



To: Faculty Council

From: Professor Doug Reeve and Professor Elizabeth Edwards

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Item: Proposal to Establish BioZone, a Centre for Collaborative Bioengineering Research in the Faculty of Applied Science and Engineering at the University of Toronto, as an Extra-departmental Unit C (EDU:C)

1. Overview

BioZone is a multidisciplinary bioengineering research centre focusing on urgent societal needs in energy, environment and health. BioZone has emerged from the Department of Chemical Engineering and Applied Chemistry at the University of Toronto and is primarily located in the Wallberg building.

BioZone's mission is to advance and capitalize on the dramatic progress in recent years in biology, particularly in genome science and genome analysis tools. There is a vast untapped reservoir of biological diversity, primarily in the microbial world, that is ripe to be mined for useful products and processes. Unfortunately, applied and environmental microbiology are not the prime focus of any specific Department on campus. BioZone fills a clear gap in this area, providing a means to connect microbiology research groups around campus and a clearinghouse for information in this area. Most importantly, BioZone fosters innovation at the interface of biology and engineering such that meaningful iterations from ideas to applications can be achieved in the context of technological, economic and public policy constraints.

Currently, BioZone is a loosely organized collection of research groups and space of nine bioengineering professors in the Department of Chemical Engineering and Applied Chemistry (Allen, Diosady, Edwards, Mahadevan, Master, McGuigan, Savchenko, Saville, Yakunin). This facility is used by the students, PDFs, research associates and staff working on projects overseen by these nine professors, as well as by researchers engaged in collaborative or co-supervised projects. A large number of collaborations exist with other research groups within and outside the department and University, and therefore many of the researchers in BioZone hail from departments other than Chemical Engineering and Applied Chemistry. Notably BioZone includes students from Cell and Systems Biology, Biochemistry, Civil Engineering, Mechanical Engineering, IBBME, Geology, Medicine, and Geography. BioZone today comprises approximately 41

Master's students, 22 PhD students, 16 PDFs, 17 undergraduate summer and 4th year thesis students and about 30 other staff including research associates, managerial staff and technicians, for a grand total of over 130 scientific and administrative personnel. Research funding received by BioZone PIs and collaborators has been strong. In the 2009-2010 year alone, BioZone PIs brought in \$6.5 Million to the U of T. BioZone space is undergoing significant renovation, funded substantially by a CFI NIF/MRI award; when all construction is complete by 2012 (see section 2), BioZone will occupy approximately 1,800 m² (NASM) in the Wallberg building. We have not yet reached capacity and expect continued growth in the years to come.

In summary, BioZone represents a unique opportunity for the University of Toronto, for the province of Ontario and for Canada to capitalize on existing strengths to create a new model for integrated research, development and technology transfer in applied bioengineering.

We propose that BioZone be formally recognized as an EDU:C as an important step in its development.

2. History of BioZone

The idea of dedicating common space to share know-how and integrate research approaches has developed from a strong track record of highly successful and well-funded interdisciplinary bioengineering research efforts. Specific examples of research foci include the following: (PIs in Chemical Engineering unless noted)

- Groundwater bioremediation (Edwards, Sherwood Lollar (Geology), Sleep (Civil) and Major (Geosyntec Consultants), Mabury (Chemistry), Mahadevan, Lovley (U. Mass.));
- Pulp and paper bioprocesses (Allen, Edwards, Master, and Tembec Inc.);
- Mammalian cell culture and tissue engineering (McGuigan, Woodhouse (Queen's), Sefton, Shoichet, Mahadevan, Edwards, Radisic)
- Development of valuable bio-products in the food and forest industries (Diosady, Master, Allen, Acosta, Saville);
- Systems biology, microbial community genome sequencing and computational analyses of cell metabolism (Edwards, Mahadevan, Cluett, Master, Loeffler (GTech), Beiko (Dalhousie), Tillier (UHN) and the US DOE Joint Genome Institute);
- Biofuels and bioenergy (Saville, Master, Mahadevan, Edwards, Yakunin, Allen, MacLean (Civil), Thomson (Mechanical), Liss (Queens) Wolfaardt (Ryerson))
- Enzyme discovery and characterization (Edwards, Yakunin (Medicine), Savchenko (Medicine), Major (Geosyntec), Saville, Campbell (Cell and Systems Biology) and Master);
- Novel enzyme targets for treatment of infectious diseases and new antibiotic drug candidates (Savchenko, Navarre (Molecular Genetics), Brumel (UHN), Wright (McMaster))
- Technology transfer, Life Cycle Analysis and policy (Major (Geosyntec Consultants, Diosady, Saville, MacLean (Civil), Reeve and Edwards).

In 2007, Professors Edwards, Mahadevan and Master secured a CFI LOF (\$550 K) to begin Wallberg building renovations in order to create a common research space for BioZone "Phase I". Renovations to Wallberg rooms 301, 302, 303, 305, 307, 308, 311,

315, and 319 were completed in 2008, providing state-of-the-art laboratory space, dedicated equipment rooms, and student workspaces shared among these three professors.

In 2009, over \$6 million in CFI NIF/MRI funds were awarded to the core of nine professors for BioZone “Phase II”. BioZone Phase II will fund the creation of new space in the Wallberg building to incorporate the significant research groups of Alexander Yakunin and Alexei Savchenko who co-lead a world-class protein production and characterization facility (Structural Proteomics in Toronto, or “SPiT”) currently located in the UofT Faculty of Medicine’s Best Building. The BioZone expansion includes approximately 270 NASM of new space in a rooftop addition on the 4th floor of Wallberg, directly above the 3rd floor BioZone space connected conveniently by an existing stairwell. BioZone “Phase II” also provides funds to renovate additional existing departmental space to accommodate the augmented BioZone activities and personnel, as well as the purchasing of new equipment for its research initiatives. Some of the new equipment includes state of the art Mass Spectrometers for metabolite analysis and a Differential Calorimeter for enzyme characterization. The Department of Chemical Engineering and Applied Chemistry and the SPiT group are also contributing funds to renovate basic laboratories to house autoclaves, dishwashing, centrifuges, culture cultivation and a brand new X-ray Diffractometer for protein structure determination. Architectural plans are well underway, and the construction of the project is planned to begin by December 2010 with occupancy by January 2012.

SPiT leaders Savchenko and Yakunin and their team of researchers bring excellent science, international reputation, state-of-the art equipment and an established high-throughput enzyme discovery pipeline that is primed to feed into the scale-up and engineering capabilities in the Faculty of Applied Science and Engineering. SPiT brings unparalleled synergies and training opportunities in biocatalysis, enzymology and protein characterization. SPiT equipment is already considerable and complementary to other research infrastructure in the Wallberg building. In recognition of their abilities to lead substantial research efforts, the Department of Chemical Engineering and Applied Chemistry has appointed both Alexei Savchenko and Alexander Yakunin as Associate Professors (status only).

In addition to funding for infrastructure renewal, the BioZone team and collaborators have also received significant operating funding for their efforts. Indeed, if one includes all funding and co-funding, leveraged funding garnered through research efforts in BioZone, the total from 2008-2014 is over \$40 Million. In particular, in 2009, Genome Canada, through the Ontario Genomics Institute, awarded the group over \$5 million over 4 years and the MRI, through the Ontario Research Fund – Global Leadership Round in Genomics and Life Sciences (ORF-GL2) program, awarded the group an additional \$3 million over 4 years for a research effort entitled Bioproducts and Enzymes from Environmental Metagenomes (BEEM). BEEM formally unites all of these researchers, collaborators at U of T and their substantial international collaborators towards the common goal of developing bioproducts and bioprocesses to address environmental concerns that are arising as Canada’s bioeconomy increases in scope and scale. In addition to obtaining research funding, BioZone has already shown its strengths in teaching and training and has produced a significant number of graduates that have been successfully employed in Canada and abroad.

3. Goals and Objectives

Our health and wellbeing are linked inextricably to the overall quality of the environment. If we are to leave this world fit for future generations to enjoy, we must balance economic progress with environmental stewardship. We believe that a key to meeting these challenges involves the application of genome-enabled biology and its 'natural' link to sustainability.

Our challenge is threefold:

- 1) To develop and deploy technically, socially and economically viable solutions to optimize use of natural resources, reuse waste material, remediate contaminated water and land, to develop robust and healthy ecosystems, to curtail disease and to offer renewable fuels and products that foster the long-term sustainability our planet and its inhabitants.
- 2) To impart students with the knowledge and ability to effectively and accurately debate and defend policies and positions that impact sustainability, so they can influence political decisions and the future of the planet.
- 3) To translate, apply and exchange biological tools developed in medicine to new applications in applied and environmental bioengineering, taking advantage of the scale of and tremendous advances in medical research.

While engineers are critical to this task - they design the devices, structures and systems that shape our world - they cannot meet this challenge alone. Given the scale of these challenges, a new paradigm for engineering research, innovation and training is necessary. It requires different techniques and diverse perspectives. The need is for a nexus, where the best minds from relevant disciplines can work together, sharing skills and expertise, to develop innovative solutions to protect and strengthen our environment and our health. BioZone provides such an opportunity. BioZone is a landscape for great minds to bring great ideas to great causes.

4. Alignment with University and Faculty Strategic Plans

University Strategic Plan

BioZone is highly aligned with most of the Major Objectives of the University of Toronto Strategic Research Plan (SRP), which are to:

- Maximize opportunities for discovery and innovation;
- Strengthen internationally competitive research and scholarship in highly promising areas;
- Foster excellence in selected areas of research that are currently undeveloped;
- Foster collaborations across disciplinary and institutional boundaries;
- Strengthen the capacity to disseminate new knowledge and innovations;
- Ensure the most effective use of our research and scholarship resources and realize the full value of intellectual property and commercialization;
- Enhance the education of undergraduate students and research training of graduate students and postdoctoral fellows; and
- Enhance our ability to attract, retain, and develop outstanding faculty, students, and research staff.

President Naylor states that "To succeed in the new global knowledge-economy, today's graduates must be creative thinkers. They must be prepared to work collaboratively with people from other cultures and other countries, draw on knowledge outside of their area of expertise and devise completely new ways of approaching the world's most pressing problems." BioZone aspires to these same goals.

Faculty Strategic Plan

The Faculty of Applied Science and Engineering has several collaborative graduate and undergraduate programs in Bioengineering or overlapping fields. BioZone fits very nicely with these initiatives, offering undergraduate and graduate students opportunities to carry out research projects with a clear practical focus that links to what they have learned in class. Thus, BioZone is an excellent receptor for students from the Bioengineering minor. Three new bioengineering professors (Mahadevan, Master, and McGuigan) have been recruited to the Department of Chemical Engineering and Applied Chemistry since 2005, adding to a critical mass co-located in Wallberg.

The Faculty of Applied Science and Engineering has also recently created a Centre for Sustainable Energy and is considering a Centre for Water; BioZone will complement each of these new efforts with expertise in biofuels and in biological treatment of contaminated water, respectively. BioZone also has strong links to many established centres on or near campus, including the Donnelly Centre for Cellular and Biomolecular Research (DCCBR), the Institute for Biomaterials and Biomedical Engineering (IBBME), The Structural Genomics Consortium (SGC), the Ontario Genomics Institute (OGI), the Center for Advances in Genome Evolution and Function (CAGEF), the Stable Isotope Lab (SIL) in Geology, The Nora Vaughn Laboratories in Civil Engineering, the Pulp and Paper Centre, the Graduate Collaborative Program in Genome Biology and Bioinformatics, the University Health Network (UHN) microarray and proteomic facilities, the Centre for Composites and Biomaterials Processing, and the Applied Biotechnology Program at the Mississauga Campus (among many others).

5. Structure of BioZone

BioZone organization is structured into four functional regimes: Counsel, Oversight (Steering Committee), Support and Output as shown in Figure 1 (see next page).

Steering Committee: The BioZone Director will chair a Steering Committee of four professors (including the Director) that will meet at least once a month to review strategic directions and new opportunities, provide an organizational framework for students and researchers, and oversee lab and computational resources. This Steering Committee will be assisted in its decisions by advice from a User Committee comprised of selected students, staff and PDFs. Membership in the Steering Committee will rotate among BioZone professors. The Director of BioZone will be appointed by the Dean. The Director will report administratively to the Dean who will undertake reviews at intervals corresponding to the appointment or re-appointment of the Director. Reviews will be based on benchmarks for success as described in Section 5.

The Steering Committee will oversee the following functions:

- 1) Strategic leadership (Vision, breaking edge science, recruitment, cultivation and support of faculty, organizational values and processes, external partners, fund raising)
- 2) Students (Recruitment, Orientation, Learning and Life, Seminars, Training, Tea-time, etc.)
- 3) Facilities (Space, Equipment, Methods, Safety)
- 4) Computational Resources (Hardware, Software, Network, IT Staff)

Since funding for both BioZone Phase II construction and associated research has been awarded, key administrative and technical staff members have been recruited. Note that all hires have been, and will be, made under the auspices of the Department of Chemical Engineering and Applied Chemistry or another appropriate department.

BioZone will host an annual research symposium, as well as a number of guest speakers throughout the year, a few as part of the Departmental Lectures at the Leading Edge. Student-led research events, such as “BioZone Big Thinking” are highly encouraged. “BioZone Big Thinking” is monthly event during which a topic is selected and vigorously debated. Topics to date have included “ethanol – food or fuel”, “the perils or promise of synthetic biology” and other such current events or hot issues.

6. EDU:C Status, Faculty Complement and Academic Programs

It is proposed that BioZone be established as an Extra Departmental Unit: C (EDU:C). As an EDU:C, BioZone will not be authorized to make primary teaching appointments. BioZone will track students for information and communication purposes only. Students will follow a designated program as prescribed in the calendar of the department in which they are registered.

Formation of a BioZone EDU:C will be an important step forward for those working in this field within the Faculty and beyond. It will provide a focal point and a clearinghouse for information on applied and environmental microbiology research at the University. It will provide the framework for further development of the brand, culture, methodologies and networks of BioZone. The BioZone EDU:C will enhance our outreach to prospective students, prospective collaborators and prospective industry partners. It will facilitate coherence and continuity for the research and teaching in the field.

As an EDU:C, BioZone will coordinate a set of graduate courses in applied bioscience and bioengineering and related disciplines. Various departments already offer courses in these areas across campus. BioZone will streamline and coordinate with instructors of existing courses, to develop new complementary courses and mount a cohesive and progressive suite of graduate courses to develop and build expertise and critical thinking skills in these disciplines.

7. Benchmarks and Measures of Success

The success of BioZone will be measured based on its ability to provide an outstanding research and instructional environment to develop viable technological innovation in energy, environment and health, and to be known nationally and internationally for the caliber of the research and breadth of training.

Specific measures include:

- 1) International recognition of the high quality of the research, innovation and technology transfer stemming from BioZone
- 2) The number of tangible demonstrations of technology or information transfer to industry or the public sector for societal good
- 3) The number of high caliber Canadian and International students and researchers attracted to study and enhance their careers in BioZone at the University of Toronto
- 4) The number of large research initiatives led by members of BioZone and their collaborators
- 5) The development and deployment of a cohesive stream of cross-disciplinary graduate courses in applied and environmental bioscience and bioengineering
- 6) The number of new partnerships and collaborations between BioZone and partners from academia, industry and the community.
- 7) The number of initiatives to promote integrity, ethics, sharing, collaboration, development and collegiality
- 8) The success rate and type of jobs obtained by our alumni
- 9) The ability to attract and recruit other faculty into BioZone

Recommendation and Motion for Faculty Council:

THAT the Faculty establishes “BioZone, a Centre for Collaborative Bioengineering Research” as an Extra-Departmental Unit: C (EDU:C) with the mandate to engage in research and scholarly work in applied bioscience and bioengineering, and to provide viable technological innovation in energy, environment and health.