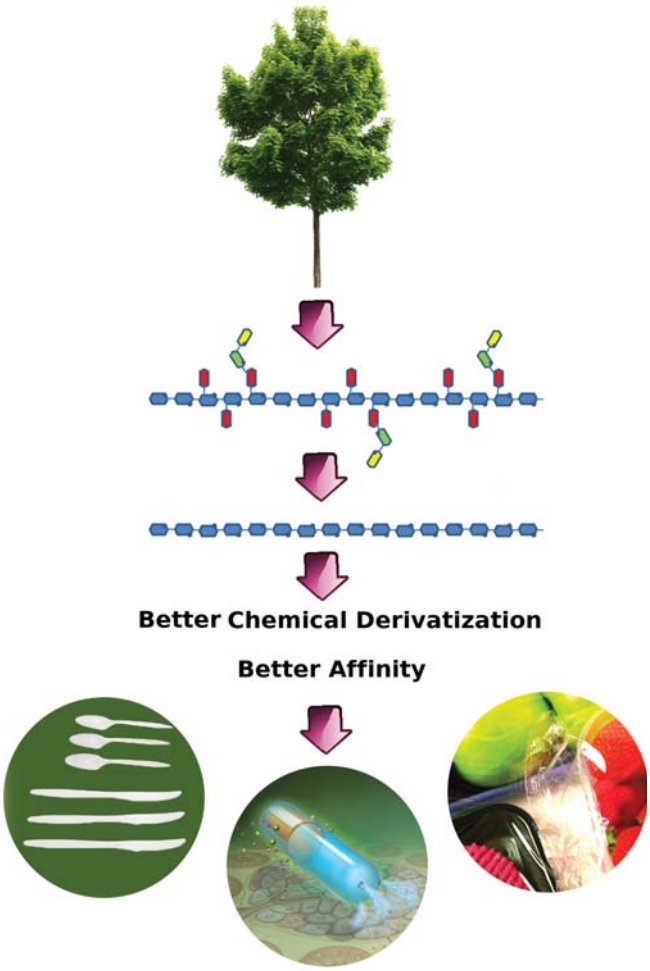


Fig. 1: Optimizing chemical derivatization of xylan by selective debranching.

Alumni

Master's Students

Nicholas Bourdakos, M.A.Sc., international

Johanna Chan, M.A.Sc., Canadian private sector

Tahmineh Khazaei, M.A.Sc., international

Lana Kwan, M.A.Sc., Canadian public sector

Peter Yan Li, M.A.Sc., Canadian private sector

Marie Manchester, M.A.Sc., Canadian private sector

Elisa McGee, M.A.Sc., continuing graduate studies at U of T

Yaseen Mottiar, M.Sc., continuing graduate studies at another Canadian university

Anooradha Nursimulu, M.Eng.

Angjalie Sangakkara, M.A.Sc., Canadian public sector

Tim Shen, M.A.Sc., Canadian private sector

Supraja Sridharan, M.Eng., Canadian public sector

PhD Students

Roya Gitiafroz, Ph.D., international

Laura Hug, Ph.D., Postdoctoral Fellow, Berkeley University

Jacqueline MacDonald, Ph.D., Canadian public sector

Laurence Yang, Ph.D., international

Personnel

Nisa Dar, Bioinformatician, Canadian public sector

Melanie Dowler, Administrative Assistant, University of Toronto

Nazerit Hagos, Administrative Assistant

Anna Ho, Administrative Assistant, Pulp & Paper Centre and Chemistry Dept., University of Toronto

Kamini Kaul, Research Assistant

Anna Zila, Research Assistant, Canadian private sector

BioZone's alumni work in a wide variety of institutions and companies within Canada and abroad.

This page lists graduates and personnel who completed their tenure during the 2011 - 2012 reporting period, as well as the sector of their current position, where known.

For updates from our previous alumni, please see our *2012 Report on BioZone*, available on our website.

Continuing Researchers & Personnel

BioZone's researchers and personnel who joined the centre before the current reporting period and are continuing their work are listed below.

For full profiles, please see our *2012 Report on BioZone*, available through our website.

Master's Students

Christine Achampong
Parthiv Amin
Johnathan Brunetti
Sarat Cautha
Scott Genin
Benjamin Hijar
Cleo Ho
Patrick Hyland
Alan Lam
Jine Jine Li
Eugene Ma
Olivia Molenda
Mehdi Nouraei
Jon Obnamia
Peter Schnurr
Vyacheslav Shuvalov
Tim Sun
Christopher Tran
Kai Wei

PhD Students

Nikolaos Anesiadis
Yaldah Azimi
Sofia Bonilla
Cheryl Devine
Alex Dumitrache
Maryam Foumani
Julie-Anne Gandier
Srinath Garg
Pratish Gawand
Mahbod Hajighasemi
Ahsanul Islam
Sahar Javaherian
Camila Londono
Fei Luo
Elisa McGee
Azadeh Namaazi
Vik Pandit
Fahimeh Salimi
Mohamed Sherif
Sayeh Sinichi
Solmaz Tabtabaei
Shuiquan Tang
Alex Tsai
Ruoyu Yang
Ivy Yang
Kai Zhuang

Postdoctoral Fellows

Natalia Beloglazova
Resmi Capron
Chris Gowen
Jianxun Han
Xiaoming Liang
Sonam Mahajan
Mohammed Pourbafrani
Peter Stogios
Hitoshi Suzuki
Thu Vuong
Hongyan Zheng

Research Personnel

Greg Brown
Bih-King Chen
Hong Cui
Rosa Di Leo
Olga Egorova
Elena Evdokimova
Robert Flick
Marina Kudritska
Line Lomheim
Torsten Meyer
Olena Onopriyenko
Ana Popovic
Darren Rodenhizer
Alex Sapronov
Alexander Singer
Tatiana Skarina
Anatoli Tchigvintsev
Xioahui Xu
Veronica Yim
Jiao Zhao

Research Support

Melanie Duhamel
Weijun Gao
Christina Heidorn
Monika Ignacak
Endang Susilawati

Publications

The following publications were published during the September 2011 - August 2012 reporting period.

Refereed articles

Azimi, Y., Allen, D.G., and R.R. Farnood (2012). **Kinetics of UV inactivation of wastewater bioflocs.** *Water Research*, 46(12):3827-3836.

Barlett, M., Zhuang, K., Mahadevan, R., and D.R. Lovley (2012). **Integrative analysis of *Geobacter* spp. and sulfate-reducing bacteria during uranium bioremediation.** *Biogeosciences*, 9:1033-1040.

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Chan, W.W.M., Grostern, A., Löffler, F.E., and E.A. Edwards (2011). **Quantifying the effects of 1,1,1-trichloroethane and 1,1-dichloroethane on chlorinated ethene reductive dehalogenases.** *Environmental Science & Technology*, 45(22):9693-9702.

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García-Becerra, F.Y., Acosta, E.J., and D.G. Allen (2012). **Wood adhesives based on alkaline extracts from wastewater biosolids and mustard protein.** *Journal of the American Oil Chemists' Society*, 89(7):1315-1323.

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Hug, L.A., Beiko, R.G., Rowe, A.R., Richardson, R.E., and E.A. Edwards (2012). **Comparative metagenomics of three *Dehalococcoides*-containing enrichment cultures: the role of the non-dechlorinating community.** *BMC Genomics*, 13(327).

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Lemak, S., Tchigvintsev, A., Petit, P., Flick, R., Singer, A.U., Brown, G., Evdokimova, E., Egorova, O., Gonzalez, C.F., Chernikova, T.N., Yakimov, M.M., Kube, M., Reinhardt, R., Golyshin, P.N., Savchenko, A., and A. Yakunin (2012). **Structure and activity of the cold-active and anion-activated carboxyl esterase OLEI01171 from the oil-degrading marine bacterium *Oleispira antarctica*.** *Biochemical Journal*, 445:193-203.

Li, Y.O., and L.L. Diosady (2012). **Microencapsulation and its application in micronutrient fortification through "engineered" staple foods.** *Agro Food Industry Hi-Tech*, 23(2):18-21.

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Mundle, S.O.C., Johnson, T., Lacrampe-Couloume, G., Perez-de-Mora, A., Duhamel, M., Edwards, E.A., McMaster, M., Cox, E., Revesz, K., and B. Sherwood Lollar (2012). **Monitoring biodegradation of ethene and bioremediation of chlorinated ethenes at a contaminated site using CSIA.** *Environmental Science & Technology*, 46(3):1731-1738.

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Tsai, A.Y., Canam, T., Gorzsás, A., Mellerowicz, E.J., Campbell, M.M., and E.R. Master (2012). **Constitutive expression of a fungal glucuronoyl esterase in *Arabidopsis* reveals altered cell wall composition and structure.** *Plant Biotechnology Journal*, 10(9):1077-1087.

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Wagner, D., Hug, L., Hatt, J., Spitzmiller, M., Padilla-Crespo, E., Ritalahti, K., Edwards, E., Konstantinidis, K., and F. Löffler, F. (2012). **Genomic determinants of organohalide-respiration in *Geobacter lovleyi*, an unusual member of the *Geobacteraceae*.** *BMC Genomics*, 13(1):200.

Waller, A.S., Hug, L.A., Mo, K., Radford, D.R., Maxwell, K.L., and E.A. Edwards (2012). **Transcriptional analysis of a *Dehalococcoides*-containing microbial consortium reveals prophage activation.** *Applied and Environmental Microbiology*, 78(4):1178-1186.

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Zheng, H., Filippova, E., Tkaczuk, K., Dworzynski, P., Chruszcz, M., Porebski, P., Wawrzak, Z., Onopriyenko, O., Kudritska, M., Grimshaw, S., Savchenko, A., Anderson, W., and W. Minor (2012). **Crystal structures of putative phosphoglycerate kinases from *B. anthracis* and *C. jejuni*.** *Journal of Structural and Functional Genomics*, 13(1):15-26.

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Book Chapters

Li, Y. O., Diosady, L.L., Bohac, L., Wesley, A.S. and M.G. Venkatesh Mannar. **Double fortification of salt with iron and iodine as an effective tool in simultaneously alleviating two micronutrient deficiencies.** In *Micronutrients: sources, properties, and health effects*, A.I. Betancourt and H.F. Gaitan (Eds). pp. 222, Nova Science Publishers (2011).

Patents

Diosady, L.L., Xu,L. and B.-K. Chen. **Production of high-quality protein isolated from oil seeds**, U.S.Patent 8,048,463 (2011).

Theses

Bourdakos, N. (2012). **Construction and characterization of microbial fuel cells using a defined co-culture of *G. sulfurreducens* and *E. coli*.** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Chan, J. (2012). **Extracting lipids and carotenoids from microalgae with lecithin-linker microemulsions .** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Gitiafroz, R. (2011). **Microorganisms and metabolic pathways involved in anaerobic benzene biodegradation under nitrate-reducing conditions.** Ph.D., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Hug, L. (2012). **A metagenome-based examination of dechlorinating enrichment cultures: Dehalococcoides and the role of the non-dechlorinating microorganisms.** Ph.D., *Dept. of Cell and Systems Biology*, University of Toronto.

Khazaei, T. (2011). **Ensemble modeling of cancer metabolism.** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Kwan, L. (2012). **Triple fortification of salt with vitamin A, self-emulsifying drug delivery system, iron and iodine.** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Li, P.Y. (2012). ***In silico* metabolic network reconstruction of *Scheffersomyces stipitis*.** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

MacDonald, J. (2012). **Identifying genetic adaptations that promote softwood utilization by the white-rot basidiomycete fungus, *Phanerochaete cornosa*.** Ph.D., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Manchester, M. (2011). **Characterization of dechlorinating populations in the WBC-2 Consortium.** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

McGee, E. (2012). **The fortification of salt with Iodine, iron and folic acid.** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Mottiar, Y. (2011). **Enzymes and feedstocks for sustainable biomass utilisation.** M.Sc., *Dept. of Cell and Systems Biology*, University of Toronto.

Nursimulu, A. (2011). **Characterisation of Abyssinian mustard.** M.Eng., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Sangakkara, A.R. (2011). **Double fortification of salt with folic acid and iodine.** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Shen, T. (2012). **Life cycle modelling of multi-product lignocellulosic ethanol systems.** M.A.Sc., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Sridharan, S. (2012). **Base-catalysed transesterification of yellow mustard oil using a mixed alcohol system.** M.Eng., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Yang, L. (2012). **Mathematical optimization of biological systems.** Ph.D., *Dept. of Chemical Engineering and Applied Chemistry*, University of Toronto.

Conference presentations and invited talks

Allen, D.G., Brunelle, R., Edwards, E.A., Allan, E., Mahmood, T., and M.I. Yang. **The effect of pulp washer effluent on the anaerobic conversion of wastewater into methane.** *2nd International Biorefinery Symposium in Paper Week.* Montreal, QC. Feb. 1, 2012

Anesiadis, F., Koboyashi, H., Fong, S., Cluett, W.R., and R. Mahadevan. **Dynamic metabolic engineering for lactate production.** *AIChE Annual Meeting*. Minneapolis, MN. Oct. 16-21, 2011

Anesiadis, N., Kobayashi, H., Cluett, W.R., and R. Mahadevan. **Enhancing bioprocess productivity through dynamic control of gene expression.** *RAFT IX: Recent Advances in Fermentation Technology*. Marco Island, FL. Nov. 6-9, 2011

Chan, C, L.L. Diosady, and E.J. Acosta. **Microalgae milking with microemulsions.** *61st Canadian Chemical Engineering Conference*. London, ON. Oct. 23-26, 2011

Chandra, S., Martin, V., and R. Mahadevan. **Model-based design of S. cerevisiae for improved amino acid production.** *CsChE Annual Meeting*. London, ON. Oct. 24-26, 2011

Devine, D., Luo, F., Gitiafroz, R., Ho, C., Beiko, R., Mahadevan, R., and E.A. Edwards. **Unravelling the pathways and roles of organisms in anaerobic benzene-degrading cultures.** *95th Chemical Society of Canada Conference.* Calgary, AB. May 26-30, 2012

Edwards, E.A. **New frontiers in bioremediation.** *University of Western Ontario.* London, ON. Jan. 20, 2012

Edwards, E.A. **Application of genomics to hydrocarbon resource development: status, opportunities and reality check.** *Genome Alberta: Canada's Public Policy Forum.* Calgary, AB. Feb. 17, 2012

Edwards, E.A. **Unravelling the pathways and roles of organisms in anaerobic benzene-degrading cultures.** *95th Chemical Society of Canada Conference.* Calgary, AB. May 26-30, 2012

Edwards, E.A. **Applications: Bioremediation.** *International Functional genomics Workshop.* St. Jacobs, ON. May 6-8, 2012

Edwards, E.A. **Anaerobic benzene-degrading communities.** *112th General Meeting of the American Society for Microbiology.* San Fransisco, CA. June 16-19, 2012

Edwards, E.A., Tang, S., Chan, W., Fletcher, K., Liang, X., and E. Padilla. **Ascribing function to reductive dehalogenase genes.** *Society for Industrial Microbiology and Biotechnology Annual Meeting.* Washington, DC. Aug. 12-16, 2012

Edwards, E.A. **New frontiers in bioremediation.** *EAWAG - Swiss Federal Institute of Aquatic Science and Technology.* Dübendorf, Switzerland. Aug. 28, 2012

Edwards, E.A. **Pathways and organisms in anaerobic benzene-degrading cultures.** *University of Konstanz*. Konstanz, Germany. Aug. 29, 2012

Edwards, E.A. (2011). **New frontiers in bioremediation.** *61st Canadian Chemical Engineering Conference*. London, ON. Oct. 23-26, 2011

Edwards, E.A., Perez de Mora, A., and L. Lomheim. **Dehogenases in the environment and monitoring bioremediation.** *Innovative Combined Treatment Technologies for Remediating Contaminated Groundwater Kickoff Meeting.* Toronto, ON. Jan. 30, 2012

Foumani, M., Vuong,T., and E. Master. **Glucooligosaccharide oxidase fusion with carbohydrate binding modules: tools for synthesizing new polysaccharide-based materials.** *Bioconversion Network Annual General Meeting*. Vancouver, BC. June 6-8, 2012

Gawand, P., and R. Mahadevan. **Higher order gene deletions reveal insights on the role of latent pathways in *E. coli*.** *AIChE Annual Meeting*. Minneapolis, MN. Oct. 16-21, 2011

Goacher, R., Edwards, E.A., Mims, C., and E.R. Master. **Development of ToF-SIMS enzyme screening assays.** *18th International Conference on Secondary Ion Mass Spectrometry*. Riva del Garda, Italy. Sep. 18-23, 2011

Goacher, R., Edwards, E.A., Mims, C., and E.R. Master. **First use of ToT-SIMS for screening assays: enzymes active on wood.** *America Vacuum Society 58th Annual International Symposium*. Nashville, TN. Oct. 30 - Nov. 4, 2011

Gowen, C. and R. Mahadevan. **Synthetic biosystems for the production of high-value plant metabolites using microbial systems biology.** *Workshop on Modeling and Databases for the Enhancement of Terpenes in Plants, COST PlantEngine.* Wageningen, Netherlands. Feb. 16, 2012

Ho, H. C., Devine, C., Edwards, E., Beiko, R., and R. Mahadevan. **Phylogenetic and functional analysis on an anaerobic benzene-degrading community.** *61st Canadian Chemical Engineering Conference*. London, ON. Oct. 23-26, 2011

Hong, Y., Nizami, A.-S., Pourbafrani, M., Saville, B.A., and H.L.MacLean. **Environmental–economical analysis of cellulase production.** *Bioconversion Network Annual General Meeting*. Vancouver, BC. June 6-8, 2012

Javaherian, S., and A.P. McGuigan. ***In vitro* model system of gene expression patterning.** *TERMIS-NA Annual Meeting*. Houston, TX. Dec. 11-14, 2011

Jeremic, D. , and E.R. Master. **Enzymes and wood: fundamental of penetration and chemical degradation.** *61st Canadian Chemical Engineering Conference*. London, ON.

Li, Y.X., and Edwards, E.A. **Adapting KB-1 a dechlorinating enrichment culture to dechlorinate acidic contaminated sites.** *61st Canadian Chemical Engineering Conference.* London, ON. Oct. 23-26, 2011, 2012

Li, J.J. **Adaptation of a dechlorinating culture to acidic environments.** *8th International Coference on Remediation of Chlorinated and Recalcitrant Compounds*. Monterey, CA. May 21-24, 2012

Ma, E., Zhuang, K., and R. Mahadevan. **Microbial community modeling and the design of effective bioremediation strategy.** *CsChE Annual Meeting.* London, ON. Oct. 24-26, 2011.

Mahadevan, R. **Model-based engineering of metabolism.** *ASBMB Special Symposia of Chemical, Synthetic and Systems Biology*. Snowbird, UT. Oct. 15, 2011

Mahadevan, R. **Model-based design of metabolism.** *Synthetic Biology Symposium*. Montreal, QC. May 21, 2012

Mahadevan, R. **Robustness of metabolic networks.** *Complex Systems Seminar Series, Northwestern University*. Evanston, IL. Feb. 23, 2012

Mahadevan, R. **Model-based approaches for engineering metabolism.** *12th Annual Conference of the Canadian Society of Microbiologists*. Vancouver, BC. June 20-23, 2012

Mahadevan, R. **Model-based design of metabolism.** *Pacific Northwest National Laboratory*. Richland, WA. July 19, 2012

Master, E.R. **Enzymes for the production of high-value bioproducts.** *University of Tromsø*. Tromsø, Norway. May 31, 2012

Master, E.R. **Development of surface analysis techniques to monitor enzyme action on insoluble plant biomass.** *University of Copenhagen*. Copenhagen, Denmark. June 12, 2012

Master, E.R. **Enzyme technologies for the production of high-value polymers and chemicals from forest resources.** *Phytochemistry Society of North America*. London, ON. Aug 11-15, 2012

Master, E.R. **Enzymes for plant fibre engineering.** *Glycoscience Symposium*. Jyväskylä Finland. 2011

Master, E.R. **Development of novel carbohydrate oxidases through protein engineering.** *Kemira*. Finland. 2011

Master, E.R. **Enzymatic valorization of plant biomolecules.** *VTT*. Finland. 2011

Master, E.R. **Enzymatic modification of plant fibre.** Stora Enso. Imatra, Finland. 2011

Master, E.R. **Harnessing enzyme specificity for biosynthesis of new materials from complex plant polymers.** *The UMK Colloquium on New Materials*. *Aalto University*. Espoo, Finland. Nov. 2, 2011

McGee, E and L.L. Diosady. **Triple fortification of salt with iodine, iron, and folate.** *14th Annual CSChE Ontario-Quebec Biotechnology Meeting*. Ottawa, ON. May 30-31, 2012

McGuigan, A.P. **Microfabricated systems for engineering tissue morphogenesis *in vitro*.** *IBBME Distinguished Lecture Series*. Toronto, ON. Jan. 26, 2012

McGuigan, A.P., and S. Javaherian. **Designing *in vitro* tools to pattern gene expression using inducible gene expression.** *Experimental Biology Conference*. San Diego, CA. Apr. 21-25, 2012

Perez de Mora, A. **Overview of research at U of T during the outgoing phase of AnDeMiC.** *Helmholtz Centre*. Munich, Germany. June 5, 2012

Perez de Mora, A., Zila, A., McMaster, M., and E.A. Edwards. **Enhanced *in situ* bioremediation of chloroethenes in fractured bedrock: A combined approach to assess remediation and microbial activity.** *OMICS Group 2nd World Congress on Biotechnology*. Philadelphia, PA. Nov. 29 - Dec. 1, 2011

Pourbafrani, M., McKechnie, J., Saville, B., and H.L. MacLean. **Life cycle greenhouse gas impacts of ethanol, biomethane and limonene production from citrus waste.** *Bioconversion Network Annual General Meeting*. Vancouver, BC. June 6-8, 2012

Puentes Jácome, L. **An investigation on the influence of wettability on the recovery of entrapped LNAPLs via surfactant flushing.** *36th Michael Bozozuk Student Forum, Ottawa Geotechnical Group*. Ottawa, ON. Mar. 7, 2012

Salimi, F., and R. Mahadevan. **Clostridial co-culture for cellulosic biobutanol production.** *CsChE Annual Meeting*. London, ON. Oct. 24-26, 2011.

Sanscartier, D., MacLean, H.L., and B. Saville. **Cost of greenhouse gas emissions mitigation for anaerobic digestion under Ontario's feed-in-tariffs.** *LCA XI Conference*. Chicago, IL. Oct. 3-6, 2011

Savchenko, A. **Structural insights into function of bacterial pathogenic factors.** University of Florida, Gainesville, FLA, USA. March 2012

Soleas, J., Waddell, T.K., and A.P. McGuigan. **Engineering aligned epithelium using nanogroove topography.** *TERMIS-North American Annual Conference and Exposition*. Houston, TX. Dec. 11-14, 2011

Soleas, J. P., McGuigan, A. P, and T.K.Waddell.. **Engineering organized tracheal epithelium by modulating physical forces.** *12th Annual Respirology Day - University of Toronto*. Toronto, ON. June 6, 2012

Tabtabaei, S. and L.L. Diosady. **Factors minimizing emulsion stability during aqueous extraction of dehulled yellow mustard flour.** *61st Canadian Chemical Engineering Conference*. London, ON. Oct. 23-26, 2011

Tabtabaei, S. and L.L. Diosady. **Production of biodiesel from yellow mustard emulsion.** *103rd AOCS Annual Meeting & Expo*. Long Beach, CA, USA April 29 - May 3, 2012

Tran, C., Chan, P., Yakunin, A., and E. A. Edwards. **Use of isothermal titration calorimetry in biocharacterization of haloacid dehalogenases.** *14th Annual CSChE Ontario-Quebec Biotechnology Meeting*. Ottawa, ON. May 30-31, 2012

Tsai, A., Goacher, R., and E. Master. **Compositional analysis and imaging of *Arabidopsis thaliana* mutants using time-of-flight secondary-ion mass spectrometry.** *Gordon Research Conference (Gordon Research Seminar): Plant Cell Walls.* Waterville, ME. Aug. 4-5, 2012

Yang, M.I., Meyer, T., Lacourt, M., Zheng, L., Tse, A., Edwards, E., Tran, H., and D.G. Allen. **Investigating anaerobic digestion of pulp and paper mill wastewater streams using laboratory-scale reactors.** *2nd Annual BEEM Research Meeting*. Toronto, ON. Oct. 5-6, 2011

Yakunin, A. **CRISPR-associated Cas3 HD nuclease MJ0384: structure and activity.** *2nd Molecular Microbiology Meeting.* Würzburg, Germany. April 25-27, 2012

Yakunin, A. **Nuclease activity and crystal structure of the Cas4 protein SSO0001 from *Sulfolobus solfataricus*.** *5th Annual CRISPR Meeting*. Berkeley, CA. June 20-22, 2012

Zhao, J., and R. Mahadevan. **Integrated biogeochemical modeling for sustained uranium removal.** *AIChE Annual Meeting*. Minneapolis, MN. Oct. 16-21, 2011

Zila, A., Perez de Mora, A., McMaster, M., and E.A. Edwards. **Tracking microbial populations during enhanced *in situ* bioremedation of a fractured bedrock site contaminated with chloroethenes.** *8th International Coference on Remediation of Chlorinated and Recalcitrant Compounds*. Monterey, CA. May 21-24, 2012

Conference posters

Bonilla, S., and D.G. Allen. **Enhancing the dewaterability of biosludge through enzymes: The case of lysozyme.** *14th Canadian Society for Chemical Engineering Ontario-Quebec Biotechnology Meeting*. Ottawa, ON. May 30-31, 2012

Brunetti, J., and A.P. McGuigan. **Effect of planar cell polarity signaling proteins on shear-induced response of endothelial cells.** *TERMIS-NA Annual Meeting*. Houston, TX. Dec. 11-14, 2011

Foumani, M., Vuong,T., and E. Master. **Glucooligosaccharide oxidase fusion with carbohydrate binding modules: tools for synthesizing new polysaccharide-based materials.** *Bioconversion Network Annual General Meeting*. Vancouver, BC. June 6-8, 2012

Gandier, J.-A., Linder, M., Master, E., and M. Tenkanen. **Asymmetrical flow field-flow characterization (AsF4) allows the study of the assembly size and size distribution of class II hydrophobin HFBI (*Trichoderma reesei*) in solution.** *Gordon Research Conference Biointerface Science*. Les Diablerets, Switzerland. May 20-25, 2012

Garg, S., Giribaldi, R.S., Papangelakis, V.G., and R. Mahadevan. **Comparing the catalytic influence of two iron oxidizing microbial cultures.** *Conference of Metallurgists Annual Meeting*. Montreal, QC. Oct. 1-5, 2011

Goacher, R., Edwards, E., Mims, C., and E. Master. **Development of ToF-SIMS enzyme screening assays.** 18*th International Conference on Secondary Ion Mass Spectrometry*. Riva del Garda, Italy. Sept. 18-23, 2011

Hajighasemi, M. **Screening of environmental metagenomes and purified proteins for polylactate depolymerase activity.** *112th General Meeting of the American Society for Microbiology.* San Fransisco, CA. June 16-19, 2012

Hug, L.A., McMurdie, P.J., Blainey, P.C., Sczyrba, A., Woyke, T., Quake, S.R., Spormann, A.M., and E.A. Edwards. **Single cell amplified genomes of three dechlorinating organisms reveal mechanisms of co-operative reductive dechlorination of chlorinated solvents.** *112th General Meeting of the American Society for Microbiology.* San Fransisco, CA. June 16-19, 2012

Islam, M.A., Edwards, E.A., and R. Mahadevan. **Investigating Dehalococcoides transcriptomes with a pan-genome-scale metabolic model.** *Genome Biology and Bioinformatics Annual Retreat.* Toronto, ON. May 23, 2012

Javaherian, S., and A.P. McGuigan. **Design principles for generating sharp gene expression patterns *in vitro* in dynamic and re-organizing tissues.** *Gordon Research Conference Signal Transduction by Engineered Extracellular Matrices*. Biddeford, MA. July 8-13, 2012

Jeremic, D., Goacher, R.E., Radhamony-Capron, R., and E.R. Master. **Structural and compositional analysis of residual plant fibre following enzyme treatment.** *Bioconversion Network Annual General Meeting*. Vancouver, BC. June 6-8, 2012

Kaur, A.P., Stogios, P.J., Petit, A.-P., Xu, H., Cui, H., Yim, V., and A. Savchenko. **High throughput crystallization and characterization of extracellular fungal proteins involved in biodegradation of lignocellulose.** *Genozymes AGM 2012*. Montreal, QC. Aug. 30-31, 2012

Lebron, C., Ritalahti, K.M., Loeffler, F.E., Davis, G., Ogles, D., Barros, N., Crea, C., Major, D., Petrovskis, E., Dennis, P., Druar, X., Wilkinson, J., Duhamel, M., Edwards, E.A., Perez de Mora, A., Yeager, C., and J. Hatt. **Verification of laboratory and field procedures to reduce variability in quantitative PCR testing of groundwater.** *Partners in Environmental Technology Technical Symposium and Workshop*. Washington, DC. Nov. 29, 2011

Londono, C., and A.P. McGuigan. **Engineering cell-cell interactions to control tissue morphogenesis in endothelial cell sheets.** *TERMIS-NA Annual Meeting*. Houston, TX. Dec. 11-14, 2011

Molenda, O., Liang, X., Hug, L., Manchester, M., Tang, S., and E.A. Edwards. **Deducing the role of reductive dehalogenase enzymes in mixed microbial cultures used for bioremediation of 1,1,2,2-tetrachloroethane.** *14th International Symposium on Microbial Ecology*. Copenhagen, Denmark. Aug. 19-24, 2012

Padilla-Crespo, E., Yan, J., Ritalahti, K.M., Loeffler, F.E., Tang, S., and E.A. Edwards. **Identification of reductive dechlorination biomarker genes for chlorinated solvent site assessment and bioremediation monitoring.** *Partners in Environmental Technology Technical Symposium and Workshop*. Washington, DC. Nov. 29, 2011

Salimi, F., and R. Mahadevan. **Metabolic characterization of a clostridial co-culture for cellulosic biobutanol production in a consolidated bioprocessing.** *34th Symposium on Biotechnology for Fuels and Chemicals.* New Orleans, LA. April 30-May 3, 2012.

Sherif, M., Waung, D, Abou-Zaid, M., and E. Master. **Bacterial laccases expressed using microaerobic cultivation displays oxidative activity on antioxidant phenolic compounds.** *Phytochemistry Society of North America*. London ON. Aug. 11-15, 2012

Scnurr, P.J., and D.G. Allen. **Identifying critical growth parameters and their respective ranges for the rapid growth of algae biofilms.** *14th Annual CSChE Ontario-Quebec Biotechnology Meeting*. Ottawa, ON. May 30-31, 2012

Stogios, P.J., Shakya T., Evdokimova E., Wawrzak Z., Wright G.D., and A. Savchenko. **Resisting resistance: structural genomics and drug design against antibiotic resistance.** *51st International Conference on Antimicrobial Agents and Chemotherapy*. Chicago, IL. Sept. 10-17, 2011

Stogios, P.J., So, N., Kudrytska, M., Gray-Owen, S., and A. Savchenko. **Structure-informed reverse vaccinology against *Streptococcus pneumoniae* Canada MDR 19A.** *Microbiology and Infectious Diseases Research Day, University of Toronto*. Toronto, ON. June 26, 2012

Tabtabaei, S. and L.L. Diosady. **Aqueous and enzymatic extraction processes for the production of food-grade proteins and industrial oil from dehulled yellow mustard flour.** *50th CIFST National Conference*. Niagara Falls, ON. May 27-29, 2012

Tchigvintsev A., Popovic A., Alawieh N., Tran Hai, Kovacic F., Flick R., Brown G., Tchigvintsev D., Somody C.J., Chernikova T.N., Golyshina O.V., Savchenko A., Yakimov M., Golyshin P.N., Jaeger K.-E., and Yakunin A.F. **Screening and characterization of novel esterases from marine metagenomes.** *Gordon Conference: Biocatalysis*. Smithfield, RI. July 8-13, 2012

Tran, C., P. Chan, A. Yakunin, E. A. Edwards. **Biochemical characterization of haloacetate dehalogenases.** *112th General Meeting of the American Society for Microbiology.* San Fransisco, CA. June 16-19, 2012

Tsai, A., Goacher, R., and E. Master. **Compositional analysis and imaging of *Arabidopsis thaliana* mutants using time-of-flight secondary ion mass spectrometry.** *Gordon Research Conference: Plant Cell Walls*. Waterville, ME. Aug 5-10, 2012

Zhao, J., Zhuang, K., Ma, E., Barlett, M., Tartakovsky, G., Tartakovsky, A., Fang, Y., Mahadevan, R., Scheibe, T., and D. Lovley. **Building a multi-level model framework for computer-aided uranium bioremediation design**. *US DoE SBR PI Annual Meeting*. Washington DC. April 30-May 2, 2012.

Zhao, J., Scheibe, T., Lovley, D., and Mahadevan, R. **Building multi-scale mechanistic model for assessing uranium bioremediation performance under significantly different conditions.** *112th General Meeting of the American Society for Microbiology.* San Fransisco, CA. June 16-19, 2012

Grants, Awards & Scholarships

The following grants, awards and scholarships were announced during the 2011–2012 reporting period, recognizing BioZone students and researchers for excellence in research, teaching and communication. Several of our professors also received prestigious grants from Canadian and international funders in support of their innovative research programs.

Grants

International

Development of integrated modeling methods for *Escherichia coli*
Samsung Inc.
Radhakrishnan Mahadevan (Principal Investigator)

Novel selective carbohydrate oxidizing enzymes for targeted polymer and fiber modification (ENOX)
Academy of Finland
Emma Master (Collaborator)

São Paulo - Ontario Soil and Water Remediation Consortium
UofT-FAPESP-UWO Joint Call for Proposals
Elizabeth Edwards (Co-investigator)

The study of microbial environmental processes related to the natural attenuation of uranium at the Old Rifle site using systems-level biology
U.S. Dept. of Energy Subsurface Biogeochemical Research Program
Radhakrishnan Mahadevan (Co-Principal Investigator)

Canadian

Biomolecular self-assembly of hydrophobins and fusion constructs for biocatalytic surfaces and multienzyme complexes
Natural Sciences and Engineering Research Council of Canada: Discovery Grant
Emma Master (Principal Investigator)

Development of a 2-dimensional high-speed experimental system to analyze cellular mixing and infiltration for regenerative medicine applications
University of Toronto: Connaught New Researcher Award
Alison McGuigan (Principal Investigator)

Environmentally sustainable aviation
Natural Sciences and Engineering Research Council of Canada: CREATE program
Emma Master (Co-Investigator)

Fundamental studies of drying, combustion and ash properties of biomass and impacts on pulp and paper mill operations
Natural Sciences and Engineering Research Council of Canada: Collaborative Research Grant
Elizabeth Edwards (Co-applicant)

Innovative technologies for biorefining of wood and agriculture biomass
Natural Sciences and Engineering Research Council of Canada: Strategic Grant
Emma Master (Co-applicant)

Oligosaccharide oxidases derived from *A. strictum* and uses thereof
MaRS Innovation Proof of Principle Program
Emma Master

Regenerative Medicine and Nanomedicine Initiative Team Grant
Canadian Institutes for Health Research
Alison McGuigan (Co-Investigator)

Awards

International

Conference Travel Grant
International Society for Microbial Ecology

Fellow
International Academy of Food Science and Technology
Levente Diosady

Outstanding Student Poster Awards (2)
American Society for Microbiology

Young Investigator Award
Society for Industrial Microbiology and Biotechnology
Radhakrishnan Mahadevan

Reinvent the Toilet Challenge - 3rd Place
Bill and Melinda Gates Foundation
Elizabeth Edwards, Levente Diosady (Co-investigators)

Canadian

CSB Conference Travel Grant
University of Toronto Dept. of Cell and Systems Biology

Fellow
Canadian Academy of Engineering
Grant Allen

Professor Diran Basmadjian Teacher of the Year Award
University of Toronto Dept. of Chemical Engineering and Applied Chemistry
Alison McGuigan

Queen's Diamond Jubilee Medal
Governor General of Canada
Levente Diosady

SGS Research Travel Grant (10)
University of Toronto School of Graduate Studies

Student Life Catalyst Award
University of Toronto Dept. of Chemical Engineering and Applied Chemistry
Jine Jine Li

Undergraduate Engineering Research Day Presentation Awards
University of Toronto Faculty of Applied Science and Engineering
Zahidul Islam (1st Place)

Undergraduate Engineering Research Day Poster Awards
University of Toronto Faculty of Applied Science and Engineering
Nancy Li (Runner-Up)

Scholarships

Canada Graduate Scholarship (4)
Natural Sciences and Engineering Research Council of Canada

Colin Hahnemann Bayley Fellowship in Chemical Engineering
University of Toronto

Evald Torokvei Scholarship for Community Involvement
University of Toronto

Frank Howard Guest Bursary for Academic Standing
University of Toronto Faculty of Applied Science and Engineering

Irving O. Shoichet Graduate Scholarship
University of Toronto Dept. of Chemical Engineering and Applied Chemistry

Mitacs Elevate Postdoctoral Fellowship

Norman Stuart Robertson Fellowship
University of Toronto

Ontario Graduate Scholarship (3)
Ontario Ministry of Training, Colleges and Universities

Postgraduate Scholarship
Natural Sciences and Engineering Research Council of Canada

Queen Elizabeth II Graduate Scholarship in Science and Technology (2)
Government of Ontario and University of Toronto

Regenerative Medicine Training Fellowship (2)
Canadian Institute of Health Research

Vanier Canada Graduate Scholarship
Natural Sciences and Engineering Research Council of Canada

William J. Dowkes Graduate Bursary
University of Toronto Dept. of Chemical Engineering and Applied Chemistry

Events

BioZone students, personnel and PIs organize and participate in a large variety of research-related events, volunteer activities and social outings. In addition to regular meetings among individual research groups, the events listed below highlight activities that cross disciplines to foster the exchange of ideas.

Research & Training

2nd Annual BEEM Research Meeting

On October 5 and 6, 2011, we hosted the 2nd Annual BEEM Research Meeting at Trinity College. This annual event brought together 85 researchers, international collaborators and partners from this 4-yr project to share recent research results and discuss new directions.

The meeting included a full-day research symposium as well as meetings of the Science Advisory Board and Commercialization Committee. Featured speakers included:

- Andrei Osterman (Sanford Burnham Medical Research Institute, USA)
- Manuel Ferrer (Consejo Superior de Investigaciones Científicas, Spain)
- Olga and Peter Golyshin (Bangor University, UK)
- Paul (Joey) McMurdie II (Stanford University, USA)

Also in attendance were the members of the BEEM Science Advisory Board, who met with the project's principal investigators to review progress to date.

The meeting's full program can be found on the BEEM website at http://www.beem.utoronto.ca/news/2nd-annual-beem-research-meeting.

BioZone Research Discussion Meetings

Graduate students initiated and organized an ongoing series of open, monthly research discussion groups that meet for informal discussion of current topics of interest. The groups are:

- Protein engineering
- Genomic and transcriptomic analysis
- Fibre characterisation

Notes from each meeting are available through our internal wiki.

Wastewater Treatment Plant Tour

On April 30, several students and personnel visited the Mid-Halton region wastewater treatment plant in Oakville as part of the Water Environment Association of Ontario (WEAO). The group received a detailed tour of the facilities.

Outreach & Media

High School Science Fair Support

BioZone was proud to once again mentor enthusiastic high school students in our labs for award-winning science fair projects. Graduate students Fei Luo and Kai Wei from Elizabeth Edwards' research group mentored a group of Gr. 9 students competing in the Sanofi BioGENEius Challenge with a project on the inhibition of cyanobacteria. Three additional graduate students served as volunteer judges at the Toronto regional competition of this fair.

Radhakrishnan Mahadevan and graduate student Vik Pandit mentored a high school student for a science fair project titled "Co-inoculation of *S.oneidensis* and *G.sulfurreducens* for Novel Microbial Fuel Cell Enhancement". The project was selected as one of eighteen from across Canada to be part of Team Canada ISEF to compete in the Intel International Science and Engineeering Fair in Pittsburgh, and won 3rd place overall in the microbiology category ($1000 prize).

DEEP Summer Academy

Several BioZone personnel were involved in the 2012 DEEP Summer Academy, reaching a total of over 100 high school students. PhD Student Alex Tsai gave a 30 min talk on his work on transgenic *Arabidopsis* to Gr. 9 and 10 in the genetic engineering course, followed by lab tours. PhD Student Maryam Foumani led a lab demonstration and tour for students enrolled in the synthetic biology course.

Christina Heidorn also led 45 min. tours for Gr. 9 and 10 students enrolled in the biomolecular engineering course.

In addition, BioZone hosted about 50 students from the DEEP program for a 1-hr Lunch & Learn session on bioengineering. Undergraduate summer student Amy Sang and Christina Heidorn presented an overview of the field, and PhD Student Cheryl Devine gave a lively talk on bioremediation.

Lab Tours

As in previous years, BioZone often hosts visiting groups for tours of our facilities. Whenever possible these are led by graduate students to provide an opportunity to hone their public communication skills.

This year, over 300 visitors participated in these tours, including:

- LOT: Thirty undergraduate students as part of the Leaders of Tomorrow program.
- Graduate Research Weekend: Approximately 25 prospective graduate students from around the world during this annual event.
- March Break Open House: Approximately 100 high school students toured our facilities with several of our graduate students during this annual event for prospective undergraduates. Tours showcased anaerobic biorectors, fuel cells, the molecular biology lab and anaerobic gloveboxes.
- Welcome to Engineering: In May, approximately 80 students and parents toured our facilities as part of this annual event.
- Spring Reunion: We were delighted to welcome approximately 60 alumni to our labs during the annual Spring Reunion event.
- Convocation tours: Graduates and their families had the opportunity to visit our facilities during the annual Convocation event in the Wallberg Building.

BioZone Research in the Media

Several researchers' work was featured in local and national publications this year:

- *"Using bacteria to eat the toxic chemicals that pollute groundwater"*, Toronto Star, March 1, 2012
- *"Chemical Engineers Do It All"*, Jobpostings.ca online magazine, March 1, 2012
- *"From global swarming to butt-kicking bugs"* in the Globe & Mail's special section *"Report on Green Solutions"* , April 9, 2012
- *"U of T engineers win third place in Gates Foundation toilet challenge"*, Toronto Star and other news outlets, August 15, 2012

Guest Speakers & Visitors

In addition to the visiting speakers at the BEEM Research Meeting (see pg. 41), BioZone PIs hosted a number of guest speakers throughout the year, some as part of the Lectures at the Leading Edge seminar series:

Lorenz Adrian, Helmholtz Centre for Environmental Research (Edwards)
Dan Cullen, Forest Products Lab, Madison (Master)
Hiroaki Kitano, Okinawa Institute of Science and Technology Graduate University, Japan (Mahadevan)
Eugene Koonin, National Center for Biotechnology Information, NIH, Bethesda (Yakunin)
Richard Luthy, Stanford University (Edwards)
Matthew Scott, Waterloo University (Mahadevan)
Trevor Stuthridge, SCION, New Zealand (Allen)

Grant Allen hosted visiting scholar Professor Prasad Dhurjati from the Univeristy of Delaware's Dept. of Chemical Engineering for a two-month visit.

We were pleased to welcome a delegation of professors from Tianjin University of Commerce in China, led by Dean Zhang Kun Sheng, to BioZone for a day-long visit that included a tour of our facilities and discussion with PIs.

On June 5, twelve PhD students and faculty members from Wageningen University visited BioZone as part of a tour of North American research institutions. The visit included presentations by Dutch and BioZone researchers, as well as an extensive tour of our facilities (pictured below).

Sixteen prospective graduate students and two professors from Saudi Arabia toured BioZone's facilities during a visit organized by the FASE recruitment office. Tours were led by graduate students and a postdoctoral fellow.

Social & Team Events

Tea Time

Every Tuesday at 3 pm, interested students, postdocs, staff and professors gather for tea and cookies at this popular event that fosters friendship, collaboration and discussion among BioZone's many researchers and labs. Birthdays are celebrated with cake!

BioZone Team Building Event

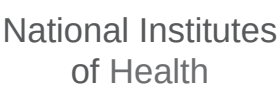
On July 17, 2012, about 60 BioZone members participated in an engaging 3-hr team building event facilitated by staff from the Faculty's Leaders of Tomorrow program. The session focused on identifying one's leadership style, and included fun and thought-provoking activities designed to teach improved team work.

Holiday Party

The annual potluck holiday party was once again a smashing success. Students organized a fantastic spread of international food, drawing on the culinary skills of our multicultural group.

We wish to thank the industry partners and foundations who supported our work this year.

We wish to thank the public sector agencies who supported our work this year.



UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Report on BioZone
July 2013

An electronic copy of this report is available through www.biozone.utoronto.ca.