# IBBME
# ANNUAL REPORT
# 2016-2017

Institute of Biomaterials & Biomedical Engineering
UNIVERSITY OF TORONTO

# Message from the Director

I am delighted to share the Institute of Biomaterials and Biomedical Engineering's (IBBME) 2016-2017 annual report, which showcases our many accomplishments over the past academic year.

It has been a great period of growth for IBBME. Our academic programs remained popular with students, with enrolment in our undergraduate minor, Undergraduate Summer Research Program, and graduate programs each reaching all-time highs. Graduate enrolment was boosted in part by the first class of our new Master of Engineering (MEng) in Biomedical Engineering, a professional degree program that focuses on the design, development and commercialization of biomedical devices. We also developed a MEng pathway for MD students and admitted seven of them into the program, putting IBBME at the leading edge of an emerging global trend to integrate engineering into medical training.

IBBME continued to broaden its educational mission beyond the university to the Toronto community through STEM outreach. We welcomed another cohort of Grades 7, 8 and 9 students into our IBBME Biomedical Engineering and Me (iBEAM) program over the summer, while launching the new IBBME Discovery outreach program. Developed by IBBME graduate students in partnership with the Toronto District School Board's George Harvey Collegiate Institute, Discovery engages Grade 11 and 12 students to explore biomedical engineering applications based on topics covered in the current science curriculum. Both programs have proven very popular with a diversity of students and are poised for even greater growth and impact.

Research impact is central to IBBME's mission, and we continued to lead in this regard globally. Despite historically-low federal funding rates, total research and student fellowship funding in IBBME for 2016-2017 equalled our all-time high. IBBME researchers translated their funding into several discoveries and innovations, including new nanoparticles to target cancer; novel electrical stimulation methods in clinical trials to control bladder function; improved diagnostic tests for rapid determination of risk in acute leukaemia; and injectable patches to repair damaged hearts. IBBME faculty members also continued to drive broader research enterprises at U of T, including as leads of the Medicine by Design program in regenerative medicine and the heart failure-focused Translational Biology and Engineering Program in the Ted Rogers Centre for Heart Research.

The leadership capabilities of our faculty members were highlighted in other ways this past year as well. Our former associate director of graduate studies, Julie Audet, was appointed vice-dean of graduate studies for the Faculty of Applied Science & Engineering, and our former director, Christopher Yip, was appointed to lead global initiatives as U of T's associate vice-president of international partnerships. IBBME is especially proud of Molly Shoichet for receiving the Killiam Prize in Engineering, and Paul Santerre for being recognized with the Governor General's Innovation Award.

I am proud of our progress and accomplishments in the past year. Warren Chan will take over as IBBME director in 2018 and I am excited for what lies ahead under his leadership. I hope you will continue to engage and follow with us as we embark on the next exciting phase of our growth.

**Craig A. Simmons**, Distinguished Professor of Mechanobiology & Interim Director

# IBBME Leadership, 2016-2017

## Director

Christopher M. Yip (*until June 30, 2017*)
Craig A. Simmons (*interim—effective July 1, 2017*)

## Associate Director, Graduate Programs

Julie Audet (*until June 30, 2017*)
Eli D. Sone (*effective July 1, 2017*)

## Associate Director, Professional Programs

Jan Andrysek (*effective July 1, 2017*)

## Associate Director, Research

Jonathan V. Rocheleau

## Associate Director, Undergraduate Programs

Dawn M. Kilkenny

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# Facts & Figures, 2016-2017

| | | |
|---|---|---|
| **127**<br>Undergraduate students[1] | **291**<br>Graduate students | **39%**<br>Women graduate students |
| **91**<br>New graduate students | **7**<br>Direct-entry PhD students | **9**<br>MD / PhD candidates |
| **47**<br>Total graduate degrees awarded | **$7.8M**<br>Research funding | **$6.7M**<br>Student funding |

1) This figure represents total enrolment in the Biomedical Engineering Minor and the Division of Engineering Science's Biomedical Engineering Systems Major in the 2016-2017 academic year. IBBME does not currently offer direct-entry undergraduate degree programs.

# Chapter 1: Undergraduate Programs

Undergraduate programs supported by IBBME continued to grow in the 2016-2017 academic year. Registrations in the Biomedical Engineering Minor increased by 55 per cent and our Undergraduate Summer Research Program reached an all-time high of 80 students in 2017.

Our emergent student outreach programs also engaged more than 100 pre-university students from across the Greater Toronto Area.

Our growth in undergraduate programming strengthens the pipeline for our graduate programs and serves as a solid indicator of interest in our field and Institute.

## Biomedical Engineering Minor

Enrolment in our biomedical engineering minor has continued to increase since its launch in 2014. Developed to expose undergraduate students to the field of engineering applications in health care, this program culminates in an opportunity for students to engage in one of two fourth-year courses that provide hands-on experiential learning in faculty research labs and at the Hospital for Sick Children through the *Innovation, Hammers & Nails* initiative.

A total of five courses are required for students to complete this minor. Students can declare the minor in their first year with courses concentrated in third and fourth year. All students in the Faculty of Applied Science & Engineering, with the exception of Engineering Science students in the Biomedical Systems Engineering Major, may enrol in this minor.

### Figure 1.1 Biomedical Engineering Minor Enrolment[1]

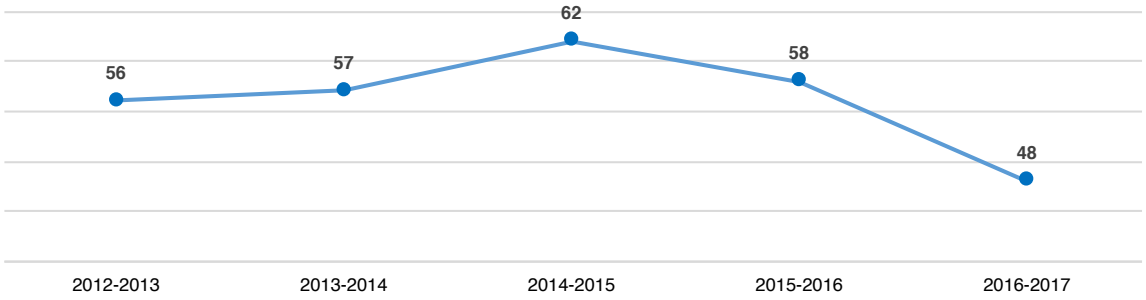
| Academic Year | ChemE | CivE / MinE | ECE | EngSci | MIE | MSE | Total |
|---|---|---|---|---|---|---|---|
| **2014-2015** | 7 | 2 | 5 | 0 | 8 | 2 | **24** |
| **2015-2016** | 15 | 0 | 14 | 1 | 16 | 5 | **51** |
| **2016-2017** | 19 | 1 | 21 | 2 | 30 | 6 | **79** |

1) Enrolment figures in this table have been updated to more accurately reflect the number of students enrolled in the Biomedical Engineering Minor in each academic year.

# Biomedical Systems Engineering Major

Enrolment in the Biomedical Systems Engineering Major has remained robust and continues to serve as one of eight areas of upper-year study for Division of Engineering Science students.

## Figure 1.2a Biomedical Engineering Systems Major Enrolment, Years 3 & 4

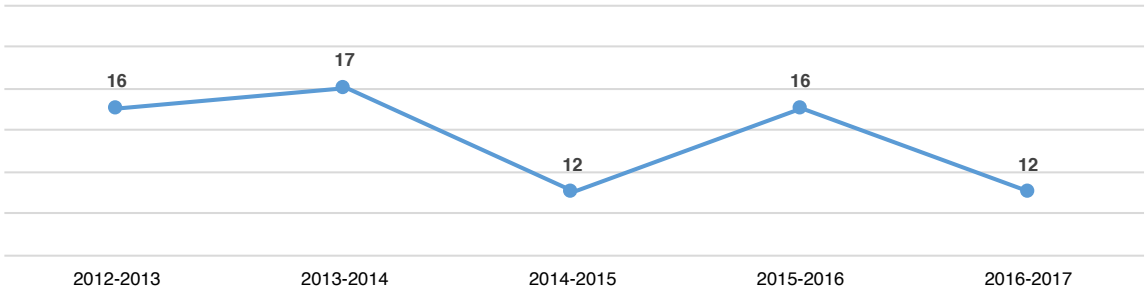



2, 3

2) The Biomedical Engineering Option was phased out between 2012 to 2014 and replaced with the Biomedical Engineering Systems Major by 2014-2015. Student enrolment reflects total headcount in both programs during the transition period.

3) Enrolment figures do not include students conducting internships in the Professional Experience Year (PEY) program.

## Figure 1.2b Biomedical Engineering Systems Major Students on Professional Experience Year (PEY) Internships



# Undergraduate Summer Research Program (USRP)

Registration in our Undergraduate Summer Research Program (USRP) reached a record high for 2017. At a total count of 80 students, this year's program continued to experience unprecedented trainee participation from students that attend U of T, but also institutions across Canada, the USA and for the first time, Turkey.

IBBME continued to provide student funding through our Director's Summer Research Opportunities (DSRO) program. This year, we supported 20 students at $2,400 each that helped leverage close to $350,000 for all 80 USRP students through matched funding from NSERC's Undergraduate Student Research Awards (USRA), U of T's Undergraduate Research Opportunity Program (UROP) and faculty supervisors.

## Figure 1.3 Undergraduate Summer Research Program Enrolment

| | U of T | Ontario[4] | Canada[4] | USA & Int'l | Total |
|---|---|---|---|---|---|
| **2013** | 15 | N/A[5] | N/A[5] | N/A[4] | **23** |
| **2014** | 20 | N/A[5] | N/A[5] | N/A[4] | **31** |
| **2015** | 49 | 5 | 1 | 0 | **55** |
| **2016** | 55 | 13 | 2 | 2 | **72** |
| **2017** | 55 | 16 | 5 | 4 | **80** |

4) Ontario figures are exclusive of U of T students while rest of Canada figures are exclusive of both U of T and Ontario figures.

5) Additional data not recorded prior to 2015.

# Undergraduate Programs Highlights

## Course innovations spur students to create award-winning capstone design solutions

For the 2016-2017 academic year, innovations in teaching and course delivery were exemplified through outstanding successes in the two capstone design courses: BME 489—*Biomedical Systems Engineering Design*, and BME 498—*Biomedical Engineering Capstone Design*.

With the opening of the expanded Design Studio, the added space provided a new environment to offer biomedical engineering design instruction to students in an open, collaborative environment that supports active, experiential hands-on learning through open-ended design projects.

In the single-semester BME 489 course, client-driven design projects enable students to learn how to work effectively in teams to design and implement solutions for clinical challenges. The *Innovation, Hammer & Nails* program sourced projects from the Hospital for Sick Children, giving students opportunities to interact with clinicians, nurses, staff and fellows to develop design solutions for real-world biomedical problems identified by these experts.

One of the BME 489 student teams, Xpan, took advantage of the new rapid prototyping capabilities in the Design Studio and developed an "adjustable trocar"—an expandable instrument used for insertion of instruments and cameras during minimally-invasive surgery. Presented as a problem by SickKids surgeon Dr. **Priscilla Chiu**, the team's design addressed an issue faced by surgeons who sometimes discover that they must remove the instrument mid-surgery and replace it with a larger one—an inefficient method that exposes patients to additional risk.

The Xpan team was invited to present their design at the American Society for Artificial Internal Organs (ASAIO) annual conference in Chicago in June 2017, and was selected as the second-place recipient in the Student Design Competition.

Xpan consequently participated in *The Hatchery Nest*, a four-month accelerator program, and won the $10,000 Lacavera Prize at U of T Engineering's Hatchery Demo Day in September 2017. Xpan also received another $5,000 from a U of T Health Innovation Hub (H2i) pitch competition, and was recognized with the 2017 IBBME Director's Biodesign Award as the top biodesign project team in BME 489 and BME 498.

In the full-year BME 498 course taught by Professor **Christopher Bouwmeester**, open-ended, student-driven design projects enable students to learn how to identify an important biomedical engineering problem as a critical first step toward inventing, designing and implementing solutions for clinical challenges. An inverted classroom approach encourages students to use pre-class assignments to come to class prepared, be engaged with relevant topics, brainstorm ideas, and develop and test their design ideas in a hands-on way in collaborative groups during class in the Design Studio.

MoveQ, a student design team from BME 498, designed MusiKinesia—a wearable electronic device constructed to help Parkinson's patients by providing auditory cues to help them practice certain movements. The team interviewed physiotherapists with expertise in Rhythmic Auditory Stimulation (RAS), a form of

therapy that provides auditory cues that enable patients to synchronize and better control their movements. They also were inspired by observing a class at the National Ballet School for Parkinson's patients. MoveQ received U of T Engineering's 2017 John W. Senders Award for Imaginative Design.

## Enrolment in the Undergraduate Summer Research Program keeps growing

Enrolment in our Undergraduate Summer Research Program (USRP) rose to a record high of 80 students in 2017. Participants included 10 students from the Translational Biology and Engineering Program (TBEP), the U of T component of the Ted Rogers Centre for Heart Research (TRCHR).

This year's theme was *Community in Undergraduate Research* and promoted the fostering of collaborative relationships and networking outside students' labs. Workshops and additional professional development activities were held throughout the 16-week program. These workshops included industry speakers, faculty research talks, laboratory skills sessions and tours of local biomedical facilities. Students also wrote abstracts and peer-reviewed the work of others, and disseminated their studies through scientific poster presentations at a final symposium.

USRP placements were held in faculty labs across U of T and at partner health-care institutions, including Holland Bloorview Kids Rehabilitation Hospital, the Hospital for Sick Children, Toronto Rehabilitation Institute, Toronto Western Hospital and the Princess Margaret Cancer Centre.

Professor **Alison McGuigan** gave the keynote address for the closing symposium, titled "Tissue-engineered culture platforms for therapy discovery."

## Outreach programs inspire pre-university students

IBBME's two student outreach programs engaged students in Grades 7 to 8 and 11 to 12.

Discovery, led by Professor **Dawn Kilkenny** and PhD candidate **Locke Davenport Huyer**, was launched and completed a successful pilot year. This unique student outreach initiative introduced senior high school students to the field of biomedical engineering by creating an immersive semester-long educational experience around IBBME's four research themes.

The 2016-2017 program theme, *The Science Behind Prosthetics*, was developed for approximately 60 Grade 11 and 12 science students from the Toronto District School Board's (TDSB) George Harvey Collegiate Institute (GHCI), in collaboration with their science teachers.

Teams of four GHCI students were created and each group was guided by an IBBME graduate student mentor to develop experimental protocols that merged prosthetics design with topics presented in the biology, chemistry or physics class they were enrolled in. GHCI students were hosted in IBBME's Teaching Laboratory and Design Studio three times during the semester-long program to execute their work. During the program, IBBME graduate students had opportunity to develop professional skills that support their thesis work. These included opportunities in curriculum creation, delivery of lectures, communication with students and high school educators, as well as oversight of practical, hands-on learning activities.

Discovery culminated in a symposium hosted at U of T where GHCI students presented their work in scientific poster format. Student presentations were

evaluated by USRP participants engaging in development of peer-assessment skills, with their recommendations contributing to the selection of three winning high school teams. Professor **Jan Andrysek** delivered a keynote address at the symposium, titled "Rehabilitation technologies targeting physical activity and mobility globally."

IBBME Biomedical Engineering and Me (iBEAM) is another outreach program that engages students in Grades 7 and 8 from across Toronto.

Led by Professor **Penney Gilbert** and executed primarily during the summer months of July and August, iBEAM hosted a total of 75 students in 2016-2017 for one-day field trips to learn about tissue engineering, medical devices and biomedical lab research in our Teaching Laboratory, Design Studio and partner facilities at U of T.

Participating students were hosted from four organizations: Big Brothers Big Sisters of Peel, Crawford Adventist Academy, TDSB's First Nations School of Toronto and Visions of Science Network for Learning.

# Chapter 2: Graduate Programs

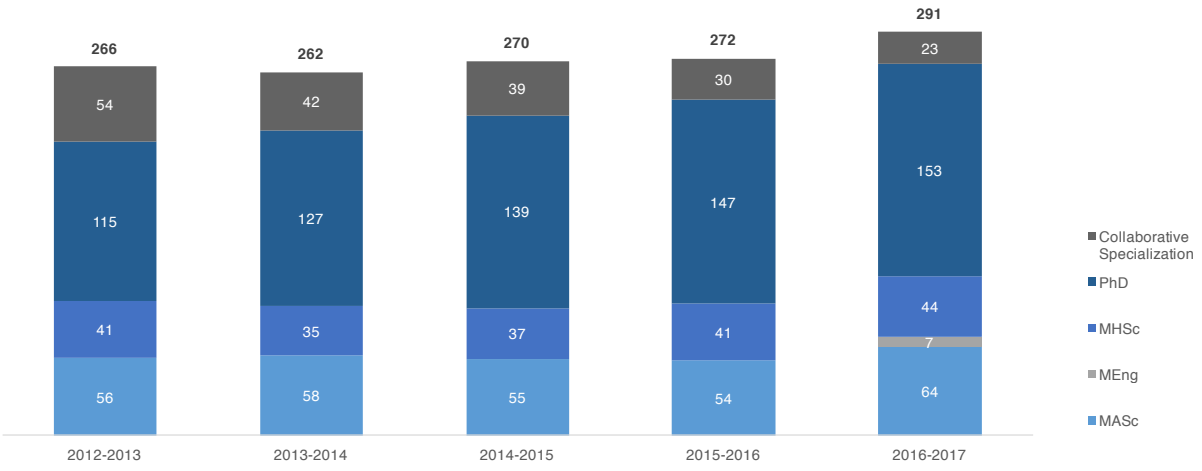
## Enrolment

Our graduate student enrolment continued to increase in 2016-2017 as our programs attracted top students from Canada and around the world. A total of 291 students pursued one of our four graduate degree programs or the Collaborative Specialization in IBBME.

Our 2016-2017 PhD enrolment continued to exceed the Faculty of Applied Science & Engineering's average number of doctoral candidates per academic unit. This trend again enforces our strength and leadership in training highly-qualified persons in biomedical engineering.

The launch of our Master of Engineering (MEng) program yielded seven registered students in 2016-2017. Additional interest from the Faculty of Medicine also spurned the development of an MD / MEng cohort, creating a part-time option for courses and an internship structured to complement the existing MD curriculum. Both streams will continue to enhance and broaden our leadership in the field of biomedical device design, development and commercialization.

### Figure 2.1 Total IBBME Graduate Student Headcount by Academic Year




| Academic Year | MASc | MEng | MHSc | PhD | Collaborative Specialization | Domestic MASc / MEng / MHSc / PhD | International MASc / MEng / MHSc / PhD | Total Students |
|---|---|---|---|---|---|---|---|---|
| **2012-2013** | 56 | N/A | 41 | 115 | 54 | 198 | 14 | 266 |
| **2013-2014** | 58 | N/A | 35 | 127 | 42 | 200 | 20 | 262 |
| **2014-2015** | 55 | N/A | 37 | 139 | 39 | 212 | 19 | 270 |
| **2015-2016** | 54 | N/A | 41 | 147 | 30 | 221 | 21 | 272 |
| **2016-2017** | 64 | 7 | 44 | 153 | 23 | 240 | 28 | 291 |

## Figure 2.2 Collaborative Specialization Headcount by Academic Year

| Year | Arts & Science | | Dentistry | Engineering | | | | Medicine | | | | | | Pharmacy | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHM | PHY | | ChemE | ECE | MIE | MSE | BCH | IMS | LMP | MBP | PSL | RSI | | |
| **12-13** | 0 | 0 | 5 | 20 | 10 | 9 | 1 | 2 | 0 | 0 | 0 | 1 | 5 | 2 | 54 |
| **13-14** | 0 | 0 | 3 | 17 | 5 | 7 | 2 | 1 | 0 | 0 | 0 | 1 | 5 | 1 | 42 |
| **14-15** | 0 | 0 | 3 | 19 | 3 | 6 | 1 | 2 | 0 | 0 | 0 | 1 | 3 | 1 | 39 |
| **15-16** | 0 | 0 | 3 | 14 | 3 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 30 |
| **16-17** | 0 | 0 | 2 | 8 | 2 | 5 | 1 | 2 | 0 | 0 | 1 | 0 | 2 | 0 | 23 |

**BCH**—Department of Biochemistry; **ChemE**—Department of Chemical Engineering & Applied Chemistry; **CHM**—Department of Chemistry; **ECE**—Edward S. Rogers Sr. Department of Electrical & Computer Engineering; **IMS**—Institute of Medical Science; **LMP**—Department of Laboratory Medicine & Pathobiology; **MBP**—Department of Medical Biophysics; **MIE**—Department of Mechanical & Industrial Engineering; **MSE**—Department of Materials Science & Engineering; **PHY**—Department of Physics; **PSL**—Department of Physiology; **RSI**—Rehabilitation Sciences Institute

## Figure 2.3 IBBME Students by Gender, 2016-2017

| MASc | | | MEng | | | MHSc | | | PhD | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | F | N/A | M | F | N/A | M | F | N/A | M | F | N/A | M | F | N/A |
| 35 | 28 | 1 | 3 | 4 | 0 | 24 | 19 | 1 | 86 | 54 | 13 | 148 (55%) | 105 (39%) | 15 (6%) |

## Figure 2.4 IBBME Students by Primary Research Location, 2016-2017

| Location | Number of Students |
|---|---|
| **St. George Campus**[1] | **126** (47%) |
| **Off-Campus Total**[1] | **142** (53%) |
| **Baycrest Health Sciences** | 1 |
| **Holland Bloorview Kids Rehabilitation Hospital** | 21 |
| **Hospital for Sick Children** | 16 |
| **Institute for the Advancement of Technology for Health (TECHNA)** | 4 |
| **Translational Biology & Engineering Program (TBEP)** | 29 |
| **Mount Sinai Hospital** | 6 |
| **North York General Hospital** | 1 |
| **Princess Margaret Cancer Centre** | 8 |
| **St. Michael's Hospital** | 3 |
| **Sunnybrook Health Sciences Centre** | 12 |
| **Toronto General Hospital** | 6 |
| **Toronto Western Hospital** | 6 |
| **Toronto Rehabilitation Institute** | 28 |
| **University of Toronto Mississauga** | 1 |
| **Total** | **268** (100%) |

1) This figure includes all MASc, PhD and second year MHSc candidates' research laboratory locations based on the primary appointment of each student's thesis supervisor. MHSc students in year one and MEng students are counted as studying on the St. George campus. Collaborative Specialization students are excluded.

## Figure 2.5 IBBME Students in MD / PhD and External Collaborative Specializations, 2016-2017

| | |
|---|---|
| **Cardiovascular Sciences** | 3 |
| **Developmental Biology** | 2 |
| **Health Care, Technology & Place** | 4 |
| **Musculoskeletal Sciences** | 2 |
| **MD / PhD** | 9 |
| **Neuroscience** | 18 |
| **Knowledge Media Design** | 1 |
| **Women's Health** | 1 |
| **Total** | 40 |

## Figure 2.6 Comparison of IBBME with the Faculty of Applied Science & Engineering, 2016-2017

| | IBBME | APSC Average[2] | APSC Total |
|---|---|---|---|
| **Professional Master's** (MEng & MHSc) | 51[3] | 126 | 880 |
| **Research Master's** (MASc) | 64 | 87 | 608 |
| **Doctoral** (PhD) | 153 | 125 | 877 |
| **All Students** | 268 | 338 | 2,365 |

2) This figure represents the average number of students in each of the Faculty of Applied Science & Engineering's (APSC) seven graduate units.

3) IBBME is the only unit offering the MHSc in Clinical Engineering program. This figure accounts for 100 per cent of the Faculty of Applied Science & Engineering's MHSc student headcount.

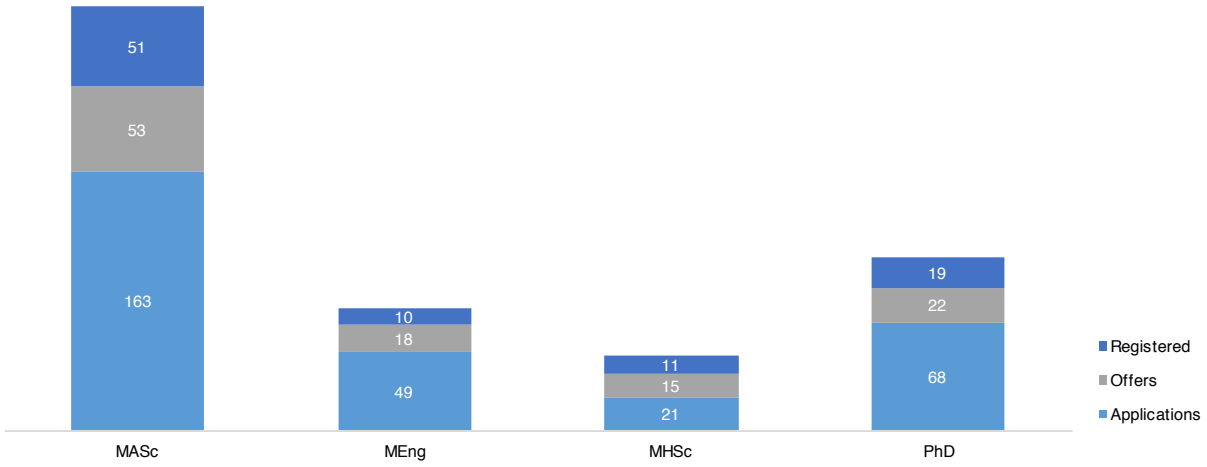
# Admissions

Applications to our graduate programs continued to reflect growing demand for degrees that offer advanced skills and training in biomedical engineering.

Newly registered students from the 2016-2017 admissions cycle increased by 30 per cent over the previous academic year.

Our Master of Engineering program registered ten new students for 2017-2018. We anticipate this program to increase in enrolment over the next few years, particularly with the establishment of the MD / MEng cohort.

## Figure 2.7 Admissions Summary for the 2016-2017 Academic Year




| | Applications | Offers | Registered[4] | Yield |
|---|---|---|---|---|
| MASc | 163 | 53 | 51 | 96% |
| MEng | 49 | 18 | 10[5] | 56% |
| MHSc | 21 | 15 | 11 | 73% |
| PhD | 68 | 22 | 19 | 86% |
| **Total** | 296 | 108 | 91 | 84% |

4) Newly registered students as of November 1, 2017.

5) This figure excludes the first cohort of seven MD / MEng students who were admitted directly by the School of Graduate Studies.

## Research Programs Admissions—MASc & PhD

### Figure 2.8a Master of Applied Science (MASc) in Biomedical Engineering, DOMESTIC & INTERNATIONAL

| Academic Year | Applications | | Offers | | Registered | | Yield | |
|---|---|---|---|---|---|---|---|---|
| | Domestic | International | Domestic | International | Domestic | International | Domestic | International |
| **2012-2013** | 105 | 47 | 22 | 4 | 20 | 2 | 91% | 50% |
| **2013-2014** | 86 | 42 | 30 | 4 | 26 | 3 | 87% | 75% |
| **2014-2015** | 91 | 38 | 33 | 2 | 25 | 2 | 84% | 100% |
| **2015-2016** | 102 | 42 | 31 | 4 | 25 | 2 | 81% | 50% |
| **2016-2017** | 121 | 42 | 50 | 3 | 48 | 3 | 96% | 100% |

### Figure 2.8b Doctor of Philosophy (PhD) in Biomedical Engineering, DOMESTIC & INTERNATIONAL

| Academic Year | Applications | | Offers | | Registered | | Yield | |
|---|---|---|---|---|---|---|---|---|
| | Domestic | International | Domestic | International | Domestic | International | Domestic | International |
| **2012-2013** | 27 | 48 | 14 | 3 | 13 | 3 | 93% | 100% |
| **2013-2014** | 27 | 33 | 12 | 6 | 10 | 6 | 83% | 100% |
| **2014-2015** | 25 | 34 | 13 | 4 | 9 | 4 | 69% | 100% |
| **2015-2016** | 27 | 37 | 13 | 6 | 11 | 3 | 85% | 50% |
| **2016-2017** | 24 | 44 | 17 | 5 | 15 | 4 | 88% | 80% |

### Figure 2.8c Number of Direct-Entry PhD Students, DOMESTIC & INTERNATIONAL[6]

| Academic Year | IBBME | APSC Average[7] |
|---|---|---|
| **2012-2013** | 5 | 1 |
| **2013-2014** | 7 | 1 |
| **2014-2015** | 3 | 1 |
| **2015-2016** | 5 | 2 |
| **2016-2017** | 7 | 2 |
| **Total** | 27 | 8 |

6) Figures from this table have been adjusted to more accurately reflect the number of direct-entry PhD students by excluding previous inclusion of select candidates who were registered in master's programs and returned for doctoral studies after a significant number of years between enrolment.

7) This figure represents the average number of direct-entry PhD students across seven graduate units in the Faculty of Applied Science & Engineering (APSC).

## Professional Programs Admissions—MEng & MHSc

### Figure 2.9a Master of Engineering (MEng) in Biomedical Engineering, DOMESTIC & INTERNATIONAL

| Academic Year | Applications | | Offers | | Registered | | Yield | |
|---|---|---|---|---|---|---|---|---|
| | Domestic | International | Domestic | International | Domestic | International | Domestic | International |
| **2015-2016** | 30 | 16 | 10 | 4 | 4 | 3 | 40% | 75% |
| **2016-2017** | 24 | 25 | 14 | 4 | 10 | 0 | 70% | 0% |

### Figure 2.9b Master of Health Science (MHSc) in Clinical Engineering, DOMESTIC & INTERNATIONAL

| Academic Year | Applications | | Offers | | Registered | | Yield | |
|---|---|---|---|---|---|---|---|---|
| | Domestic | International | Domestic | International | Domestic | International | Domestic | International |
| **2012-2013** | 27 | 2 | 20 | 1 | 15 | 1 | 75% | 100% |
| **2013-2014** | 30 | 8 | 23 | 2 | 17 | 0 | 74% | 0% |
| **2014-2015** | 32 | 7 | 26 | 3 | 17 | 1 | 65% | 33% |
| **2015-2016** | 39 | 9 | 28 | 2 | 21 | 1 | 75% | 50% |
| **2016-2017** | 19 | 2 | 14 | 1 | 10 | 1 | 79% | 100% |

## Figure 2.10 Geographic Origin of Newly Registered Students, 2016-2017[8]

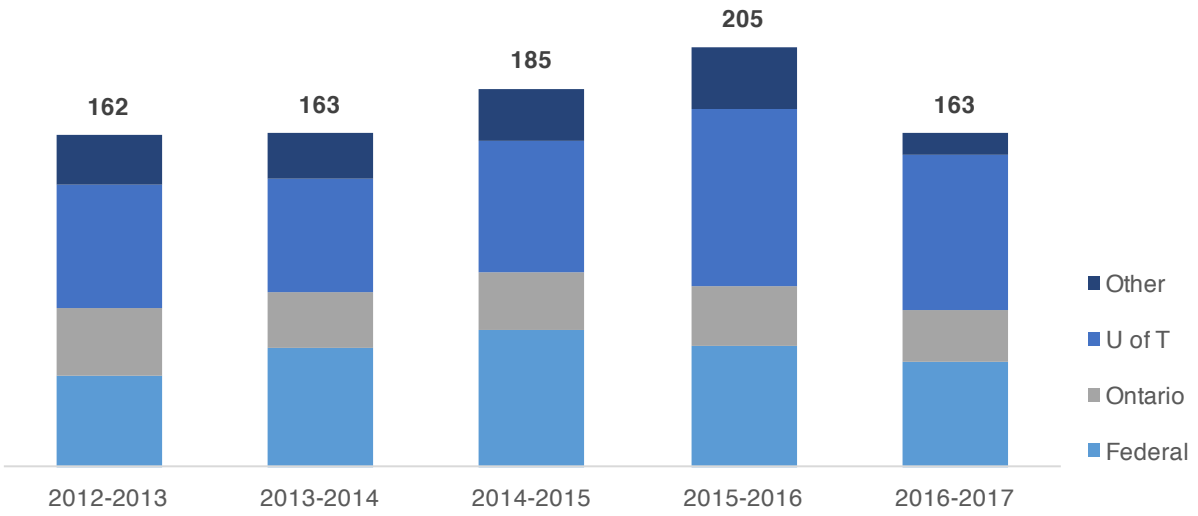
| Location | Number of Students |
|---|---|
| **Canada** | **80** |
| Alberta | 4 |
| British Columbia | 1 |
| New Brunswick | 1 |
| Ontario | 74 |
| **Iran** | **3** |
| **Japan** | **1** |
| **South Korea** | **1** |
| **Mexico** | **1** |
| **United States of America** | **4** |
| California | 1 |
| Florida | 1 |
| Massachusetts | 2 |
| **United Kingdom** | **1** |
| **Canada Total** | **80** (88%) |
| **Outside of Canada Total** | **11** (12%) |
| **Total Newly Registered Students** | **91** (100%) |

8) This table presents information based on each student's initial mailing address at the time of application.

# Student Scholarships & Funding

Our graduate students continued to receive a high number of scholarships and awards in 2016-2017, acquiring more than $6.5 million in total student funding. Our research-stream students held more than $1 million in federal tri-council awards, including seven Vanier Canada Graduate Scholarships.

## Figure 2.11 Number of Student Awards & Scholarships by Source




| Academic Year | Federal[8] | Ontario[9] | U of T[10] | Other[11] | Total |
|---|---|---|---|---|---|
| **2012-2013** | 44 | 34 | 60 | 24 | 162 |
| **2013-2014** | 58 | 27 | 56 | 22 | 163 |
| **2014-2015** | 67 | 28 | 64 | 26 | 185 |
| **2015-2016** | 59 | 29 | 87 | 30 | 205 |
| **2016-2017** | 51 | 26 | 76 | 10 | 163 |

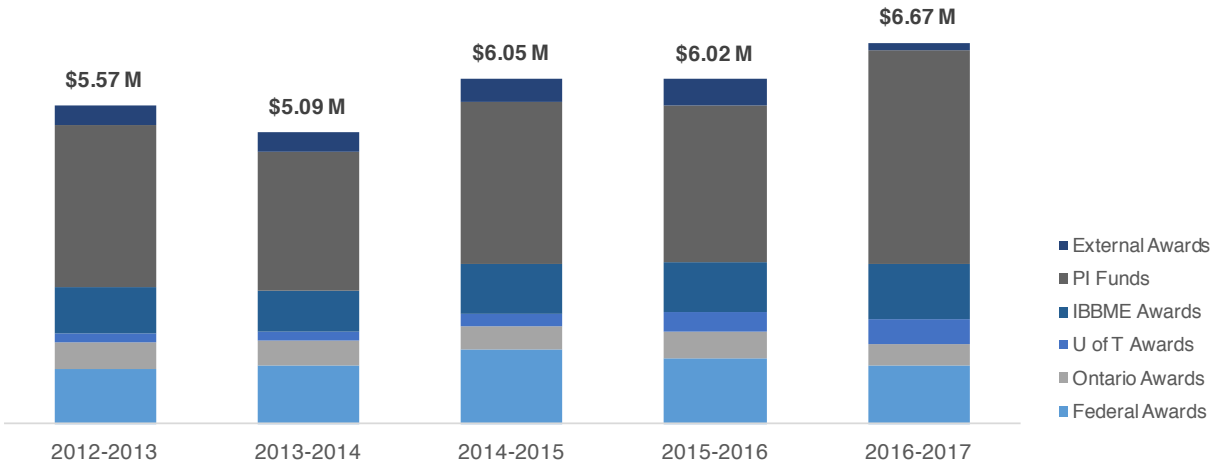
8) Federal figures represent funding from the Canadian government, such as award programs issued by the Canadian Institutes of Health Research (CIHR) and the Natural Sciences & Engineering Research Council of Canada (NSERC).

9) Ontario figures represent scholarships funded by the provincial government, including the Ontario Graduate Scholarship (OGS) program, the Queen Elizabeth II Graduate Scholarships in Science & Technology (QEII-GSST) program, and the Ontario Trillium Scholarships (OTS) program.

10) U of T awards represent funding administered by the School of Graduate Studies and awarded to IBBME students.

11) Other awards include support for students from partner hospitals, outside organizations and governments.

## Figure 2.12 Student Funding by Source




| Academic Year | Federal Awards[12] | Ontario Awards[13] | U of T Awards[14] | IBBME Awards[15] | PI Funds[16] | Other Awards[17] | Total |
|---|---|---|---|---|---|---|---|
| **2012-2013** | $943,985 | $481,667 | $139,138 | $816,119 | $2,851,345 | $341,101 | $5,573,355 |
| **2013-2014** | $1,017,583 | $424,920 | $154,745 | $734,665 | $2,419,866 | $338,071 | $5,089,850 |
| **2014-2015** | $1,287,303 | $414,267 | $216,909 | $861,878 | $2,853,474 | $412,939 | $6,046,770 |
| **2015-2016** | $1,137,918 | $474,897 | $326,770 | $885,184 | $2,744,817 | $454,265 | $6,023,852 |
| **2016-2017** | $1,004,248 | $393,334 | $424,953 | $979,519 | $3,745,998 | $124,547 | $6,672,599 |

12) Federal figures represent funding from the Canadian government, including award programs issued by the Canadian Institutes of Health Research (CIHR) and the Natural Sciences & Engineering Research Council of Canada (NSERC).

13) Ontario figures represent scholarships funded by the provincial government, including the Ontario Graduate Scholarship (OGS) program, the Queen Elizabeth II Graduate Scholarships in Science & Technology (QEII-GSST) program, and the Ontario Trillium Scholarships (OTS) program.

14) U of T awards represent funding administered by the School of Graduate Studies and awarded to IBBME students.

15) IBBME funding represents scholarships and financial support issued by the Institute for biomedical and clinical engineering students.

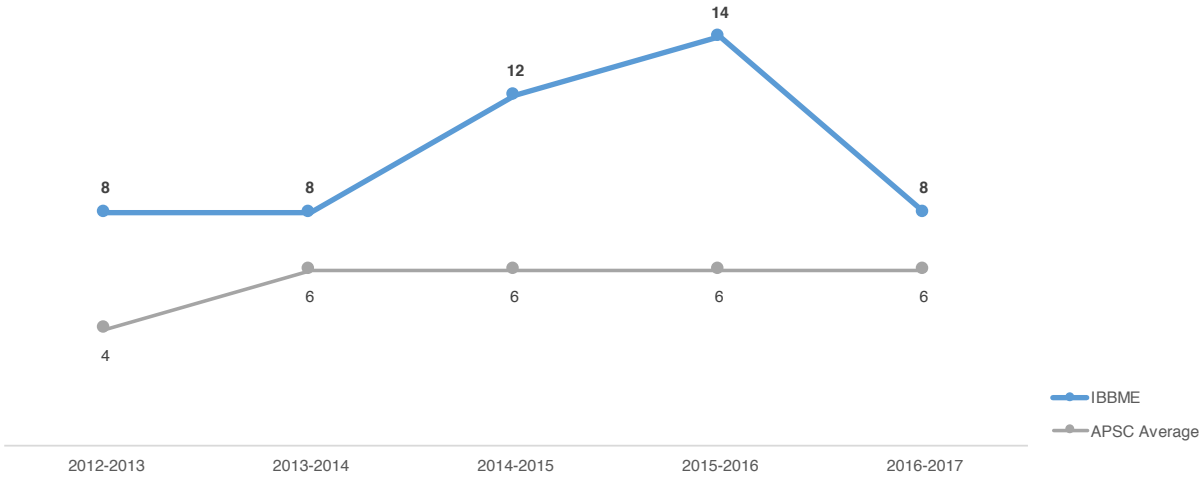
16) Principal investigator (PI) funds represent financial support for IBBME students from research grants awarded to faculty supervisors.

17) Other awards include support for students from partner hospitals, other outside organizations and governments.

# Graduate Degrees Completion

The number of students fast-tracking from MASc to PhD programs during 2016-2017 was robust. This continues to emphasize the value of a PhD degree in biomedical engineering for students pursuing a career in research.

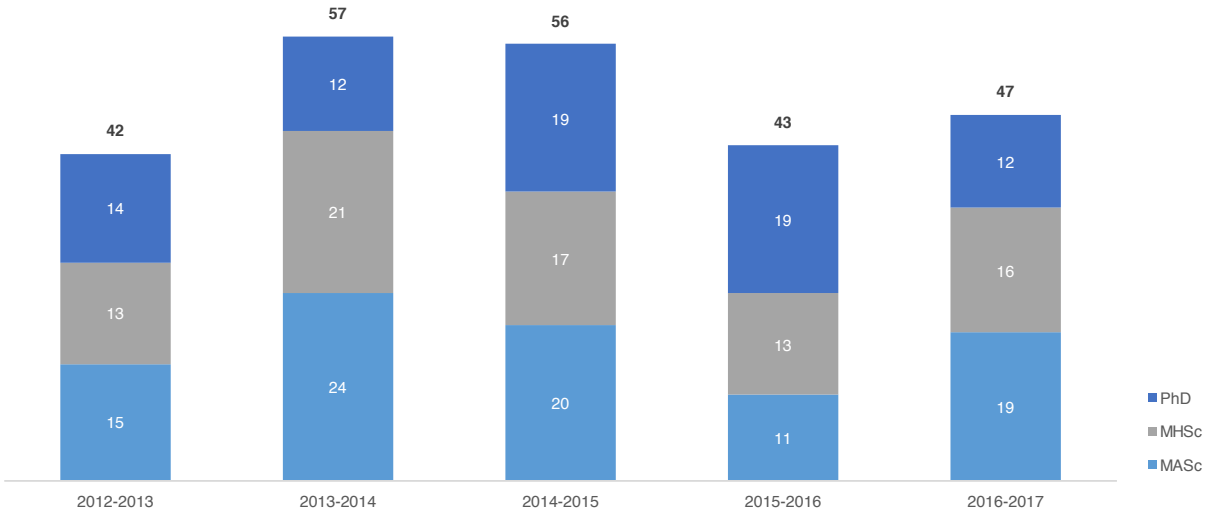
## Figure 2.13 Number of Students Fast-Tracked from MASc to PhD




| Academic Year | IBBME | APSC Average[18] |
|---|---|---|
| **2012-2013** | 8 | 4 |
| **2013-2014** | 8 | 6 |
| **2014-2015** | 12 | 6 |
| **2015-2016** | 14 | 6 |
| **2016-2017** | 8 | 6 |
| **Total** | 50 | 28 |

18) This figure represents the average number of students fast-tracked from MASc to PhD across seven graduate units in the Faculty of Applied Science & Engineering (APSC).

## Figure 2.14 Degrees Awarded by Academic Year




| Academic Year | MASc | MHSc | PhD | Total |
|---|---|---|---|---|
| **2012-2013** | 15 | 13 | 14 | 42 |
| **2013-2014** | 24 | 21 | 12 | 57 |
| **2014-2015** | 20 | 17 | 19 | 56 |
| **2015-2016** | 11 | 13 | 19 | 43 |
| **2016-2017** | 19 | 16 | 12 | 47 |

## Figure 2.15 Average Time to Completion in Years for MASc, MHSc and PhD Students[19]

| Academic Year | MASc | MHSc | PhD |
|---|---|---|---|
| **2012-2013** | 2.0 | 2.0 | 5.0 |
| **2013-2014** | 2.0 | 2.0 | 5.0 |
| **2014-2015** | 2.3 | 2.0 | 6.0 |
| **2015-2016** | 2.0 | 2.0 | 5.7 |
| **2016-2017** | 2.0 | 2.0 | 5.2 |

19) Time to completion represents the number of years between a student's initial enrolment in a graduate program and meeting all the requirements for graduation. This data only represents terms in which a student is registered and excludes leaves, lapses and (in most cases) the term in which convocation occurs. Where a student is fast-tracked from the MASc into a PhD, the total time for both programs is counted.

# Graduate Programs Highlights

## Offering biomedical device training to medical students

During the 2016-2017 academic year, IBBME worked with the Faculty of Medicine to launch an MD-oriented version of our Master of Engineering (MEng) program. The first cohort of seven students was admitted in September 2017.

This innovative, interdisciplinary program gives U of T medical students an opportunity to pair their full-time medical education with training in medical device development and design.

This program was developed by IBBME professors **Julie Audet** and **Christopher Yip,** and the Faculty of Medicine's Dr. **Marcus Law.** It enables medical students to learn more about how biomedical devices are created and brought to market through a series of courses in biomedical sciences, engineering technology and commercialization. It includes an applied internship on a schedule that complements the MD curriculum.

This interdisciplinary program fosters collaboration between engineering and medical professionals to help develop new biomedical devices essential to advancing care. It also provides a unique opportunity for engineering and medical students in the same classroom to share complementary perspectives that will help to identify and address unmet health-care needs.

## Strategic recruitment of domestic graduate students

In February 2017, IBBME hosted 18 top prospective students from Canadian universities outside of the Greater Toronto Area as part of the third Graduate Research Days event. This initiative, executed across the Faculty of Applied Science & Engineering, hosted more than 100 students and provided them with opportunities to meet one-on-one with potential faculty supervisors, visit research facilities and interact with current students and alumni over a three-day period.

IBBME successfully enrolled six students for the 2017-2018 year from this event—two into the MASc program, one into the MHSc program and three into the PhD program.

# Chapter 3: Research

## Research Highlights

Over the last academic year, our faculty and students continued to push the boundaries of biomedical engineering research. Here are several highlights of their work.

### New delivery strategies needed for more nanoparticle cancer drugs to reach their target

Targeting cancer cells for destruction while leaving healthy cells alone has been the promise of the field of cancer nanomedicine. But a new meta-analysis of 117 published papers led by Professor **Warren Chan** and post-doctoral fellow **Stefan Wilhelm** found that less than one per cent of designer nanoparticles reached their intended tumour target—and that figure hasn't changed much over the last 10 years.

Their analysis showed that altering the nanoparticles to target cancer cells made little difference in net delivery efficiency. The majority of nanoparticles end up in the liver, spleen and kidneys, since the job of these organs is to clear foreign substances and toxins from the blood. This suggests researchers may have to control the interaction with these organs to prevent nanoparticles from being filtered out of the blood before they reach the target tumour.

One strategy Chan and Wilhelm pursued involved engineering nanoparticles that could dynamically respond to conditions in the body by altering their surfaces or other properties. This strategy may help the particles to avoid being removed by filtering organs, but have the optimal properties needed to enter tumours.

They also argued that a new systemic and coordinated long-term strategy is needed to increase nanoparticle delivery efficiency and that researchers will need to understand much more about the interaction between nanoparticles and the body's various organs than they do today. To this end, Chan's lab is also developing techniques to visualize these interactions across whole organs using 3D optical microscopy. This particular work, titled "Three-dimensional optical mapping of nanoparticle in intact tissues," was published on April 21, 2016, in the journal *ACS Nano*.

The full results of their review, titled "Analysis of nanoparticle delivery to tumours," were published in *Nature Reviews Materials* on April 26, 2016.

### Novel treatment for overactive bladder receives clinical trial funding

An overactive bladder (OAB) is a condition that affects 18 per cent of Canadian adults and up to 500 million people worldwide. OAB involves a frequent and sudden urge to urinate, and it is particularly prevalent among people over 65 and more frequently diagnosed in women.

Professor **Paul Yoo** received funding to co-lead a clinical trial to test a novel treatment for OAB that targets the saphenous nerve, a peripheral nerve in the leg. Funding for the trial, announced on June 24, 2016, was provided by AGE-WELL and is co-led with Dr. **Sasha John**, a research associate at Baycrest. The team is collaborating with Dr. **Magdy Hassouna** at Toronto Western

Hospital on a pilot clinical trial involving 30 patients who are seeking relief from their OAB symptoms. The trial marks the first time the saphenous nerve has been targeted for OAB electrical stimulation therapy.

Yoo and his team recently showed in pre-clinical studies that electrical stimulation of the saphenous nerve inhibited the bladder in a similar fashion to that achieved by tibial nerve stimulation, an emerging therapy available to people with OAB. The new nerve stimulation target may provide better treatment due to the use of lower amplitude electrical pulses than tibial nerve stimulation, which would make it more comfortable for people with OAB. Also, the saphenous nerve does not activate foot muscles, like the tibial nerve does, which could make it a very versatile neural target for treating patients.

The investigators have multiple approved and pending patents on the technologies being explored by this project and have been approached by several industrial partners interested in this novel therapy for OAB. If successful, the new therapy could markedly improve independence and quality of life for those affected by OAB.

## Rapid gene expression panel predicts effectiveness of treatments for leukemia patients

The standard treatment for patients diagnosed with acute myeloid leukemia (AML) is intensive chemotherapy, but patients vary widely in their response. Currently, it is difficult to predict who will do well with chemotherapy from those that would do better with novel therapies offered by clinical trials.

A team led by **Stanley Ng**, a senior PhD candidate in Professor **Peter Zandstra**'s lab, developed a new, rapid gene expression test. This test could help clinicians determine the best management for patients with AML by making it possible to accurately predict a patient's response to chemotherapy within one to two days of diagnosis. The test is the result of a collaboration between the University of Toronto's Faculties of Applied Science and Engineering and Medicine, the Princess Margaret Cancer Centre in Toronto, and leukemia clinics in France, Germany and the Netherlands.

In AML, leukemia stem cells (LSCs) are often resistant to standard chemotherapy. To develop the predictive test, Ng analyzed data produced by his collaborators, Drs. **Jean Wang** and **John Dick** at Princess Margaret, on genes more strongly expressed in LSCs. He identified 17 genes whose expression levels can be used to calculate a numerical risk score called LSC17 for each patient.

Ng then linked LSC17 scores with patient outcomes by gathering gene expression and clinical data from more than 900 AML patients treated at Princess Margaret and across Europe. His analysis revealed that patients with low LSC17 scores responded well to standard chemotherapy and survived longer than those with high scores. Princess Margaret is validating the test and plans to use it in a prospective clinical trial in several Ontario hospitals.

The work is described in a study, titled "A 17-gene stemness score for rapid determination of risk in acute leukaemia," published on December 15, 2016, in the journal *Nature*.

## Exploring ways to stimulate damaged muscle to fix itself

If a patient suffers a debilitating muscle injury, a tissue graft often offers the best hope to restore lost function. Surgeons will replace the damaged muscle with healthy muscle from another part of the patient's body or from a donor. However, the success of this procedure can be limited by the availability of grafts and the tendency for the new tissue to die before it incorporates into the patient's body.

University Professor **Michael Sefton** and Professor **Penney Gilbert** are leading a multidisciplinary team that is taking a different approach, which could revolutionize how doctors treat skeletal muscle injuries. The researchers are exploring ways muscle stem cells can be stimulated to repair injured or damaged tissue, a process known as endogenous repair, instead of replacing injured tissue.

The team is one of 19 Medicine by Design-funded projects, announced on July 25, 2017, to accelerate discoveries in regenerative medicine and move them from the lab to patients more quickly.

To get muscle tissue to fix itself, the researchers are testing whether a novel biomaterial scaffold can coax stem cells that are present in the muscle to spring into action to heal traumatic injuries. If successful, the team's approach could shorten recovery, reduce pain and restore function sooner in patients around the world who suffer skeletal muscle injuries in car accidents, natural disasters and wars.

Sefton and Gilbert's project brings together about 20 researchers from diverse fields, including clinicians, scientists and engineers who are experts in tissue engineering, stem cell biology and medicine.

## Do physical stresses turn genes in muscle stem cells on and off?

Professor **Penney Gilbert** has been awarded a $1.4-million grant from the Human Frontier Science Program (HFSP) to lead a new, international collaboration to study how physical stress triggers the expression of genes in muscle stem cells.

While scientists have already uncovered many of the secrets that explain how and when genes are turned on and off, most of them involve 'chemical cascades' of signaling molecules and cell receptors. Many these methods can take a long time to achieve the final result.

But Gilbert and her colleagues want to test the idea that under certain circumstances, physical forces—as opposed to chemical changes—could cause certain genes to become activated or deactivated.

The project, announced on March 27, 2017, enables Gilbert to combine her expertise in muscle stem cells with advanced methods in biophysics from Professor **Timo Betz** at the University of Münster in Germany and molecular imaging techniques developed by Professor **Xavier Darzacq** at the University of California, Berkeley. Together, the team will comprehensively examine the ways in which muscle stem cells transmit the physical stresses they experience into changes in their DNA and gene expression.

The results of the study could provide scientists with new, non-chemical strategies for turning genes on and off in muscle stem cells and possibly other types of cells. And, these findings could in turn help treat genetic diseases or other conditions caused when genes fail to turn on and off in the right place or at the right time.

## Mending broken hearts—engineering a tiny tissue patch that could be injected rather than implanted

Repairing heart tissue destroyed by a heart attack or other medical conditions with regenerative cells or tissues usually requires invasive open-heart surgery. But Professor **Milica Radisic** and **Miles Montgomery**, a PhD candidate in Radisic's lab, have developed a tiny patch of heart tissue with its own blood vessels that could be injected, rather than implanted.

After many attempts, Montgomery successfully designed a heart-repair patch with shape memory that unfolds into a bandage-like structure as it emerges from an injection needle. The injected patch unfolds to nearly the same size as a patch implanted by more invasive methods and the heart cells survive the procedure well. The researchers also showed that injecting the patch into rat hearts can improve cardiac function after a heart attack.

Radisic and her team are collaborating with researchers at the Hospital for Sick Children to assess the long-term stability of the patches and whether the improved cardiac function is maintained. The injectable patch could enable surgeons to use minimally-invasive techniques, which reduce recovery time, scarring and other risks. If the procedure could be performed successfully in human patients, it would significantly improve quality of life.

The researchers have applied for patents on the invention and are exploring whether the patch could be used in other organs, such as the liver.

The research, titled "Flexible shape-memory scaffold for minimally invasive delivery of functional tissues," was published on August 14, 2017 in the journal *Nature Materials*.

## Transplanting healthy pancreatic cells under the skin to advance type 1 diabetes treatment

Researchers from University Professor **Michael Sefton**'s lab have demonstrated that the space under our skin might be an optimal location to treat type 1 diabetes (T1D).

PhD candidate **Alexander Vlahos** led a project that involved transplanting healthy pancreatic cells under the skin—an accessible and less hostile site—to produce insulin for blood glucose regulation. Once successfully implanted, these cells can then produce insulin to help regulate blood glucose levels. However, one challenge of using skin is that it has relatively few blood vessels.

Vlahos injected healthy pancreatic islets under the skin with a network support of blood vessels and found that normal blood sugar levels could be restored within 21 days, provided blood vessels are injected at the same time.

The next phase of their research will involve engineering the blood vessel network first with the hope that fewer islets will be required. This strategy would allow more of the cells to survive and function within the host, reducing the need for multiple donors per patient.

Vlahos' study, titled "Modular tissue engineering for the vascularization of subcutaneously transplanted pancreatic islets," was published on August 16, 2017 in the journal *Proceedings of the National Academy of Sciences (PNAS).*

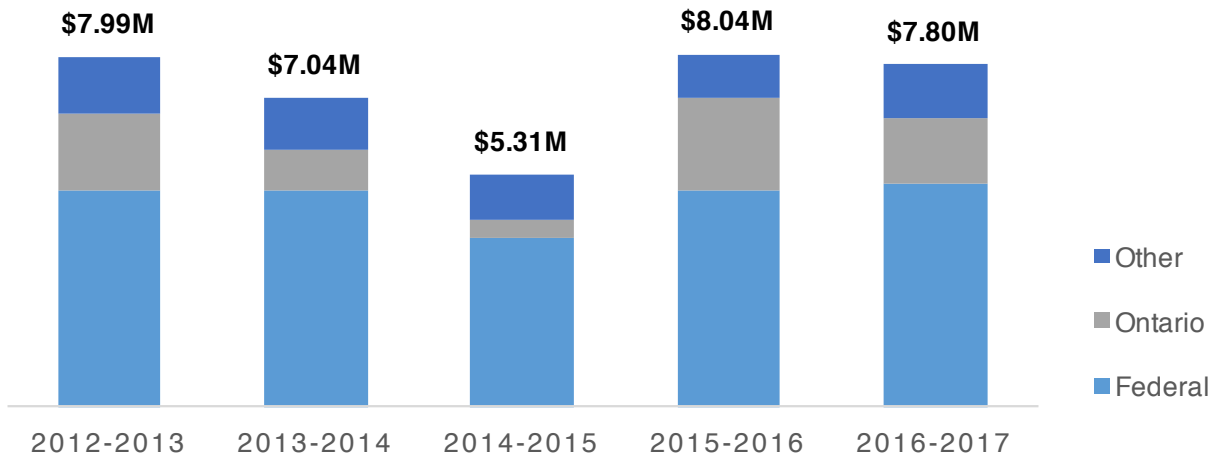
Earlier results of this work provided the basis for a $1.1-million research grant from international diabetes foundation JDRF to support a three-year study on this topic. The grant was announced on October 12, 2016.

# Research Funding

In 2016-2017, IBBME attracted $7.8 million in research funding.

This high-level of support from multiple funding agencies is a continued testament of our faculty's strength in biomedical and clinical engineering research. It will help us advance our collaborations and multidisciplinary work with our partners and continue to grow our world-class academic programs for our students.

## Figure 3.1a Total Research Funding




| Academic Year | Federal[1] | Ontario[2] | Other[3] | Number of grants[4] | Total PIs[5] | Average per PI[6] | Total |
|---|---|---|---|---|---|---|---|
| **2012-2013** | $4,947,467 | $1,754,994 | $1,291,634 | 83 | 25 | $319,764 | **$7,994,095** |
| **2013-2014** | $4,943,371 | $893,878 | $1,203,646 | 77 | 27 | $260,774 | **$7,040,894** |
| **2014-2015** | $3,864,796 | $417,792 | $1,023,422 | 64 | 26 | $204,077 | **$5,306,011** |
| **2015-2016** | $4,934,986 | $2,132,553 | $975,805 | 78 | 28 | $287,262 | **$8,043,345** |
| **2016-2017** | $5,103,294 | $1,491,583 | $1,207,210 | 82 | 28 | $278,646 | **$7,802,086** |

1) Federal figures represent all sources of national government funding, including the Canada Foundation for Innovation (CFI), Canada Research Chairs (CRC) program, Canadian Institutes of Health Research (CIHR), Natural Sciences & Engineering Research Council of Canada (NSERC), and the Networks of Centres of Excellence of Canada (NCE).

2) Ontario figures represent all sources of provincial funding, including the Ministry of Research & Innovation and the Ontario Centres of Excellence.

3) Other sources of research funding include corporate partnerships, foundations support, hospital research partnerships, internal University grants, professional organizations, and research partnerships with peer institutions.

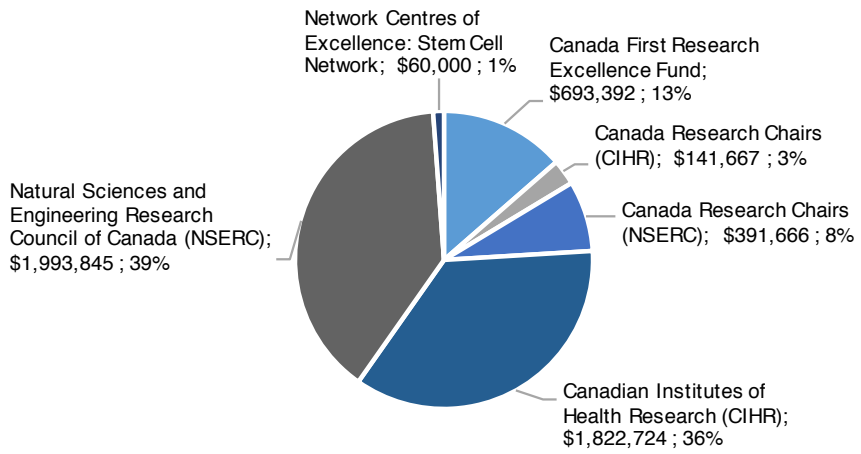
4) Total number of grants administered through IBBME.

5) Total number of core and cross-appointed faculty members who administered their research grants through IBBME.

6) Average funding per PI calculated by the total annual funding divided by the number of faculty members who administered their research grants through IBBME during the academic year.

## Figure 3.1b Federal Research Funding by Source, 2016-2017

Total federal research funding: **$5,103,294**



# Chapter 4: Experiential Learning, Community Integration & Recognition

Our dedication to educating future generations of biomedical and clinical engineers extends beyond our classroom and laboratory walls. Our commitment to world-class training includes initiatives that place our students at the heart of health-care institutions where they can be exposed to real-world challenges.

Providing experiential learning opportunities also align with our efforts to integrate trainees into their professional community by introducing them to leaders in the field. In 2016-2017, our Distinguished Seminar Series continued to host lectures by internationally-renowned researchers, where students and faculty members had the opportunity to attend a talk and subsequently share discoveries, ideas and methodologies with the guest speaker.

Our faculty members continued to garner widespread recognition for outstanding achievements in research, teaching and community service. This sustained acknowledgement continues to elevate the profile of the Institute, creating exposure that helps create new opportunities for both faculty and students alike.

## Professional Programs Internships

In 2016-2017, our Master of Health Science (MHSc) in Clinical Engineering students held 35 internship placements in Canada, parts of the U.S. and in Uganda. This type of experiential learning maintains our position as one of the most well-rounded clinical engineering master's programs in the field.

Our first cohort of Master of Engineering (MEng) in Biomedical Engineering students also held internships as part of their program. All seven placements were located in Toronto.

### Figure 4.1 Internships Placements for MHSc Clinical Engineering Students

| Academic Year | Canada | USA | International | Total |
|---|---|---|---|---|
| **2012-2013** | 32 | 8 | 1 | 41 |
| **2013-2014** | 31 | 7 | 1 | 38 |
| **2014-2015** | 33 | 2 | 2 | 37 |
| **2015-2016** | 32 | 3 | 1 | 36 |
| **2016-2017** | 32 | 2 | 1 | 35 |

## Listing of MEng Internship Placement Partners, 2016-2017

3D4MD Inc.
Avertus Inc.
FlowJEM
Ironstone Product Development
Legworks
Perimeter Medical Imaging

## Listing of MHSc Internship Placement Partners, 2016-2017

7D Surgical
Avertus Inc.
Baylis Medical
Clinical Engineering Society of Ontario
eHealth Ontario
Government of Northwest Territories
    Department of Health & Social Services
Hospital for Sick Children
Massachusetts General Hospital
Mount Sinai Hospital
    Department of Microbiology & Infection Control
Nanovista Inc.
North York General Hospital
OtoSim Inc.
Perimeter Medical Imaging
Sunnybrook Health Sciences Centre
Trillium Health Partners
University Health Network
    Centre for Global eHealth
    Healthcare Human Factors
    Institute for the Advancement of Technology for Health (TECHNA)
    Toronto General Hospital
    Toronto Western Hospital
Uganda Heart Institute
Unyte Health Inc.
Vivosonic Inc.
XOR Labs Inc.

# Selected Awards & Honours Received by Core Faculty

The following is a selected list of honours and awards received by IBBME core faculty in the 2016-2017 academic year.

## International

**Engineering Conferences International: Scale-Up and Manufacturing of Cell-Based Therapies Award**
Peter Zandstra

## National

**Canada Council for the Arts: Killam Prize in Engineering**
Molly Shoichet

**Canadian Academy of Engineering: Fellow**
Tom Chau

**Chemical Institute of Canada / Society for Chemical Industry: Kalev Pugi Award**
Molly Shoichet

**Engineering Institute of Canada: Fellow**
Anthony Easty

**Office of the Governor General: Governor General's Innovation Award**
Paul Santerre

**Stem Cell Network: Till & McCulloch Award**
Molly Shoichet

## University of Toronto

**U of T Distinguished Professor of Nanobioengineering**
Warren Chan

**U of T Early Career Teaching Award**
Dawn Kilkenny

**U of T Engineering: Faculty Teaching Award**
Craig Simmons

**U of T Northrop Frye Award**
Craig Simmons

# Distinguished Seminar Series

The IBBME Distinguished Seminar Series invites global leaders in biomedical and clinical engineering research to share their discoveries and methodologies with our community. Speakers are selected and confirmed by a faculty committee in consultation with the Biomedical Engineering Students' Association (BESA).

The 2016-2017 series committee was chaired by Professor **Penney Gilbert**. Below is a listing of invited guests over the past academic year.

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## October 31, 2016

### Oncolytic Viruses: Replicating Biological Machines for the Treatment of Cancer

**John C. Bell**, Senior Scientist, Centre for Innovative Cancer Research, Ottawa Hospital Research Institute, and Professor, Departments of Medicine and Biochemistry, Microbiology & Immunology, University of Ottawa

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## December 1, 2016

### Mapping and Interfacing with the Brain: Challenges and Opportunities

**Bin He**, Distinguished McKnight University Professor of Biomedical Engineering & Director, Institute for Engineering in Medicine, University of Minnesota

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## March 10, 2017

### Integration of actin and adhesion dynamics in cell migration

**Clare M. Waterman**, NIH Distinguished Investigator, National Institutes of Health, U.S. Department of Health & Human Services

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## May 8, 2017

### Human factors design of health IT for team-based care processes

**Pascale Carayon**, Procter & Gamble Professor in Total Quality, University of Wisconsin-Madison

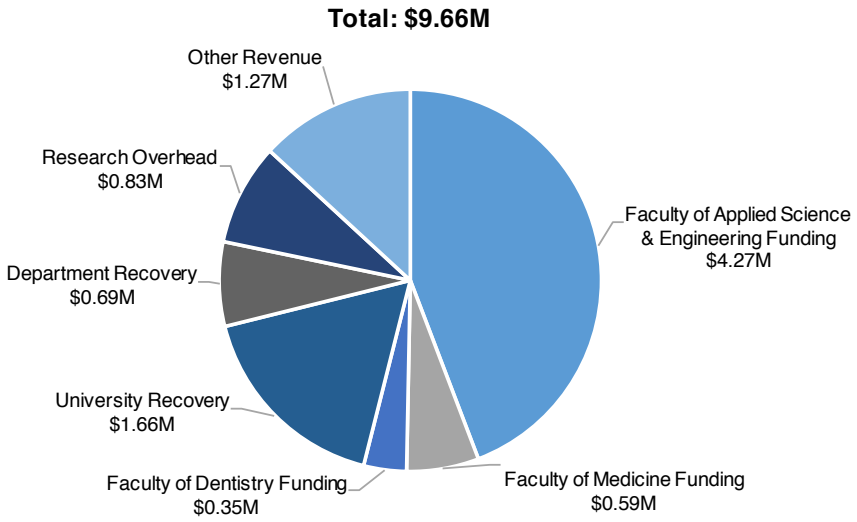
# Chapter 5:
# Financial and Physical Resources

IBBME's total revenue and associated costs are reflected in Figures 5.1 and 5.2. Our 2016-2017 budget was approximately $9.66 million.

Four fume hoods were replaced in IBBME laboratories on the third floor of the Lassonde Mining Building. Extensive renovations are also underway to upgrade research spaces for four faculty members and their groups on the fourth floor of the Rosebrugh Building.

Construction in the Rosebrugh Building is expected to be completed in early 2018. When finished, the new spaces will accommodate more graduate student researchers and allow our investigators to acquire new research equipment needed to advance research themes being undertaken in IBBME.

## Figure 5.1 Total Revenue by Source



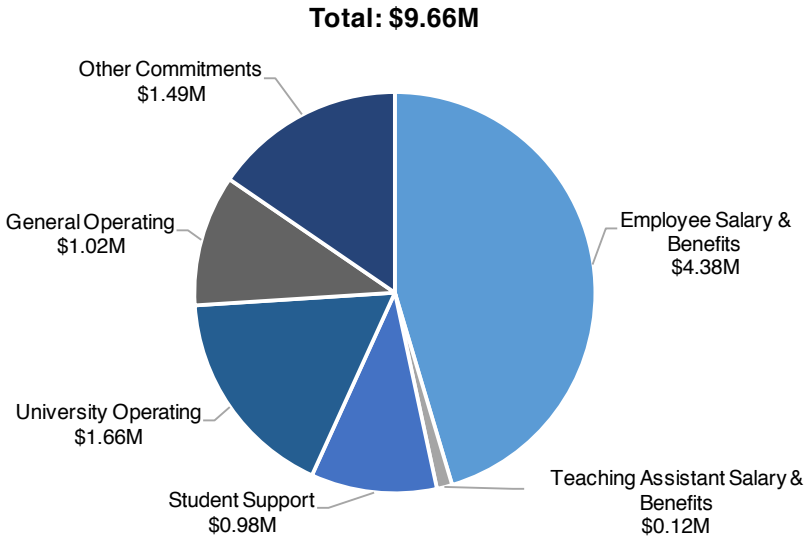

| Fiscal Year | Engineering Funding | Medicine Funding | Dentistry Funding | University Recovery[1] | Department Recovery[2] | Research Overhead | Other Revenue[3] | Total Revenue |
|---|---|---|---|---|---|---|---|---|
| **2016-2017** | $4,271,182 | $588,832 | $350,431 | $1,656,031 | $693,067 | $825,877 | $1,271,522 | $9,656,942 |

1) University recovery includes funding from Ontario's Basic Income Unit (BIU) and teaching budget revenue.

2) Department recovery includes faculty salary recuperations from the Canada Research Chairs (CRCs) program, partner hospitals and other administrative support-related costs.

3) Other revenue sources include endowed scholarships and trusts.

## Figure 5.2 Breakdown of Operating Expenses




| Fiscal Year | Employee Salary & Benefits | Teaching Assistant Salary & Benefits | Student Support | University Operating[4] | General Operating | Other Commitments[5] | Total Expenses |
|---|---|---|---|---|---|---|---|
| **2016-2017** | $4,384,338 | $121,759 | $979,519 | $1,656,031 | $1,021,970 | $1,493,326 | $9,656,942 |

4) University operating expenses include space costs and research taxes.

5) Other commitments include anticipated capital projects and faculty hires.

# Project Highlights

## Projects Completed

### Equipment upgraded in three Lassonde Mining Building labs

Four fume hoods were replaced in the labs of Professors **John E. Davies, Milica Radisic** and **Eli Sone**—all located in the Lassonde Mining Building.

The new fume hoods will allow the researchers to ventilate and store additional chemicals and conduct research more efficiently.

## Current Projects

### Major renovations and upgrading of existing laboratories in the Rosebrugh Building underway

Research lab spaces at the north and west end of the Rosebrugh Building (RS) are being renovated and upgraded to dramatically improve the quality of the facilities and create a more open, collaborative space. Funding for this vital and extensive renovation project is being provided through the federal government's Post-Secondary Institutions Strategic Investment Fund (SIF).

The renovations and upgrading of these facilities began in the spring of 2017 and are expected to be completed in early 2018. The changes include removing interior walls, improving lighting and accessibility, and installing collaborative research stations to facilitate open, cooperative work. Power and cooling systems are being upgraded to support researchers' existing and future computational needs. Emergency back-up power is being installed in RS 403—the refrigerator and freezer room.

Professor **Berj Bardakjian**'s group will be moving into a new and larger computational lab, RS 416, that will combine the previous RS 416 and RS 417 lab spaces to accommodate eight to 10 students. The new lab will have more power outlets and data ports, allowing students to carry out more computational work.

Professor **Ofer Levi**'s lab in RS 422A is being renovated and modernized, and a new fume hood will be installed.

Professor **Naomi Matsuura**'s new lab in RS 421 is being rebuilt after the previous lab space was gutted. A new fume hood is being installed and the lab will accommodate up to 10 students.

Professor **Willy Wong**'s computer lab in RS 422 is being renovated and will have additional space to accommodate 10 to 12 students.

Upon completion, this major renovation and modernization project will improve the scale, usability and flexibility of existing lab spaces. The renovated facilities will also accommodate more graduate student researchers and allow our investigators to acquire new research equipment needed to advance research themes being undertaken in IBBME.

# Appendix I: Core Faculty

### Jan Andrysek, PhD, PEng
(1) Scientist, Holland Bloorview Kids Rehabilitation Hospital, (2) Assistant Professor & Associate Director, Professional Programs (IBBME—*effective July 1, 2017*)

### Julie Audet, PhD, PEng
Associate Professor (IBBME, ChemE, DC), Associate Director, Graduate Programs (IBBME—*until June 30, 2017*) & Vice-Dean, Graduate Studies (APSC—*effective July 1, 2017*)

### Berj L. Bardakjian, PhD, PEng
Professor (ECE, IBBME)

### Elaine A. Biddiss, PhD, PEng
(1) Scientist, Holland Bloorview Kids Rehabilitation Hospital, (2) Assistant Professor (IBBME)

### J. Christopher Bouwmeester, PhD
Assistant Professor, Teaching Stream (IBBME)

### Warren C. W. Chan, PhD, FAIMBE
Distinguished Professor of Nanobioengineering (IBBME, ChemE, CHM, DC, MSE)

### Tom Chau, PhD, FAIMBE, FCAE, PEng
(1) Senior Scientist, Raymond Chang Foundation Chair in Access Innovations & Vice President, Research, Holland Bloorview Kids Rehabilitation Hospital, (2) Professor (IBBME, ECE, RSI), (3) Adjunct Scientist, Toronto Rehabilitation Institute, UHN

### Hai-Ling Margaret Cheng, PhD, PEng
(1) Assistant Professor (IBBME, ECE, PHM), (2) Adjunct Scientist, Hospital for Sick Children

### John E. Davies, PhD, DSc, FSBE
Professor (DEN, IBBME)

### Anthony Easty, PhD, PEng
Adjunct Professor (IBBME)

### Moshe Eizenman, PhD
(1) Professor (OPT, IBBME), (2) Affiliate Scientist, Krembil Research Institute, UHN

### Rodrigo Fernandez-Gonzalez, PhD
(1) Associate Professor (IBBME, CSB), (2) Adjunct Scientist, Hospital for Sick Children

### Geoffrey Fernie, PhD, FCAHS, CEng, PEng
(1) Senior Scientist & Director, Research Institute, Toronto Rehabilitation Institute, UHN, (2) Professor (SRG, IBBME)

### Penney M. Gilbert, PhD
Assistant Professor & Canada Research Chair, Endogenous Repair (IBBME, BCH, DC)

### Marc D. Grynpas, PhD
(1) Senior Scientist, Samuel Lunenfeld Research Institute, Mount Sinai Hospital, (2) Professor (LMP, IBBME, MSE, SRG)

### Rita Kandel, MD, FRCPC
(1) Clinician-Scientist & Chief, Pathology & Laboratory Medicine, Mount Sinai Hospital, (2) Professor (LMP, IBBME)

### Dawn M. Kilkenny, PhD
Assistant Professor, Teaching Stream, Associate Director, Undergraduate Programs (IBBME) & Associate Chair (EngSci—*effective July 1, 2017*)

### Azadeh Kushki, PhD
(1) Scientist, Holland Bloorview Kids Rehabilitation Hospital, (2) Assistant Professor (IBBME)

### Ofer Levi, PhD
Associate Professor (IBBME, ECE)

### Kei Masani, PhD
(1) Scientist, Toronto Rehabilitation Institute, (2) Assistant Professor (IBBME)

### Naomi Matsuura, PhD, PEng
Associate Professor (MSE, IBBME, MRAD)

### Alison McGuigan, PhD
Associate Professor (ChemE, IBBME)

### Alex Mihailidis, PhD, PEng
(1) Senior Scientist & Barbara G. Stymiest Research Chair in Rehabilitation Technology, Toronto Rehabilitation Institute, UHN (2) Professor (OCT, IBBME, CSC, RSI), (3) Scientific Director, AGE-WELL

### Milos R. Popovic, PhD, PEng
(1) Senior Scientist, Toronto Rehabilitation Chair in Spinal Cord Injury Research & Associate Scientific Director, Research, Toronto Rehabilitation Institute, UHN, (2) Professor (IBBME, ECE, MIE, IMS, RSI)

### Milica Radisic, PhD, FAIMBE, FCAE, PEng
(1) Professor, Canada Research Chair, Functional Cardiovascular Tissue Engineering (IBBME, ChemE) & Associate Chair, Research (ChemE) (2) Affiliate Scientist, Toronto General Research Institute, UHN

### Jonathan V. Rocheleau, PhD
(1) Percy Edward Hart Professor & Associate Director, Research (IBBME), (2) Scientist, Toronto General Research Institute, UHN

### Paul Santerre, PhD, FAAAS, FAIMBE, FBSE, PEng
Professor (DEN, IBBME, ChemE)

### Michael V. Sefton, ScD, FAAAS, FCIC, FBSE, FRSC, PEng
University Professor, Michael E. Charles Professor (ChemE, IBBME, DC) & Executive Director, Medicine by Design (*effective July 1, 2017*)

### Molly S. Shoichet, OOnt, PhD, FAAAS, FBSE, FCAHS, FCAE, FRSC, FTERM
University Professor & Canada Research Chair, Tissue Engineering (ChemE, IBBME, CHM, DC, IMS)

### Craig A. Simmons, PhD, FCSME, PEng
(1) Distinguished Professor of Mechanobiology (MIE, IBBME, DEN) & Interim Director (IBBME—*effective July 1, 2017*), (2) Scientific Director, U of T Translational Biology & Engineering Program (TBEP), Ted Rogers Centre for Heart Research

### Eli D. Sone, PhD
Associate Professor (IBBME, MSE) & Associate Director, Graduate Programs (IBBME—*effective July 1, 2017*)

### David A. Steinman, PhD, FASME, PEng
Professor (MIE, IBBME)

### Kien (Kevin) Truong, PhD, PEng
Associate Professor (ECE, IBBME)

### Aaron R. Wheeler, PhD
Professor & Canada Research Chair, Bioanalytical Chemistry (CHM, IBBME)

### Willy Wong, PhD
Associate Professor (ECE, IBBME)

### Christopher M. Yip, PhD, FAAAS, FEIC, PEng
Professor (ChemE, IBBME, BCH, DC), Director (IBBME—*until June 30, 2017*) & Associate Vice-President, International Partnerships (U of T—*effective July 1, 2017*)

### Paul B. Yoo, PhD, PEng
Assistant Professor (IBBME, ECE)

### Lidan You, PhD, FCSME, PEng
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### Peter Zandstra, PhD, FAAAS, FAIMBE, FRSC, PEng
(1) University Professor & Canada Research Chair, Stem Cell Bioengineering (IBBME), (2) Professor & Director, School of Biomedical Engineering, and Director, Michael Smith Laboratories, University of British Columbia

### José Zariffa, PhD, PEng
(1) Scientist, Toronto Rehabilitation Institute, (2) Assistant Professor (IBBME)

### Jinzi Zheng, PhD
(1) Scientist, Institute for the Advancement of Technology for Health (TECHNA), UHN, (2) Assistant Professor (IBBME)

# Glossary

| | |
|---|---|
| **APSC** | Faculty of Applied Science & Engineering |
| **BCH** | Department of Biochemistry |
| **ChemE** | Department of Chemical Engineering & Applied Chemistry |
| **CHM** | Department of Chemistry |
| **CSB** | Department of Cell & Systems Biology |
| **CSC** | Department of Computer Science |
| **DEN** | Faculty of Dentistry |
| **DC** | Donnelly Centre for Cellular & Biomolecular Research |
| **ECE** | Edward S. Rogers Sr. Department of Electrical & Computer Engineering |
| **IBBME** | Institute of Biomaterials & Biomedical Engineering |
| **IMS** | Institute of Medical Science |
| **LMP** | Department of Laboratory Medicine & Pathobiology |
| **MIE** | Department of Mechanical & Industrial Engineering |
| **MRAD** | Department of Medical Imaging |
| **MSE** | Department of Materials Science & Engineering |
| **OCT** | Department of Occupational Science & Occupational Therapy |
| **OPT** | Department of Ophthalmology & Vision Sciences |
| **PHM** | Leslie Dan Faculty of Pharmacy |
| **RSI** | Rehabilitation Sciences Institute |
| **SRG** | Department of Surgery |
| **UHN** | University Health Network |

# Appendix II: Staff

## Academic Programs

### Brittany Lauton
Acting Undergraduate Programs Assistant

### Brittany Lawrence
Undergraduate Programs Assistant

### Jeffrey Little
Graduate Programs Administrator

### Rhonda Marley
Professional Programs Coordinator

## Administration & Finance

### Elizabeth Flannery
Human Resources Administrator &
Finance Officer

### Judy Gilligan
Operations Assistant

### Angela Rosa
Finance Officer, Research

### Nefeteria Wickham
Manager of Operations

## Communications & External Relations

### Luke Y. H. Ng
Communications & External Relations Officer

## Design Studio

### Maximiliano Giuliani
Design Studio Coordinator

## Director's Office

### Jody Prentice
Executive Assistant to the Director

## Information Technology

### Derek Boodoosingh
Information Technology Systems Supervisor

### David Seto
Information Technology Support Specialist,
Web & Audio-Visual

## Teaching Laboratory

### Lindsey Fiddes
Acting Teaching Laboratory & Safety Coordinator

### Andrey Shukalyuk
Teaching Laboratory & Safety Coordinator

# Data Sources

Data and information presented in this report were obtained from the sources below.

**2017 Annual Report of Performance Indicators**
Faculty of Applied Science & Engineering, University of Toronto

**Academic Programs Office**
Institute of Biomaterials & Biomedical Engineering, University of Toronto

**Administration & Finance Office**
Institute of Biomaterials & Biomedical Engineering, University of Toronto

**Director's Office**
Institute of Biomaterials & Biomedical Engineering, University of Toronto

**Division of Engineering Science**
Faculty of Applied Science & Engineering, University of Toronto

# IBBME Annual Report, 2016-2017

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