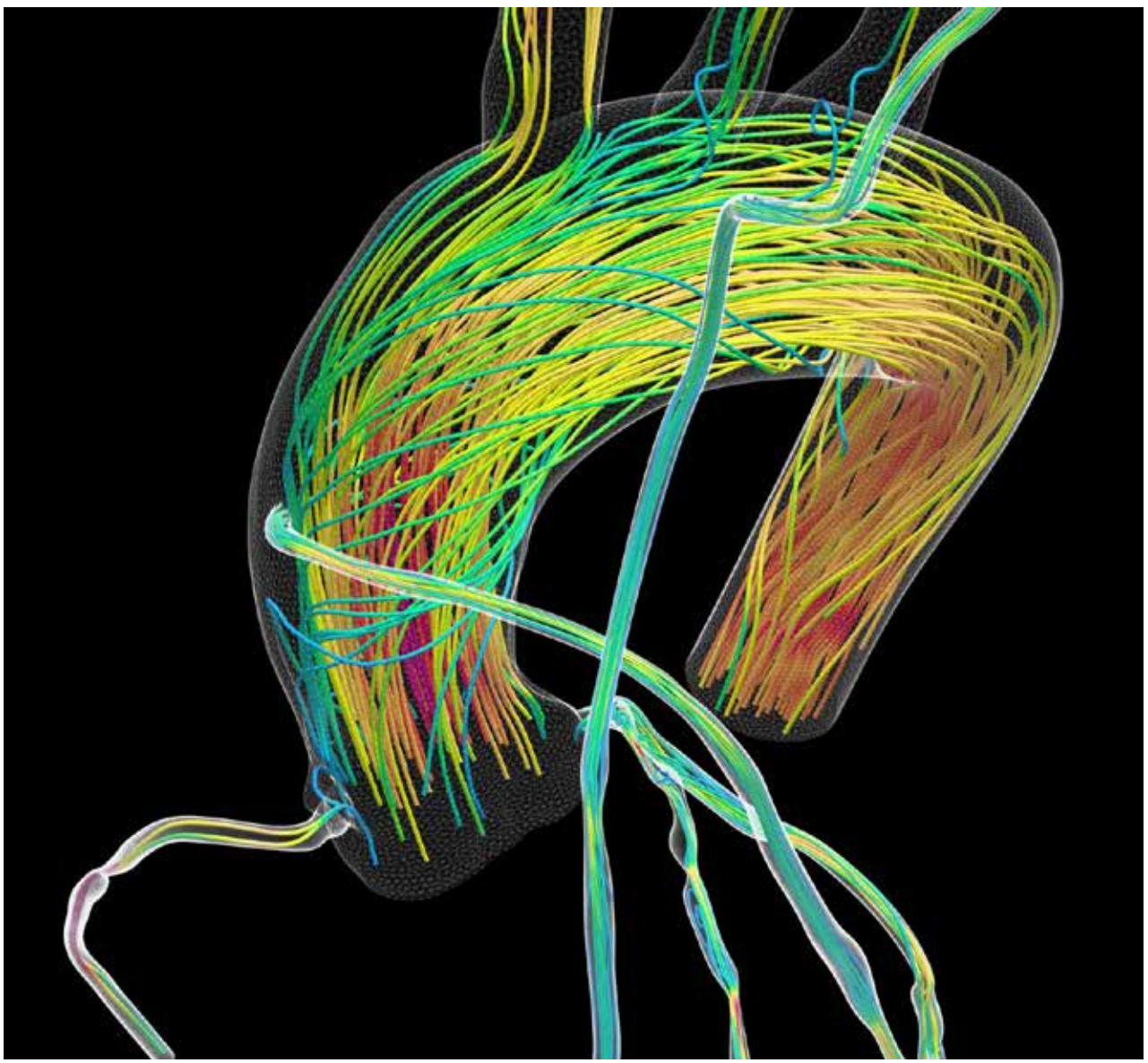
BIOMEDICAL ENGINEERING

Annual Magazine | Volume 2 | 2019

Faces of BME



Institute of Biomaterials & Biomedical Engineering
UNIVERSITY OF TORONTO

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Cover:

Professor Piero Triverio and Francesca Condemi

Blood velocity in the aorta and coronary arteries of a patient suffering from coronary artery disease, obtained with a computational fluid dynamics simulation guided by medical images. This simulation is part of a project that aims to improve the way we understand and treat coronary artery disease, the leading cause of death in Canada.

As the joint effort of IBBME faculty, students and physicians, this single image embodies IBBME's mission: bring together engineers, life scientists and physicians to make the world a better place.

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IBBME

BIOMEDICAL ENGINEERING

Institute of Biomaterials & Biomedical Engineering
UNIVERSITY OF TORONTO

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Grow stem cells

Develop therapies

Understand diseases

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DIRECTOR | NOTE

Welcome to the second edition of the Institute of Biomaterials and Biomedical Engineering (IBBME) magazine.

The people in the Institute are the major drivers of our success. Our trainees continue to succeed in their endeavors even after finishing their study at IBBME. In this issue we featured six of our alumni in two different companies. Although their roles are different from one another, they leveraged the skillset gained during their studies in IBBME to further their career.

Aside from academic excellence, our students are also multi-talented outside of their research lab. This year we started a feature called "Faces of Biomedical Engineering" that captured the student life in Biomedical Engineering at the University of Toronto. In the future years we hope to grow this feature to the faculty and staff members as well.

Our student body had experienced tremendous growth last year. With more than 140 graduate students entering the Institute, there is a broad interest in the field of Biomedical Engineering.

Finally, we highlighted some of the research activities within the Institute. The research developments and discoveries are innovative and state-of-the art. These articles illustrate the excellent research done by our trainees and professors.

I hope you enjoy this volume and we look forward to another exciting year ahead!

Warren C.W. Chan
Professor and Director

PAGE CONTENT

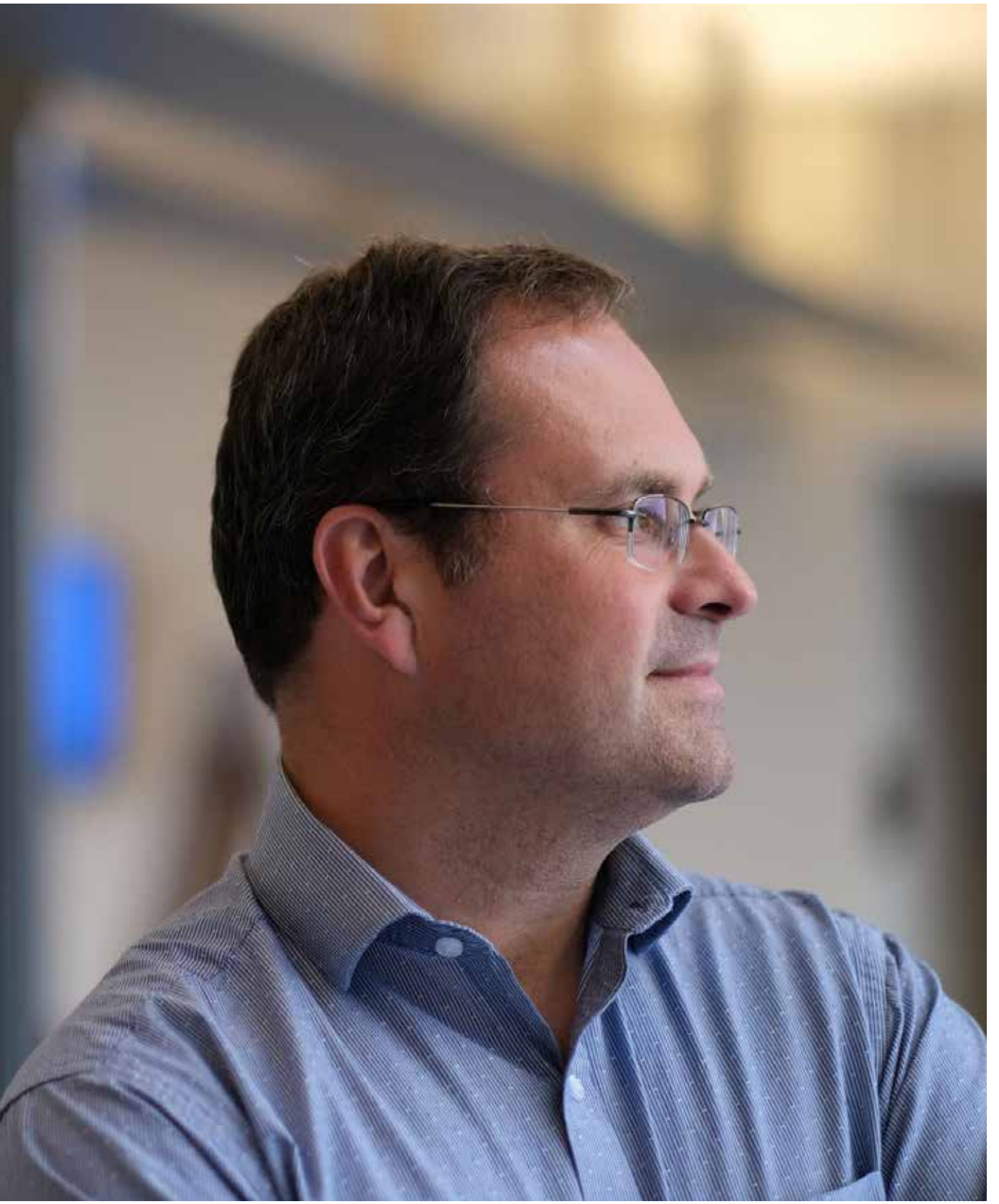
WALKING MANUAL

WORDS & PHOTOS:
QIN (BILL) DAI

Dr. Jan Andrysek and his lab offers solutions for amputees to walk again.

When Dr. Jan Andrysek was a master's student at Holland Bloorview Hospital in 1998, he was already working alongside rehabilitation engineers and clinicians to develop solutions to help kids walk.

"There were a lot of gaps in terms of prosthetic technology that, particularly kids, which make a bit of a niche group", says Jan, "My project at the time was to design a pediatric prosthetic knee joint. At the time prosthetics were not durable enough for kids, and they didn't provide the function that was needed. We didn't



get to a solution at the end of my masters, but I did get an understanding of what worked and what didn't work."

Fast forward 21 years, Jan's research project has already developed a niche within the prosthetic rehabilitation community. While running his research lab at the Holland Bloorview Children's Rehabilitation Hospital, Jan patented this knee joint technology and brought it to market via LegWorks, a Canadian company co-founded by Jan in 2014. Under the brand name of All-Terrain Knee, more than 2,000 units were sold across 40 countries over the past several years. "What distinguishes our device from others on the market is its durability, cost effectiveness, and functionality. MaRS Innovation, Holland Bloorview Hospital, and Grand Challenges Canada have all been investors in the past."

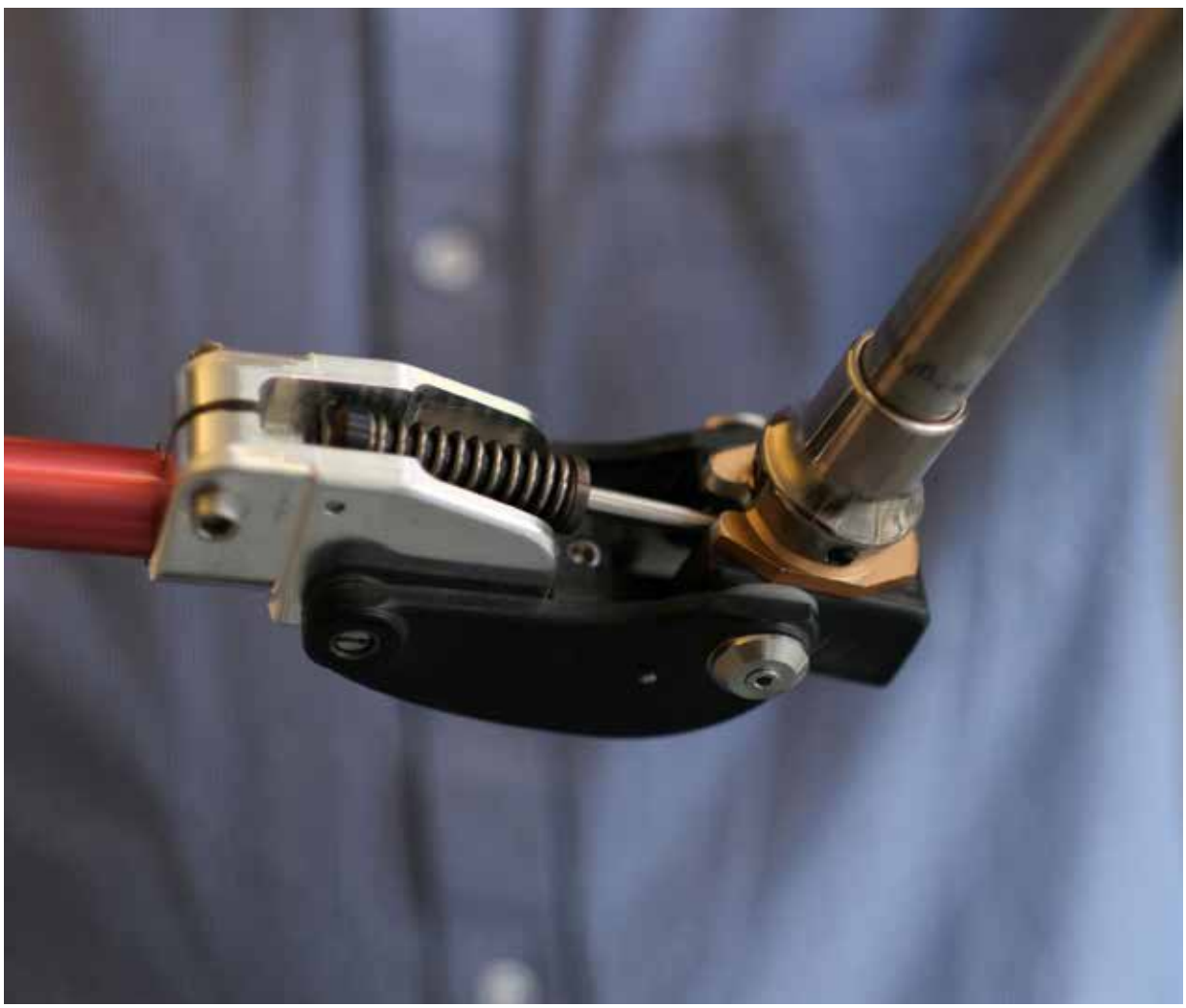
In Canada, the cost of an entire prosthetic leg would range from $5,000 to $10,000 for low end, and up to $100,000 for devices with heavy digital components. For the knee component, it would cost around $5,000 alone. While clients in developed countries are generally reimbursed via insurance for these prosthetic devices, the accessibility of these devices in developing countries is stymied by the cost.

"80% of the world do not have access to prosthetic technology," says Jan, "We are in the business of helping people, and if existing prosthetic devices are not reaching a wide audience, we are doing something terribly wrong." In Tazania, Kenya, Cambodia and a dozen other low-income countries, the All-Terrain Knee is sold at cost – the price of production – to ensure its affordability. Alternatively, people in developed countries are paying a higher price for a premium version of these knee joints. This "Tier-pricing system" allows the company to serve both low-income markets while sustainably providing a reliable product for clients in Canada and United States.

We are in the business of helping people, and if existing prosthetic devices are not reaching a wide audience, we are doing something terribly wrong.

"Instead of costing $5,000, we want to bring that down to 1/10 of the market price," says Jan, "Right now we are working with non-government organizations to ensure that people in developing countries have access to this technology, but also being able to receive support if necessary."

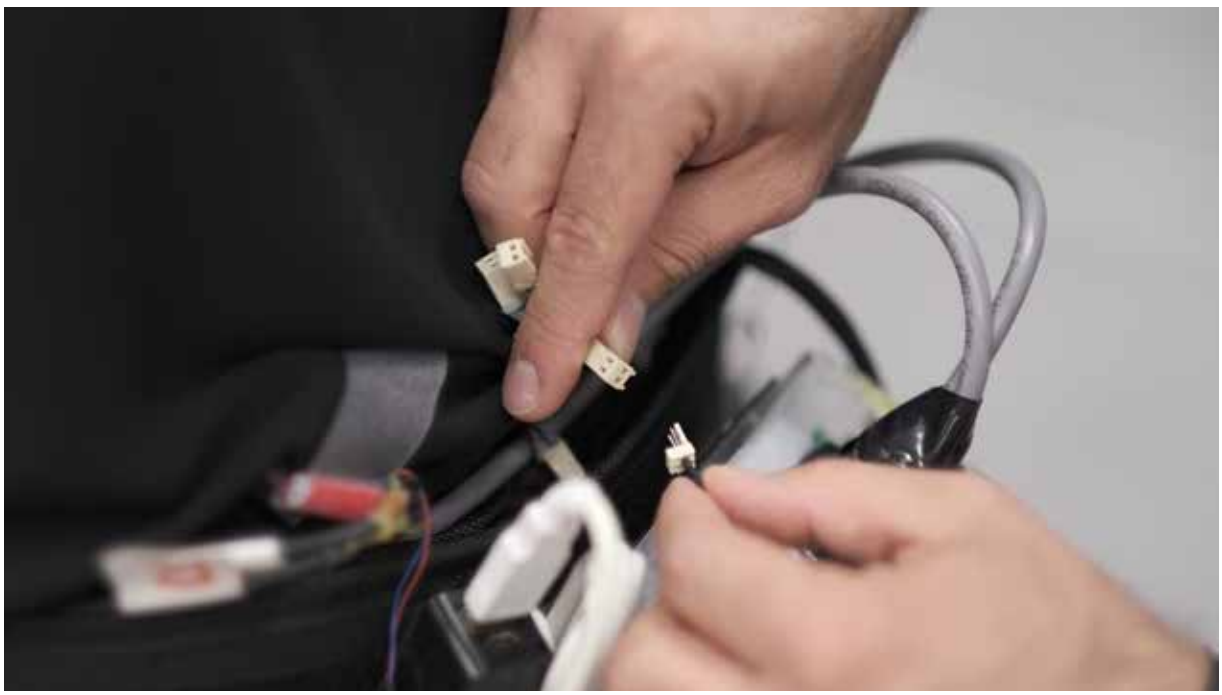
The knee joint utilizes a novel locking technology, to improve safety and minimize falls, while encouraging good walking patterns. Many patients who require these prosthetic devices are individuals who had suffered a previous injury or ailment that requires amputation, or congenital deficiencies at birth.



↑ One of the All-Terrain Knee prototypes in Dr. Jan Andrysek's lab.

↑ Sensors are attached to the shoe to measure various gait parameters.

↓ Microcontroller device that sends biofeedback signals to the leg.



The life-style requirement for these prosthetic devices also differ between countries. In Canada, a gap in the market would be to use prosthetic devices for recreational uses such as sports. Whereas in developing countries, the All-Terrain Knee is often the primary means by which a person is able to conduct their daily activities, such as working or going to school. In both contexts, the durability and functionality of the knee are essential to ensure that the user can conduct their necessary activities, in a safe and efficient manner.

The technology itself operates without mechanical parts, meaning, there is no circuitry that interfaces with the mechanical movement of the knee and the biological parts of the leg. The lack of circuitry means these devices can be used in moisture dense and dirt rich environments without compromising its function. The knee joint locking mechanism is based on advanced biomechanics and works between two states. When pressure is applied on the device, the mechanical parts lock in place to ensure stability. While the patient is swinging the leg, the device engages the second state as the mechanical part releases to enable freedom of movement.

While one part of Jan's work is in product development, his lab is focused on understanding how humans move while they are working. The principles from these studies can then drive the design considerations for mobility assistive devices such as prosthetic knees.

"We are focused on understanding the biomechanical principles of movement, during walking and other higher end mobility activities. We are developing sensors that can attach to the knee and measure data like how much pressure is applied, wear and tear, and other crucial biometric information about the device and the human body," says Jan, "if we can understand how each person walks and their mobility requirements, we can design and personalize a device that's useful to them."

A major issue with prosthetic usage is that the amputee patients are not habituated in using the prosthetic devices. Whereas healthy individual would have symmetrical gait between the two legs, an amputee would spend considerably more time on the healthy leg over the other. The lack of gait symmetry could lead to other health problems such as back-injuries.

"An important aspect after lower-limb amputation is to inform and correct asymmetrical gait patterns of prosthetic users." says Rafael Escamilla Nunez, a PhD student in the Andrysek Lab, "To address this problem, we developed a biofeedback device that measures various temporal gait parameters on each leg. This information is processed by a microcontroller attached to the waist, which has embedded the control algorithms to activate the vibrating motors. For instance, if the person is spending asymmetrical time on one of the legs, our device vibrates and tells the person to correct their gait. It's basically a rehabilitation device that helps people to walk properly."

Another issue is that some patients are also not confident with their usage of prosthetic devices.

"One of the patients we worked with initially had very little confidence in walking," says Alexandria Michelini, a Masters student in the Andrysek Lab, "After a couple of rehabilitation sessions, she mentioned that she felt more confident and even started walking around the house a lot more. It feels great that our devices are making a difference in people's lives." ■

NON INVASIVE BIO SURVEILLANCE

GRAPHIC: ADOBE
PHOTOS: IVY HON
WORDS: QIN (BILL) DAI

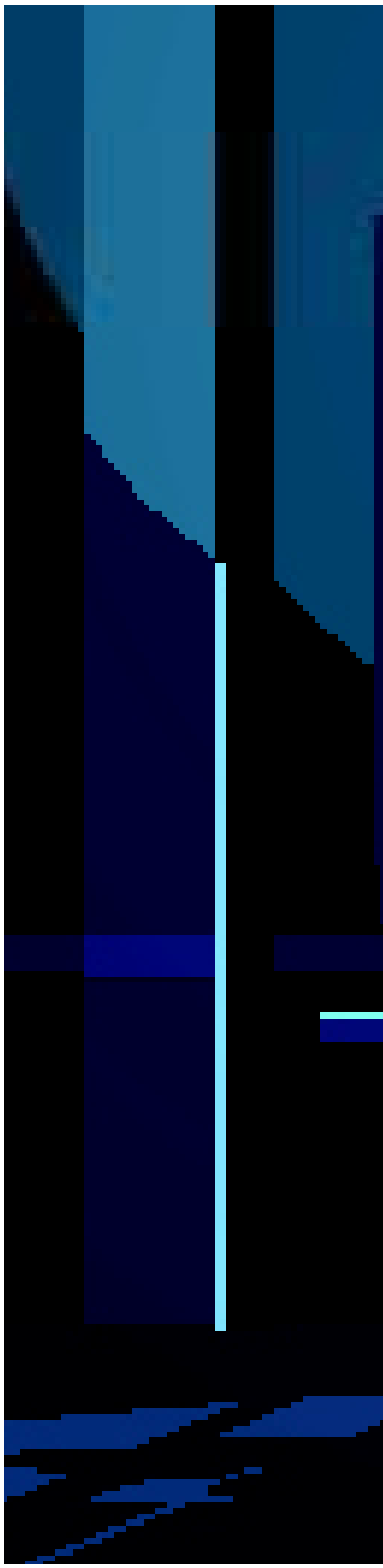
Dr. Hai-Ling Margaret Cheng is developing cell and tissue scaffold tracking contrast agents to visualize their movement in the body.

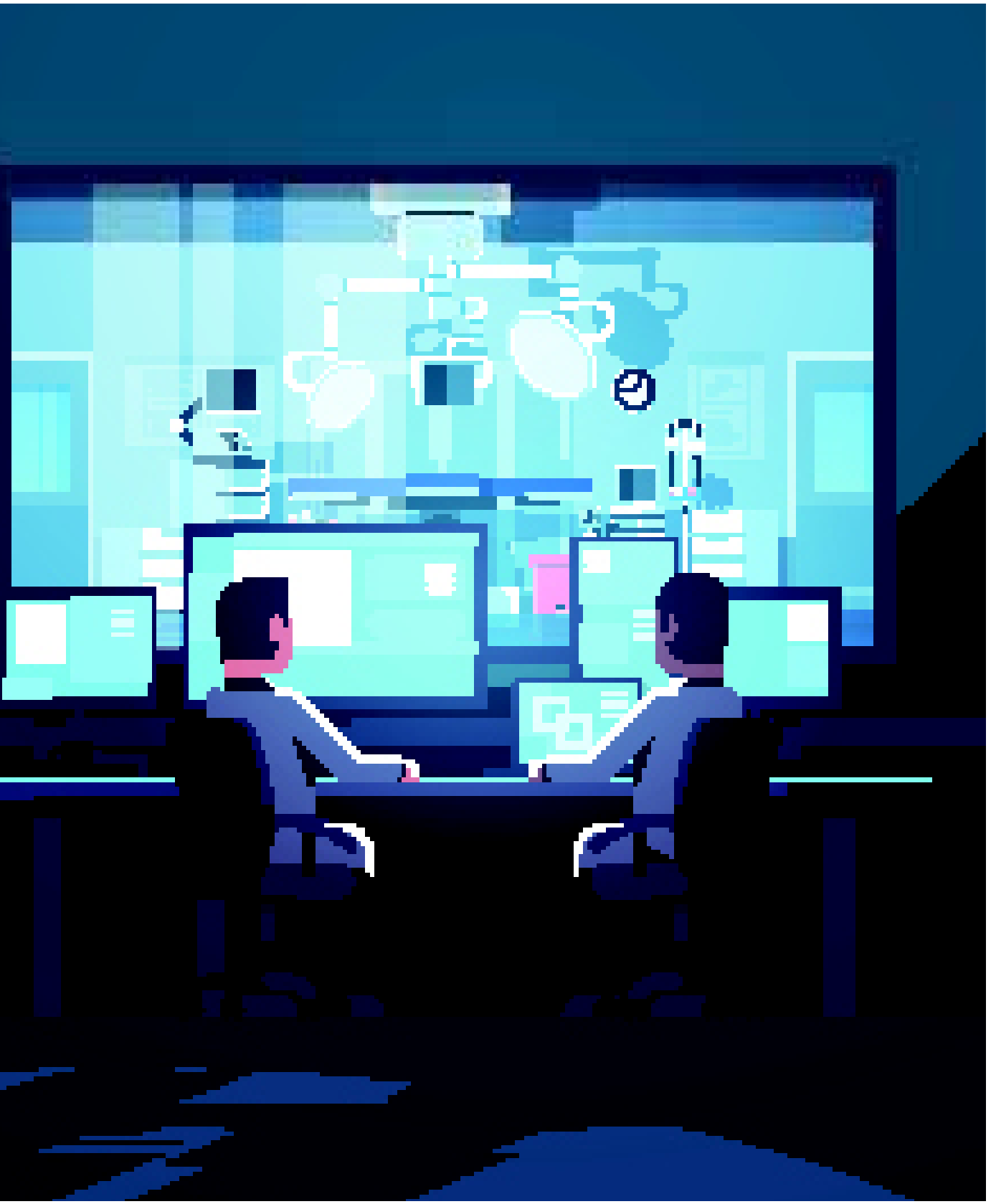
Tissue regeneration has tremendous potential to heal damaged tissues and regrow lost limbs. In the past two decades, researchers have proposed transplanting stem cells or non-cellular scaffolds into the injury site to facilitate tissue regeneration. Stem cells can differentiate into specialized cell types in the body, and the non-cellular components provide growth factors and other nutrients that facilitate tissue regrowth.

It is relatively easy to observe tissue regeneration on the skin; however, regeneration of internal organs is more difficult to visualize. Currently, no technology exists that allow researchers or clinicians to monitor non-invasively the tissue regeneration process deep inside the human body.

"It is a tremendous challenge to monitor whether these therapies are working. As a patient, the last thing you want is to have these cells implanted and then have a highly invasive surgery a couple of months down the line to check whether the cells are still there," says Dr. Hai-Ling Margaret Cheng, an IBBME/ECE principal investigator at the Ted Rogers Centre for Heart Research, "We want to ensure that the patient monitoring process is as painless as possible, and one way to do that is to use non-invasive imaging to track the cells and non-cellular components we introduce into the body."

One of the many projects in Dr. Hai-Ling Margaret Cheng's lab is to develop trackers that identify the location of these exogenous





components. Coming from a background in medical biophysics and electrical engineering, Dr. Cheng has spent more than 14 years developing technologies that can enhance Magnetic Resonance Imaging (MRI) of the human body.

Prior to MRI session, patients may need to intake a contrast agent to improve detection sensitivity and greater signal difference on MRI. If we directly incorporate these contrast agents to the stem cells or non-cellular scaffolds, contrast agents can act like miniature trackers in addition to enhancing contrast. In other words, they act as a long-term surrogate in the body.

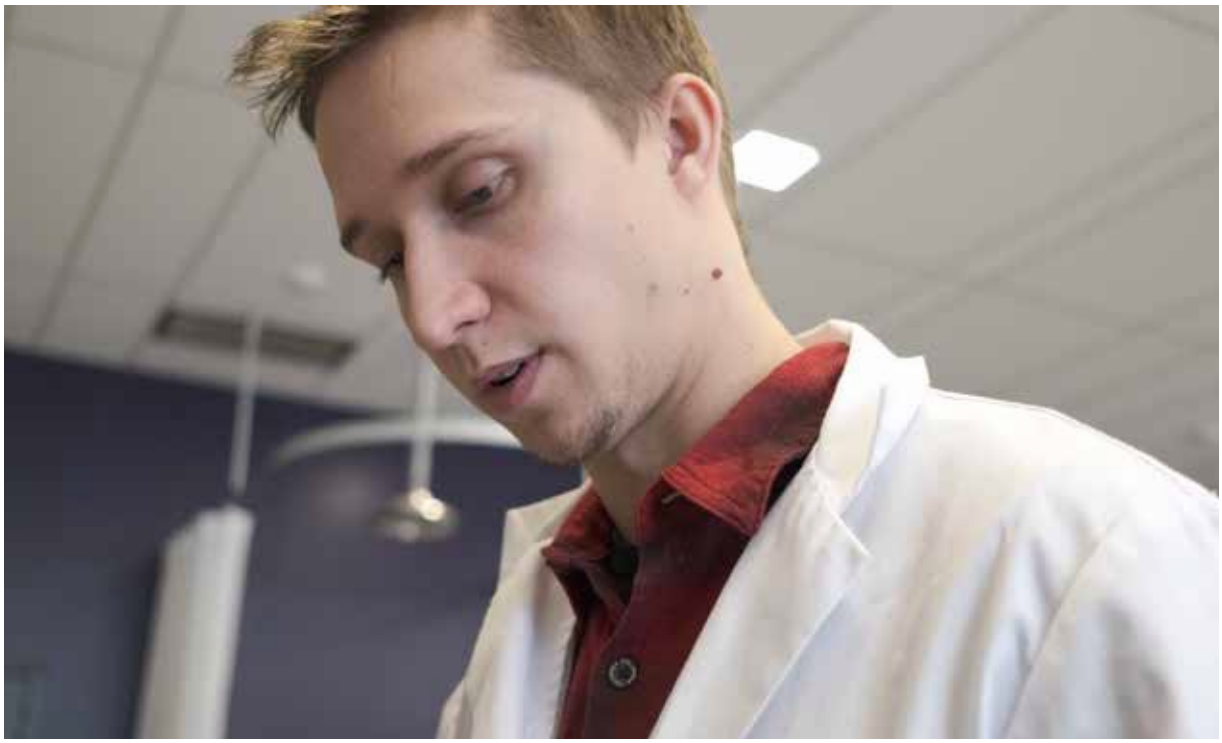
Safety is a foremost concern when it comes to designing contrast agents. While normal contrast agents last in the body for only a few hours before being excreted, contrast agents designed to monitor regenerative medicine components might stay in the body up to a few months. During that time, researchers have to evaluate their interactions with various organs such as the kidney, the blood, and the liver.

"Traditional contrast agents are completely foreign to the body, and we've seen them accumulate in the bone and the brain, leading to toxic effects. So in the context of regenerative medicine we have to design everything from scratch," says Daniel A. Szulc, a senior member in the Cheng lab who specializes in MRI contrast agent design, "These agents will be traveling through the blood stream, bypassing certain organs and getting into the cells. There's a design consideration for each step of the way."

Although the focus of this research is on regenerative medicine applications, it could also have potential in cosmetic purposes.

"When people get breast implants, they certainly do not want them to be moving around too much, let alone degrade in their body. Our contrast agents could be incorporated in these implants so individuals with these cosmetic surgeries could have their checkups with a non-invasive method like MRI," says Margaret.

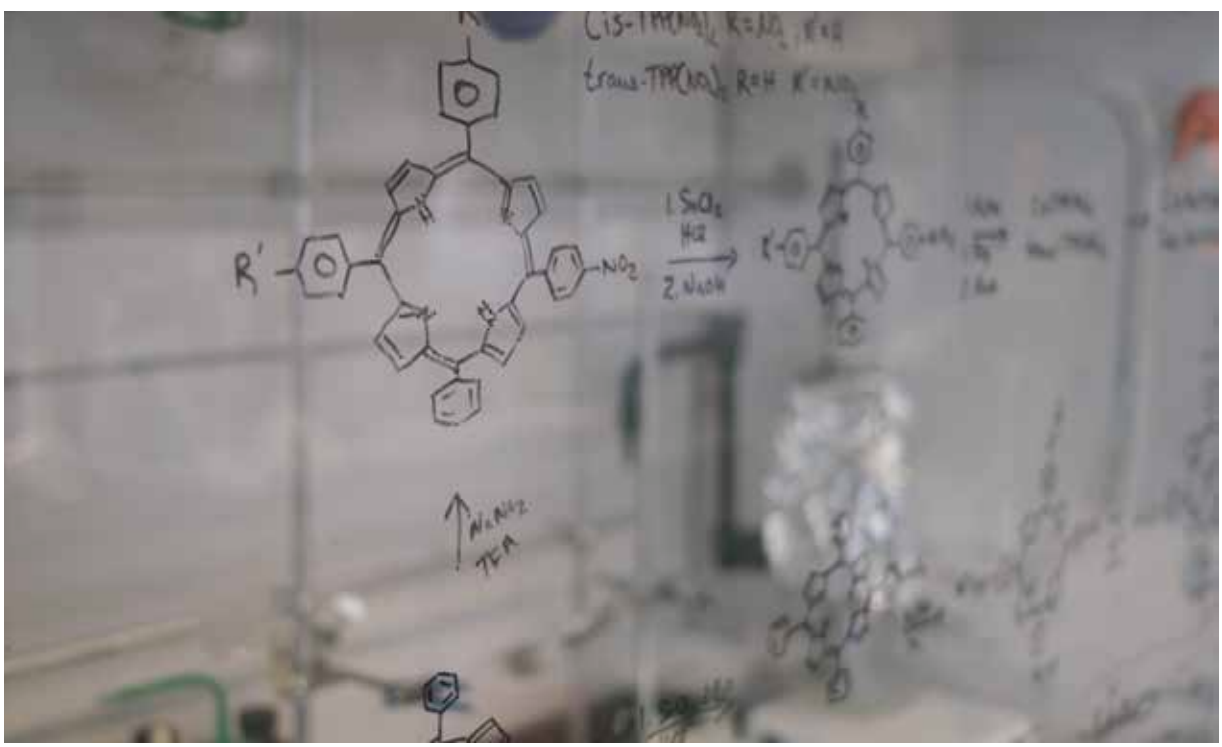
"We are planning to bring our tracking technologies into the clinic in the next five years," says Margaret. "I think it will be a game changer for everyone who's involved in tissue regeneration and regenerative medicine." ■



← Dr. Hai-Ling Margaret Cheng is an IBBME/ECE faculty member at the Ted Rogers Centre for Heart Research.

↑ Daniel Szulc is one of the senior member in Dr. Cheng's lab.

↓ Organic synthesis procedure for one of the contrast agents used in the Cheng lab.



CANCER CARTOGRAPHERS

WORDS & PHOTOS:
QIN (BILL) DAI

Researchers in Dr. Warren Chan's lab are constructing a roadmap for chemotherapeutics to navigate the chaotic environment to reach the targeted tumour.

Imagine being dropped off at the edge of an urban city with crisscrossing streets and no navigational instructions. The roads often run into dead-ends and are full of pot-holes, the network reception is non-existent, and the buildings aren't numbered. If you want to get from the edge of the city into the downtown core, the only logical way is to map out your own route.

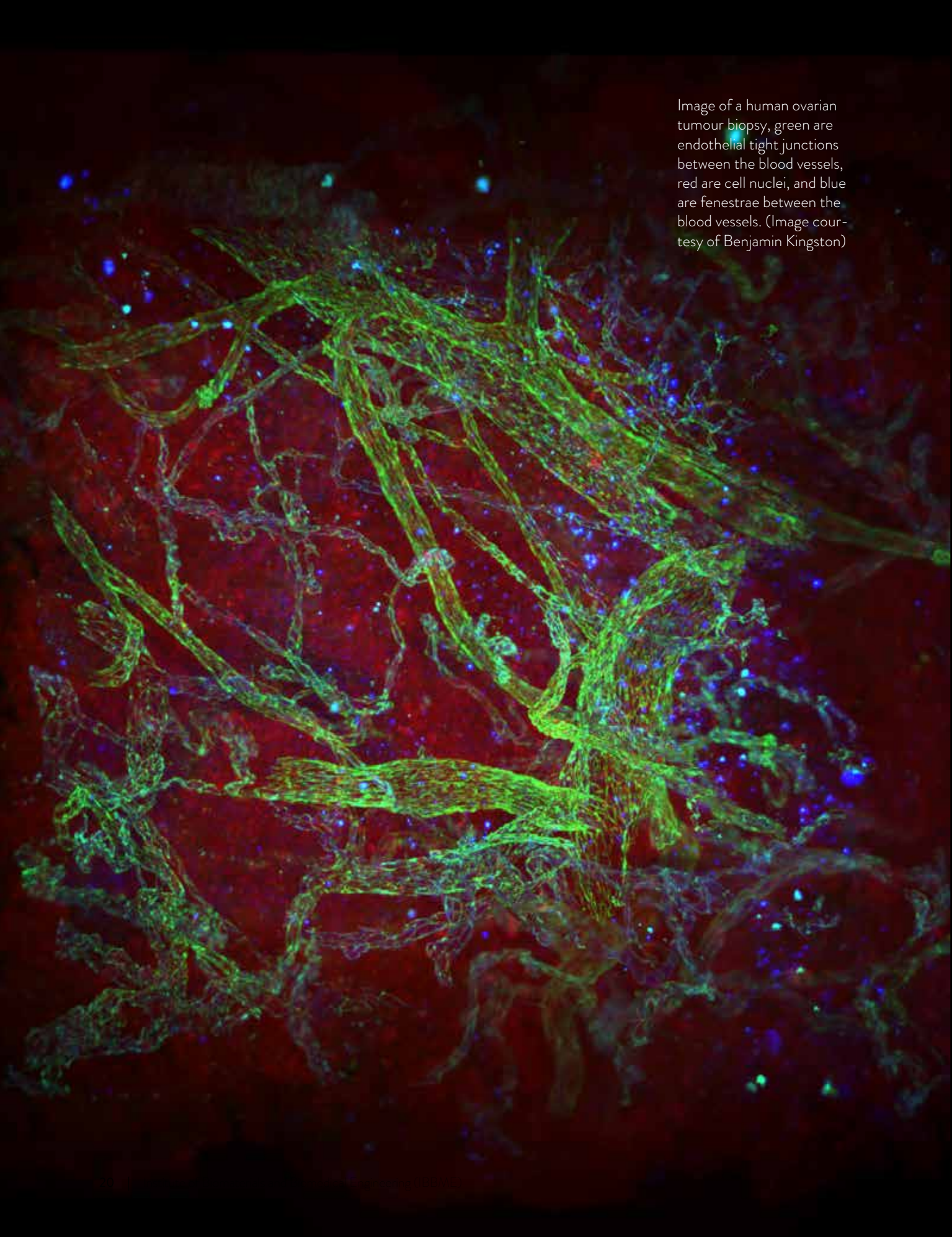


Image of a human ovarian tumour biopsy, green are endothelial tight junctions between the blood vessels, red are cell nuclei, and blue are fenestrae between the blood vessels. (Image courtesy of Benjamin Kingston)

Analogous to a nightmarish urban sprawl, architecture of the tumour microenvironment is equally difficult to navigate. The roads are replaced by blood vessels, and landmarks are replaced by various types of cells and non-cellular components. If you want to deliver drugs to the right places in the tumour, the chaotic nature of the tumour architecture is the roadblock. If no clear guides or instructions are provided, the drugs will not reach the targeted cells, therefore greatly reducing their efficacy. Worse, they could end up in healthy organs in the body, causing unintended side effects for the host. Ultimately, creating a cartographical map of the tumour is the first step in creating the '*Traveler's Guide to a Tumour*' for anti-cancer drugs.

In the last 4 years, researchers in Dr. Warren Chan's lab have been developing three-dimensional (3D) imaging tools that map out cellular and sub-cellular events in various organs. Using the tumour as a model system, researchers have been able to obtain biometric data of various types of cells and their locations within the tumour. Part of this seminal work was recently published in the Proceedings of the National Academy of Sciences (PNAS), an internationally renowned peer-reviewed journal.

"One of the biggest problems with drug carriers is that they are not going to where we'd want them to go," says Dr. Warren Chan, Distinguished Professor and the corresponding author on this research. "Our goal is to design nano-sized carriers that can deliver drugs to cancer. In order to do this we need figure out the intricate anatomy of the tumour microenvironment."

What makes cancer so deadly is its metastatic nature. During cancer progression, cells from the primary tumour (the site in which the original tumour takes place) can travel through the blood stream and populate distal sites, and secondary organs in the body. From that point, it starts to expand its own colony by generating a tumour in a new location in the body. This process of dissemination, known

← The tumour microenvironment is like a chaotic city centre, and resolving the tumour topography would allow scientists to design better drugs that targets the various compartments. (Illustration by Najila Kay)

as metastasis, is the major contributor to cancer related-deaths.

"Scientists often struggle with treating metastatic cancers because they can be hard to detect and can travel to unpredictable sites in the body," says Benjamin Kingston, a 4th year PhD researcher in Dr. Warren Chan's lab and the lead author on this research. "If you could eliminate them while they're still just a small cluster of cells, you could prevent them from growing into larger and debilitating metastatic tumours. But first we need to map out their physiological makeup. There are some fundamental differences between primary tumours and metastatic tumours, and we do not fully understand them."

Whereas the majority of the land-terrain on earth has been mapped out, the understanding of the tumour architecture is still rudimentary. The main reason for this

discrepancy is the lack of consistency in tumours. Not only are two tumours from the same patient different from one another, tumours between various patients can also greatly differ from one another. With such a wide spread set of information, one would need a personalized treatment regimen for each case.

"We are utilizing 3D imaging technology and image analysis to resolve biometric data in the tumour microenvironment." says Benjamin. Since the start of his PhD, Benjamin has been gathering physiological data such as the size of the metastases, its surface area, how spherical it is, how many cells are inside it, how far all these cells are from blood vessels, etc. This data was then used to train a mathematical model to figure out how changes in the biology of the tumour will affect the trajectory of the drug-carrying vehicle.

With an increasing complex set of data gathered on various tumour physiological parameters, it is difficult to formulate a predictive model based on one or two metrics alone. The researchers combined machine learning algorithms with large biomedical data to create a 'rule-set' to better predict how drugs will behave in the body, specifically in different tumour microenvironments.

"This is where machine learning really shines, because it offers a set of tools for you to start looking at huge numbers of variables." says Benjamin. "The computer doesn't care how many variables there are or how much a variable has changed. It just plots out a model in a non-biased way, and it can do that much faster than any human being can. Over the course of our studies we have imaged over 1,300 individual metastatic sites with our 3D imaging platform in order to generate this predictive model. There's no way I can do this by myself without some sort of automation." ■

↑ Researchers on the PNAS publication. From left to right: Jessica Ngai , Dr. Shrey Sindhwani, Dr. Abdullah Syed.

→ Gold nanoparticles was used in the study to tease out the topography of the tumour microenvironment. This is a top-down view of a flask of nanoparticles used in the study.

MAKING THE RIGHT CUT

GRAPHIC, WORDS & PHOTOS:
QIN (BILL) DAI

IBBME alumni are developing an intraoperative imaging device for high precision surgical procedures.

The term "Surgical Precision" is used to describe the finesse and the highly accurate nature in which a surgeon can cut diseased tissue from healthy tissue. This precision depends as much on the skill of the surgeon, as it does on the information they have about the tissue, to inform their surgical decision-making process. As is the case for most medical conditions, it is critical to remove and/or treat diseased tissue to prevent its spread into surrounding healthy tissue. In a disease like cancer, the complete removal of the tumour in some cases is the critical step in ensuring that relapse does not occur. But how do you know for certain that all the diseased tissue has been removed?

↑ Elizabeth Munro (IBBME0T9)

Co-founded in 2013 by Liz Munro (IBBME0T9), Perimeter Medical Imaging's mission is to provide better tools for cancer surgeons. They specialize in building real-time, high resolution imaging devices which provide sub-surface images of tissue that can be used by surgeons for intra-operative tissue assessment.

"Surgeons are usually working with images collected preoperatively – that is, before the surgery, as well as their own visual inspection and palpation of a piece of tissue once it has been excised. They have limited real-time tissue assessment tools to make more informed decisions during the operation." says Liz.

The gold standard for tissue assessment is post-operative pathology. In this process, an excised tissue specimen is fixed in formalin, embedded in paraffin, and sliced thinly to produce histology slides which can be viewed with a microscope, often leveraging dyes to highlight different cellular structures. A pathologist examines the slides and writes a pathology report outlining their findings. In the case of cancer removal surgeries, if cancer cells are reported as being close to or at the surface of the excised tissue specimen, additional intervention such as a second surgery may be recommended to the patient.

"Postoperative pathology will always be the diagnostic step for excised tissue," explains Liz, "the challenge is that it takes a significant amount of time – from half-a-day to a full week, to receive the results of this detailed analysis. With a limited number of intraoperative, tissue assessment techniques available to surgeons, a reduction in second surgeries has been a challenge. We aim to give surgeons additional information at the time of surgery, which we hope will inform their real-time decision making, allowing them to achieve better results and reduce the need for patients to come back for second surgeries."

Perimeter's first product – the OTIS™

tissue imaging system – has received United States Food and Drug Administration (FDA) clearance and the company is preparing for a sales launch in 2020. The OTIS™, is an imaging tool which provides high-resolution, real-time imaging of the margin of an excised tissue specimen, enabling clinicians to visualize sub-surface structures up to 2 mm below the surface, while maintaining the integrity of the specimen for post-operative pathology. This is a crucial data set that is currently unavailable to surgeons in real-time.

"You can think of OTIS™ like a photocopier for excised tissue," says Liz, "but it allows the user to see just inside the specimen. The imaging technique we use is called Optical Coherence Tomography, which is analogous to ultrasound, but uses light instead of sound to produce much higher resolution subsurface images. The product has come a long way since we started the company. We received FDA clearance on an earlier generation of the device in 2016, and just recently (at the start of 2019) received another FDA clearance for an updated model that is 10x faster than the original and includes a novel specimen positioning system. I'm very lucky to work with a team of talented and highly motivated individuals in making this happen."

After finishing her undergraduate studies at McGill in physics, Liz Munro pursued her Masters of Applied Sciences (MASc) degree in biomedical engineering with Dr. Ofer Levi, graduating in 2009. After an initial stint working with Ontario Centre of Excellence (OCE) on technology innovation projects, Liz started working with a local Toronto startup, Tornado Medical Systems. A project which had been incubated and researched by Tornado was spun out into a new company- Perimeter Medical Imaging, in 2013, and Liz was part of the founding team.

Since then, the company has grown from the original four founders to over 20 people, and has raised more than $21 million from private investors and government agencies.

"I remember when I started at Tornado, I was surprised by how complex their medical device quality management system was." says Liz. "There were an incredible number of standard operating procedures to learn as part of onboarding, and it was not something that I had been exposed to in the past."

Adherence to quality standards is a critical aspect of working at a medical device company. Every job function, from administration to engineering to sales must comply with applicable regulatory requirements to ensure that the medical device they design, develop and eventually manufacture, is safe, effective and can be legally sold.

"It has been a huge advantage of hiring staff out of the IBBME MEng (Masters of Engineering) program, as the curriculum includes an introduction to regulatory requirements and quality management systems. We've found that individuals coming out of this program tend to "get it" and are quick to learn the ropes of working in a medical device development environment."

From MEng to Industry

Ellen Turner (IBBME1T7) and Nicole Gauer (IBBME1T7) are two of the IBBME MEng students who have joined Perimeter Medical Imaging after their 4-month internship in 2017.

What do you do in the company?

Ellen: My title is Clinical Engineering and Applications Specialist. I work with the clinical applications team by directly interacting with doctors to train them on how to use our device. I then take their feedback to the engineering team to recommend features and functionality which could improve the device from a clinical perspective. So I have my feet in both worlds.

Nicole: My title is Software Developer which means I work on the software running on the devices – everything ranging from user interface to controlling the hardware. For instance, one thing I'm working on is the ability to transmit images from our device in the operating room to the radiology suite, so that a surgeon can consult a radiologist on image interpretation. That being said, we wear multiple hats in a start up environment.

↑ Ellen Turner (MEng, IBBME1T7)

You mentioned wearing multiple hats, what does that mean?

Ellen: By gaining exposure to areas of the company outside of your specific role, you really start to see how all the roles within the company play into each other and also identify where the focus of the company lies. It gives me perspective on how the whole company runs as a unit.

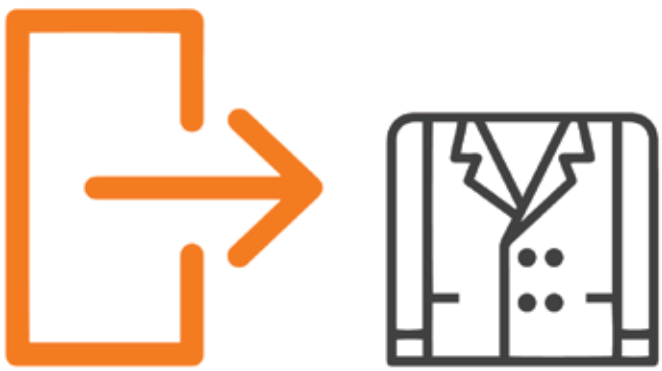
Nicole: For instance, while my primary focus is software development, I have been in charge of writing verification and validation protocols that wouldn't necessarily fall within the realm of software, and have acted as support for devices at clinical sites. I think having exposure to these things is invaluable to me.

How did the MEng program prepare you for the job?

Ellen: There's the internship component where we spent 4 months at the company. There are also extremely useful courses that touch on the regulatory aspect. I remember mentioning this course during the job interview, and the interviewer visibly perked up and got interested. There's a lot of industry lingo that we got to learn that really put us miles ahead.

Nicole: I'll have to agree with Ellen, the BME 1800/1801 courses were great first introductions to medical device development. They introduced the sort of documents and regulations you'd need to look at in order to reach commercialization. Even just learning about ISO 13485 and the different FDA and regulatory terminology is a great stepping-stone for getting into industry. ■

↑ Nicole Gauer (MEng, IBBME1T7)



EXIT STRATEGY

PHOTOS:
KLICK HEALTH

GRAPHIC & WORDS:
QIN (BILL) DAI

Sarah Sarabadani, Michael Li, and Marija Cotic worked in different Biomedical Engineering labs at the University of Toronto. Now they have all converged at Klick Health, a rapidly growing healthcare marketing and commercialization agency, headquartered in Toronto. We sat down to talk about their day-to-day activities and how they were able to leverage their skills to transition into non-traditional healthcare roles.

← Sarah Sarabadani (MASc, IBBME1T6)

What research area did you pursue in your graduate education?

Sarah: I was in Dr. Azadeh Kushki's lab between 2014 – 2016. We were studying how children with autism often have trouble expressing emotions, and tried to use alternative physiological metrics to gauge what they are feeling. Some of the parameters we measured were heart rate, respiration rate, body temperature, and electrical signals from the skin while they were exposed to various imageries. Using machine learning algorithms, we successfully showed there are patterns in physiological signals in various affective states.

Michael: I did my Masters with Dr. Babak Taati. We looked at Parkinson's disease and tried to figure out whether we could use computer vision to automate some of the tests traditionally used by doctors to assess the severity of Parkinson's symptoms, specifically involuntary movements. In current practice, a neurologist would ask a person with Parkinson's to perform a series of tasks designed to show symptoms. These tasks would be rated by the neurologist to provide a disease severity score. The goal of our assessment was to give doctors more objective and frequent information, so that they could more accurately modify treatment regimens.

Marija: I finished my PhD in 2014 and I was co-supervised by neurologist Dr. Peter Carlen and engineer Dr. Berj Bardakjian. My work primarily focused on the study of epilepsy, and we were tasked with creating signal processing tools to localize where seizures start in the brains of patients with epilepsy.

→ Michael Li (MASc, IBBME1T7)

How did graduate school prepare you for the transition into industry?

Sarah: In graduate school, I had to do a lot of MATLAB, and moving into industry made me aware that a lot of companies require an understanding of Python. So I started learning Python from multiple online sources and evolved from there. Having that self-starter mentality from graduate school really helped.

Michael: When I joined Klick Health, one of the projects the company was working on was their SymPulse™ Tele-Empathy Device that allows physicians and caregivers to experience tremors from a Parkinson's patient. I happened to have worked on Parkinson's during my Master's thesis. Having that specialized knowledge was something that helped me get a foot in the door. The other valuable skillset was the ability to take a large amount of information that's nebulous and synthesize it in a structured fashion. While I've been fortunate that the technical knowledge gained in graduate school has been transferrable, it's really been the research method and attention to detail that have been most useful to me at Klick.

Marija: Coming from a science background really prepared me to work with scientific and medical content, which is a critical part of my role. A lot of our clients are pharmaceutical companies and part of my team's role is to ensure the accuracy of all scientific and medical messaging. In graduate school, my focus was on the brain, but now I oversee work on multiple disease states. The ability to quickly and efficiently convey the science of various therapeutic areas and treatments is a reflection of my PhD education, where I was constantly evaluating, reviewing, and summarizing information. I think ultimately, graduate school teaches you how to solve problems in unclear situations and that set me up for success.

← Marija Cotic
(PhD, IBBME1T4)

What is a cool project that you have worked on?

Sarah: I recently represented Klick at a conference to speak about some innovative research from our team. We were studying social media platforms, like Twitter, trying to detect adverse drug reactions based on what people were saying. Getting the right context out of people's tweets can be a challenge, due to the non-formal languages, slang, and non-structured text they often use. We had to use text analysis and machine learning to figure out who was talking about an adverse reaction to a drug. The other challenge was the context of the tweet. For example, if someone said, "I took Advil because I had a headache", the algorithm needed to understand that headache was not the side effect of Advil, it caused the person to take Advil in the first place.

Michael: There are a few cases where we showcased our in-house coding and artificial intelligence (AI) capabilities. We participated in the Blood Glucose Prediction challenge at a high-profile AI conference last year in Sweden. The organizers released a dataset from seven anonymous individuals with Type One Diabetes. The data included continuous blood glucose levels, life event data such as meals and sleep as well as biometrics like heart rate. Our goal was to see if we could use this information to predict changes in a person's blood glucose level 30 minutes in advance, which would allow for proactive interventions to prevent hypo- or hyperglycemia.

Marija: Some of the most interesting projects I've worked on are mobile apps and Virtual Reality experiences for both patients and doctors. One of the mobile apps we created helps doctors quickly calculate non-standard doses for their patients and is also able to generate personalized calendars to help patients keep track of their medication throughout their treatment.

What are you working on?

Sarah: I mainly study marketing activities aimed at each of our client's various stakeholders like physicians. In doing so, we can ensure we optimize our content, and physicians are aware of drugs that are relevant to their prescriptions. We want to understand what physicians care about in their decision making.

Michael: We are trying to better understand how digital tools can be integrated with current practices to improve quality of care for patients and are encouraged by how in the United States, the FDA is becoming more open to clinical trials using some form of digital biomarker as a secondary outcome measure for diseases. Right now, we are seeing increased interest in digital therapeutics, where the treatment is administered through apps and online platforms, either standalone or as an adjunct to traditional therapies. As these new technologies enter the market, it's essential to understand how different customer segments perceive these treatments and find the most efficient means to get them to the people who need them the most. We're constantly working to stay ahead of the curve and understand how the pharmaceutical field is evolving.

Marija: As a Science & Regulatory Director, I work daily with my team and the extended team on healthcare marketing campaigns across multiple portfolios and clients. I travel to meet with our clients' Medical, Legal and Regulatory teams. In terms of specific activities, our team ensures the editorial integrity and quality assurance of the materials we create for our clients. Often, we collaborate with our Medical Strategy team on content creation and strategic workshops for our clients. ■

For more information on joining Klick Health and being part of its ongoing success, double-digit growth, and award-winning culture, go to http://careers.klick.com.

FACES OF BME

PHOTOS:
IVY HON & QIN (BILL) DAI

We sat down with several Biomedical Engineering graduate students and talked about what motivates them outside of their labs.

Jennifer | PhD | Zandstra Lab

On social media there is an increasing number of scientists who are being vocal about their passions, successes, and struggles, which makes the scientist figure more accessible and relatable. Hopefully this will build trust between the scientific community and those outside of it. I like to use art as a medium to reach out to a broader audience.

My favourite brushes are these two tiny ones because I like doing a lot of detailed work. I am not the most patient person, but I can spend hours upon hours refining one piece of artwork, fully immersed in a flow state.

Shrey | MD & PhD | Chan Lab

The guitar allows me to tune out what I do in the lab and focus on using a different part of my brain. I like the creative process, and the guitar gives me a different platform to embrace that.

I grew up in India, so I play a lot of Hindi songs. Recently I've been playing some songs by Eric Clapton. I really like their melodies.

It took me two months to play my first song. Initially it was a struggle, but when I finally put everything together, there was this 'aha' moment. It made me think: this is what it sounds like? That's when the song really comes alive.

Ileana | PhD | McGuigan Lab

Growing up, doing outreach has always been a big part of my life. I feel lucky to come to Canada from the Phillipines and got a good education in engineering. Not all the kids have the same opportunity, and I feel like I need to be the person to show them what's possible.

It doesn't matter whether I'm teaching a grade 7 or 11 student, I have to break down the scientific concepts, so they are more digestable to my audience. That has really helped me in communicating my research during my PhD.

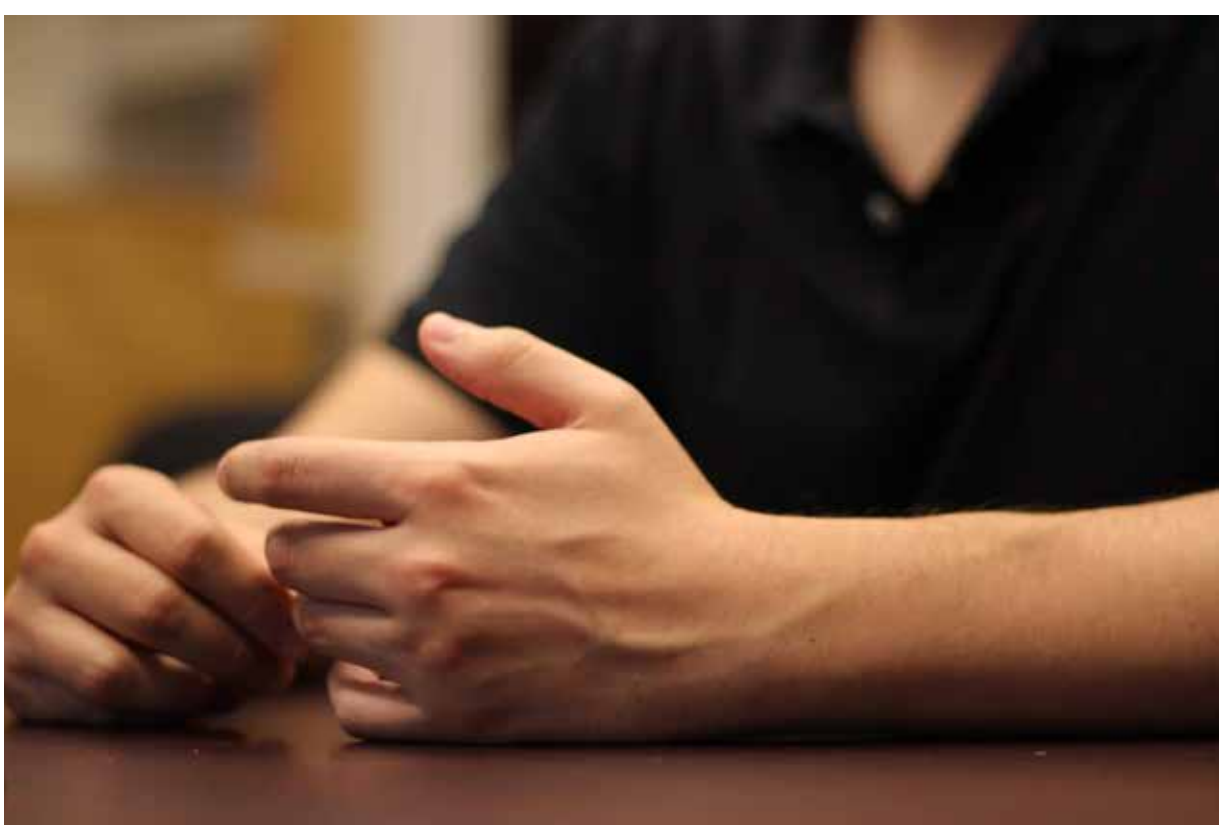
Jose | PhD | McGuigan Lab

I've been playing bass for 15 years now, but mostly as a hobby.

We started a band with a couple of people from BioZone, and we rehearse every couple of weeks. The name of the band hasn't been decided yet, but since we practice on Front Street, the name will probably have the word 'Front' in it.

We haven't written any songs about the PhD process yet, but I suppose it's a matter of time.

We do a little bit of heavy metal, progressive metal, and conceptual rock. So far we covered a couple of songs by Muse. But now we're trying to write our own songs.



Katy | PhD | Gilbert Lab

I'm part of the Triathlon Club at the University of Toronto. We are always looking for more members.

I did an half Ironman, which consists of 1.9km swim, 90km bike, and 21km run. The whole thing took me under 6 hours to complete.

I ran the Scotiabank half marathon last year, and I broke my finger in the first kilometre of the run. I fell, got up, and realized my pinkie was swollen. The pain didn't hit until I finished the marathon, and I had to go to the hospital afterwards.

All I thought about during the marathon was how hard I trained for this, and there's no way I'd quit because of a broken finger.


ROWING

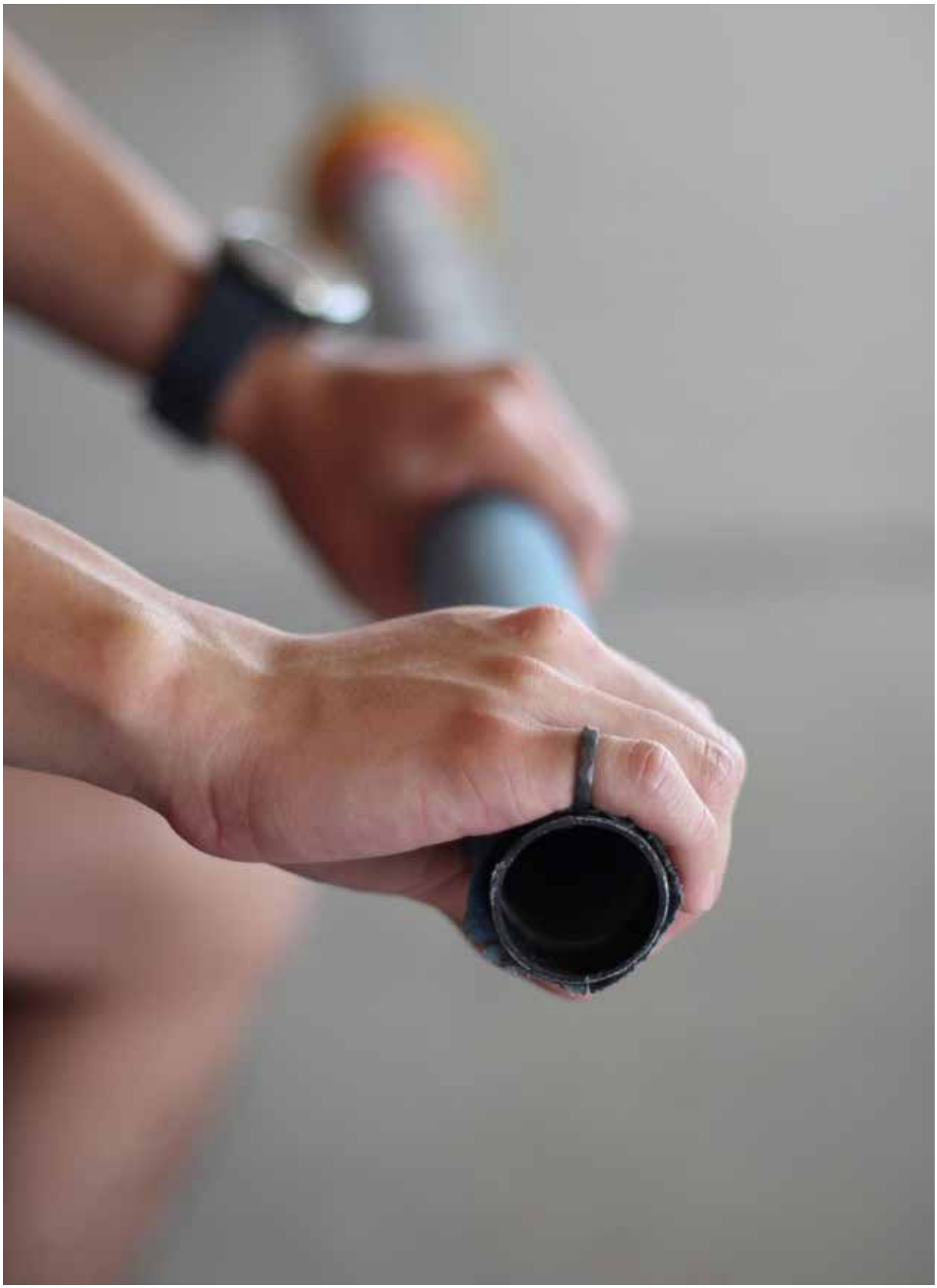
Kenny | MASc | Sone Lab

My brother was a competitive rower, and that's how I got into varsity rowing.

The rowing community have some really nice and supportive people. There's just a lot of positive, high energy all around in the sport. The fact that you need to push yourself - both physically and mentally - makes the sport really refreshing.

In a typical race, it's 2,000 meters long, and you're going down the course as fast as you can, as hard as you can. When you are working together as a team, it is a powerful feeling.

Every time you put in long distances, your hands suffer. Every two weeks I get blisters, followed by callus formation, then it falls off and the whole process starts again. ■



HOW TO: PRESENT

WORDS:
NETRA UNNI RAJESH

PHOTO:
QIN (BILL) DAI

Netra Unni Rajesh is a fourth year engineering science student with a specialization in Biomedical Engineering. During her internship with Dr. Robert Langers lab at M.I.T., she was invited by the local TEDx conference to share her experience on how Science, Technology, Engineering, Art, and Math (STEAM) transformed her perspective as a researcher. The video has since then been viewed more than 4,000 times. Here she shares some tips on presentation and public speaking.

Tip 1: Presentations were made to be practiced

Although there is a negative connotation with a presentation sounding too "rehearsed", it makes a big difference in delivery when a presenter runs through their talk multiple times with different audiences. Practice can help calm those pre-performance jitters and can serve as an opportunity to get useful feedback that will iteratively improve a presentation. Even practicing a talk in front of a mirror can provide cues on physical gestures and expressions, which contribute to the overall image of a presenter.

Tip 2: Stay away from scripting - outline instead

A script can do more harm than benefit. For one, it restricts a presenter's flow, in the sense that one is pressured to stick to the script. Although it may seem like a script helps reduce nerves, it can create breaks in the talk when a speaker forgets a part of the script and must scramble to get back on track. An outline, on the other hand, serves to break down critical ideas that should be communicated in a talk. The guideline provides enough structure yet affords flexibility for changes that occur in the spur of the moment.

Tip 3: Be aware of audience response

A presentation is ultimately for an audience, with a purpose to share an idea with a larger group. Many presenters focus on themselves on stage and it can be very difficult to get out of one's head when they are doing all the talking. Being aware of the audience's reaction to a talk can serve to motivate and gauge how to continue the presentation. If a presenter notices the audience losing interest, they may choose to incorporate a comical anecdote or an interesting fact. Looking to the crowd for cues and making personal eye contact with audience members can collectively improve everyone's experience.

Tip 4: Don't be afraid to be expressive and to emote

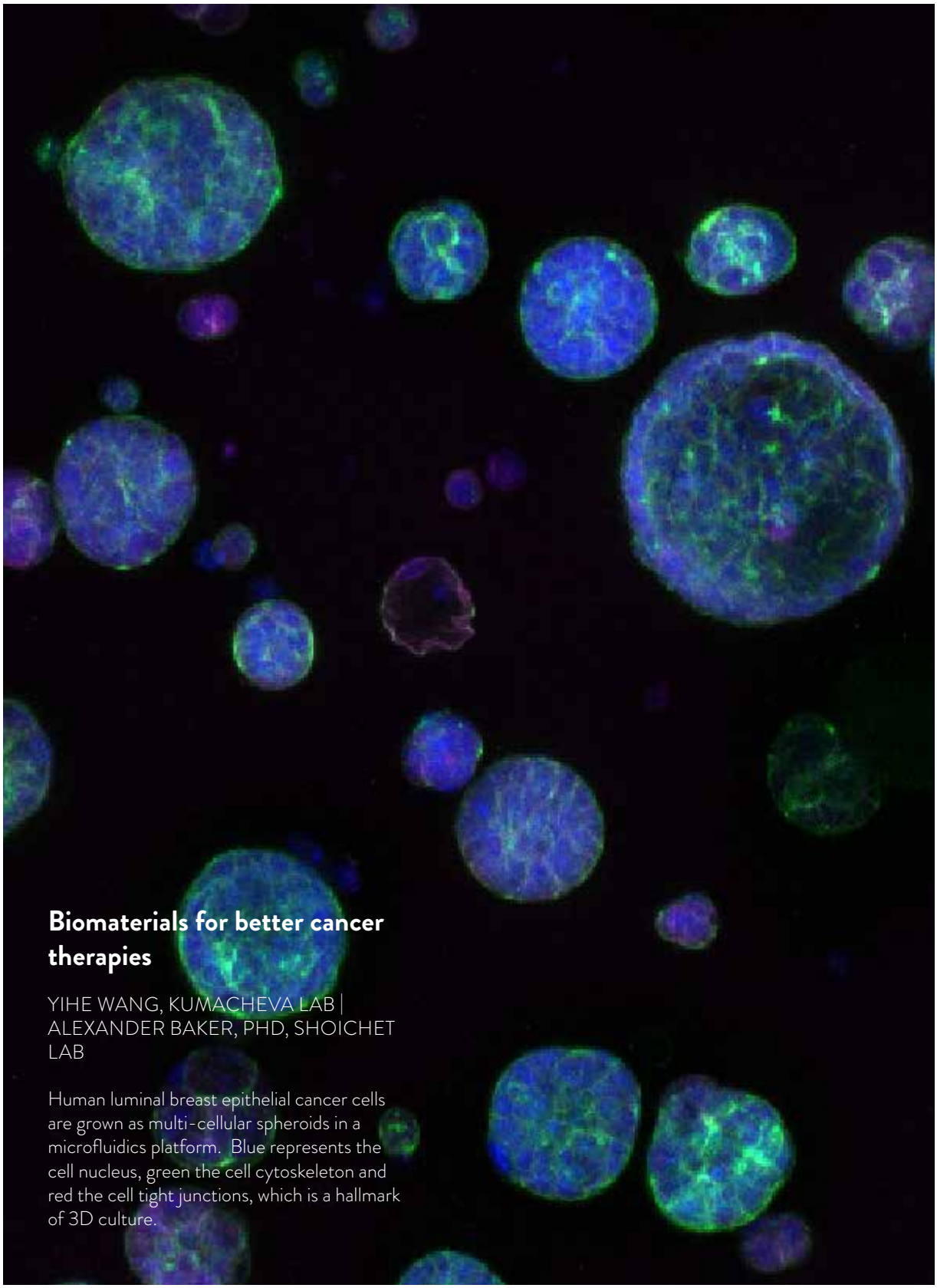
Humans are very responsive to emotion and are great at telling when it is genuine and when it is not. Being over expressive can come across as artificial; however, genuine emotion can capture the audience's interest and allow the presenter's passion to come through. Ultimately, this makes a talk more engaging and motivates the audience to at least consider the ideas being presented. The goal of a talk is always to plant an idea in the audience's mind, and this becomes a rather arduous process for the speaker and audience when it "doesn't come from the heart." ■

→ Netra on the TEDx stage on January 19, 2019. Source: YouTube.

RESEARCH GALLERY

GRAPHIC: ADOBE

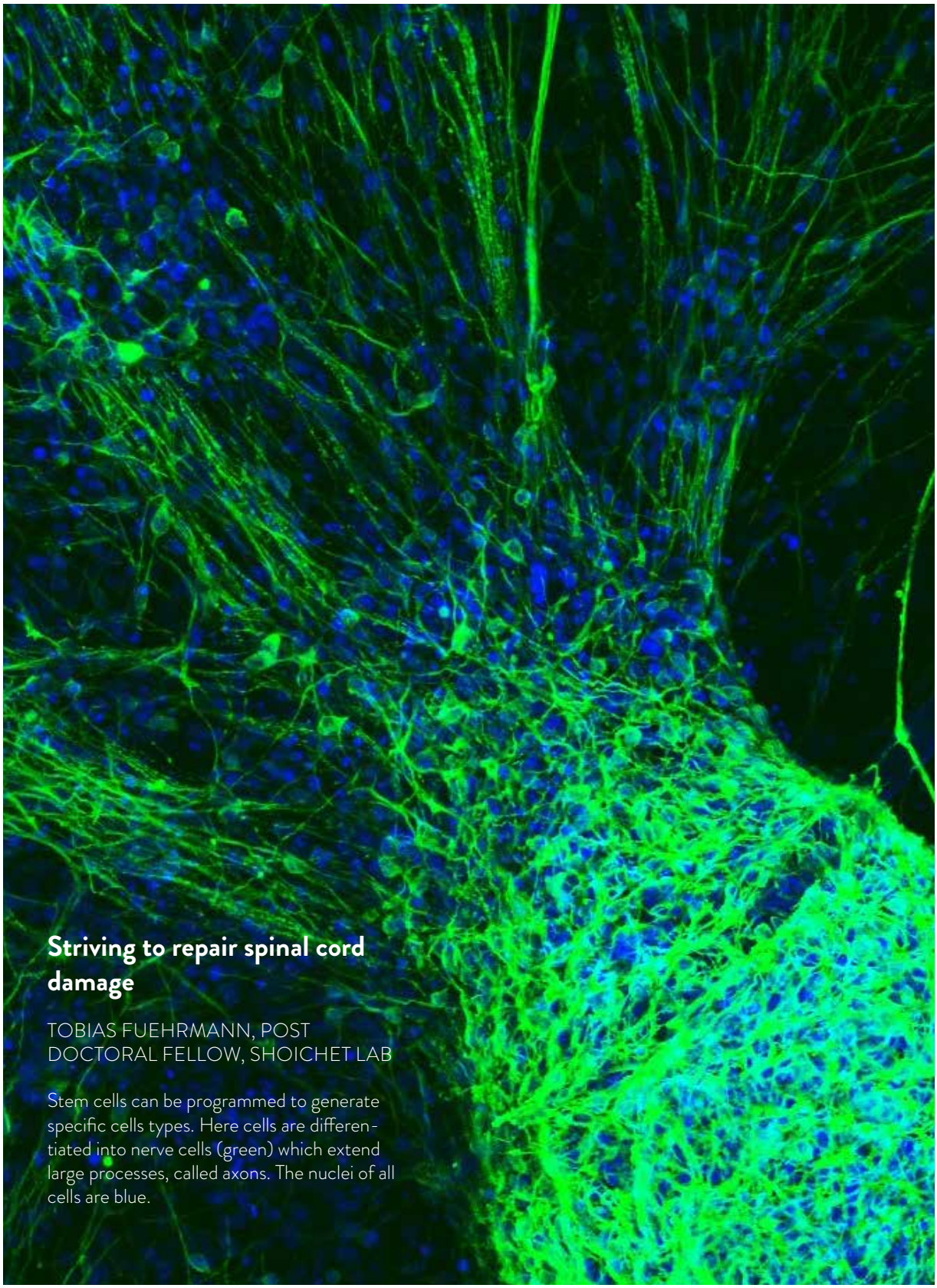
Here we curated some outstanding research image submissions by members within our community.



Biomaterials for better cancer therapies

YIHE WANG, KUMACHEVA LAB | ALEXANDER BAKER, PHD, SHOICHET LAB

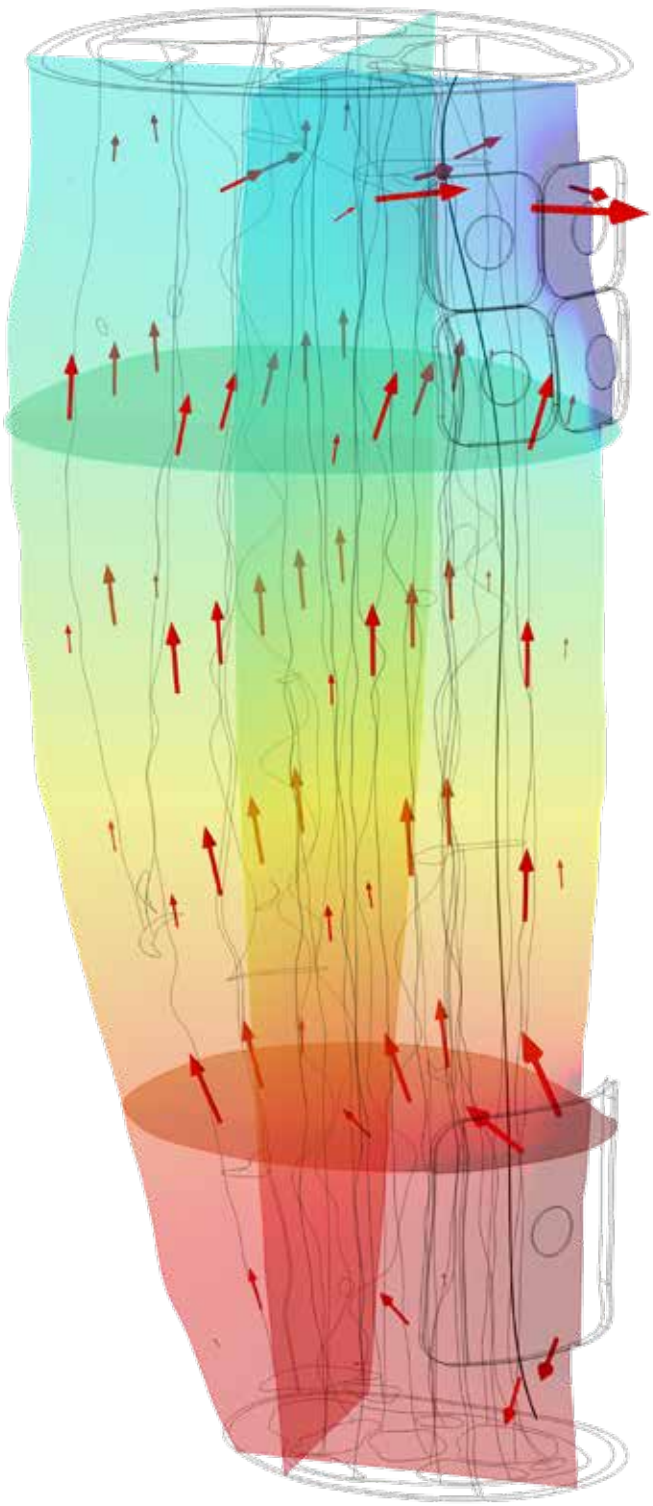
Human luminal breast epithelial cancer cells are grown as multi-cellular spheroids in a microfluidics platform. Blue represents the cell nucleus, green the cell cytoskeleton and red the cell tight junctions, which is a hallmark of 3D culture.



Striving to repair spinal cord damage

TOBIAS FUEHRMANN, POST DOCTORAL FELLOW, SHOICHET LAB

Stem cells can be programmed to generate specific cells types. Here cells are differentiated into nerve cells (green) which extend large processes, called axons. The nuclei of all cells are blue.



Neural activation of motor nerves

SILVIU AGOTICI, YOO LAB & MASANI LAB

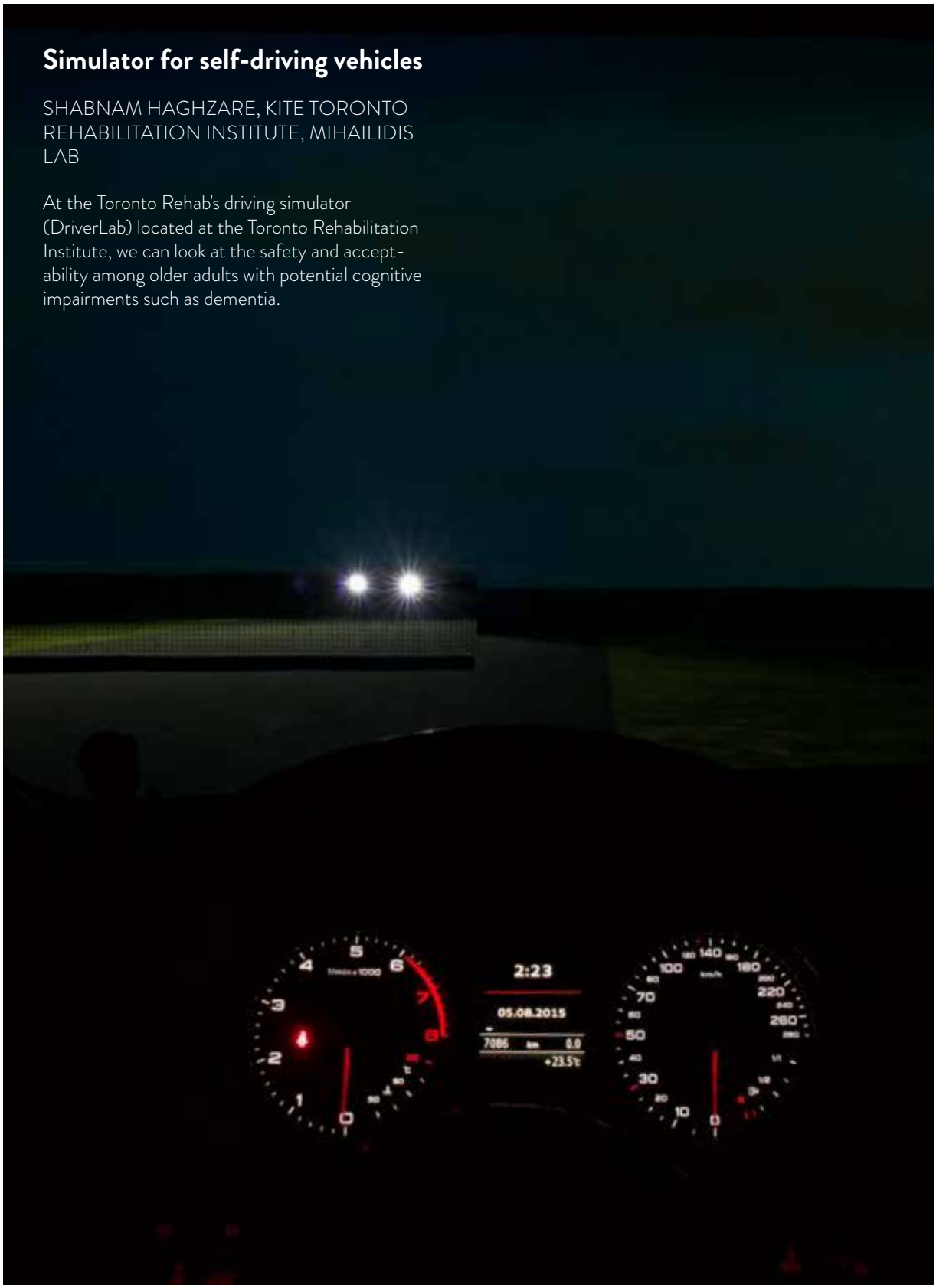
The image shows the finite element (FE) solution for the electric field (heat map) and the current flow (arrows) resulting from the simulation of transcutaneous electrical stimulation (TES) in a 28 cm section of the lower leg (just below the knee to just above the ankle).

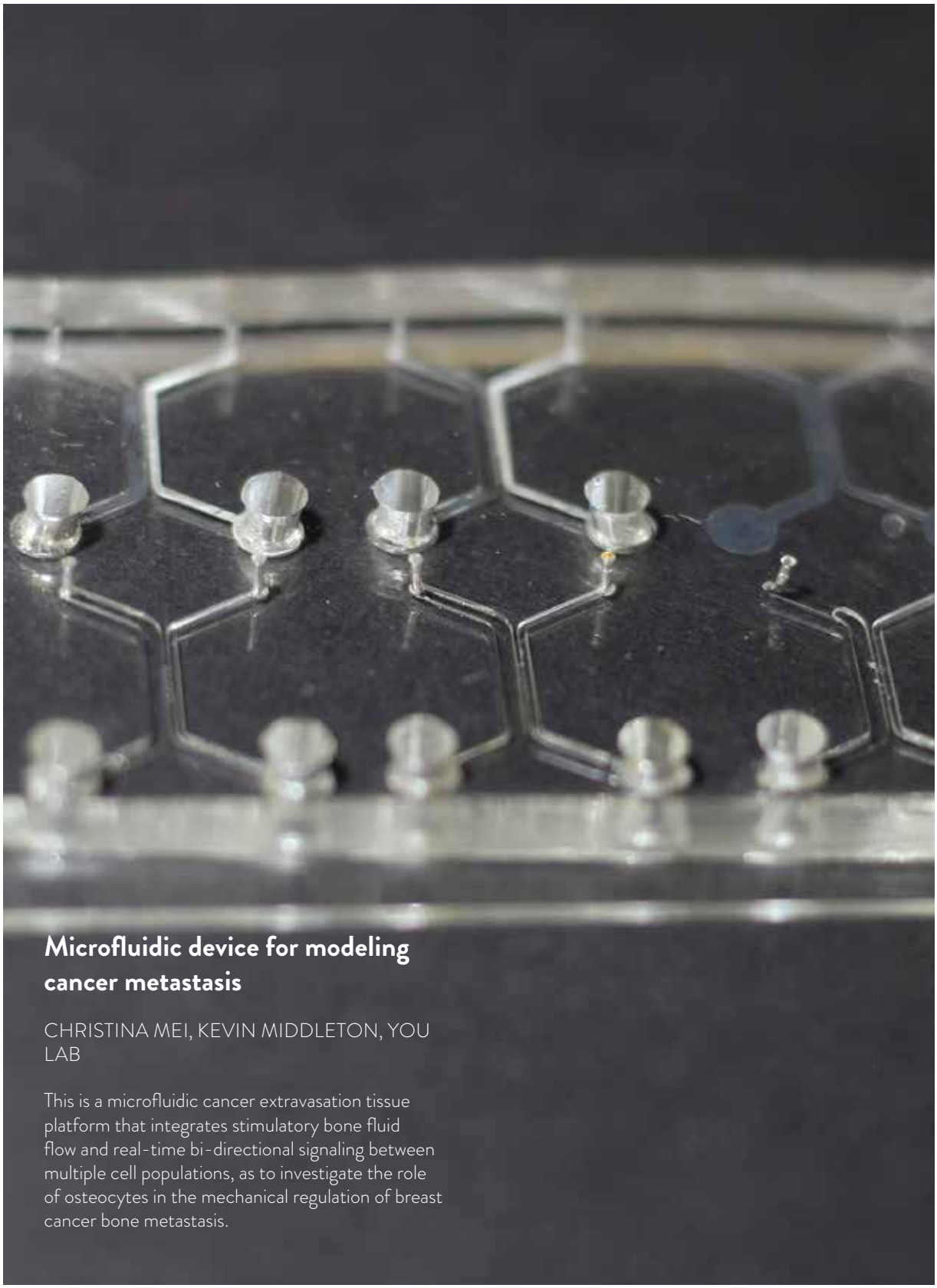
These simulation allow us to gain a deeper understanding of the effects of transcutaneous electrical stimulation variables such as electrode shape and positioning, and stimulation magnitude on neural activation.

Simulator for self-driving vehicles

SHABNAM HAGHZARE, KITE TORONTO REHABILITATION INSTITUTE, MIHAILIDIS LAB

At the Toronto Rehab's driving simulator (DriverLab) located at the Toronto Rehabilitation Institute, we can look at the safety and acceptability among older adults with potential cognitive impairments such as dementia.





Microfluidic device for modeling cancer metastasis

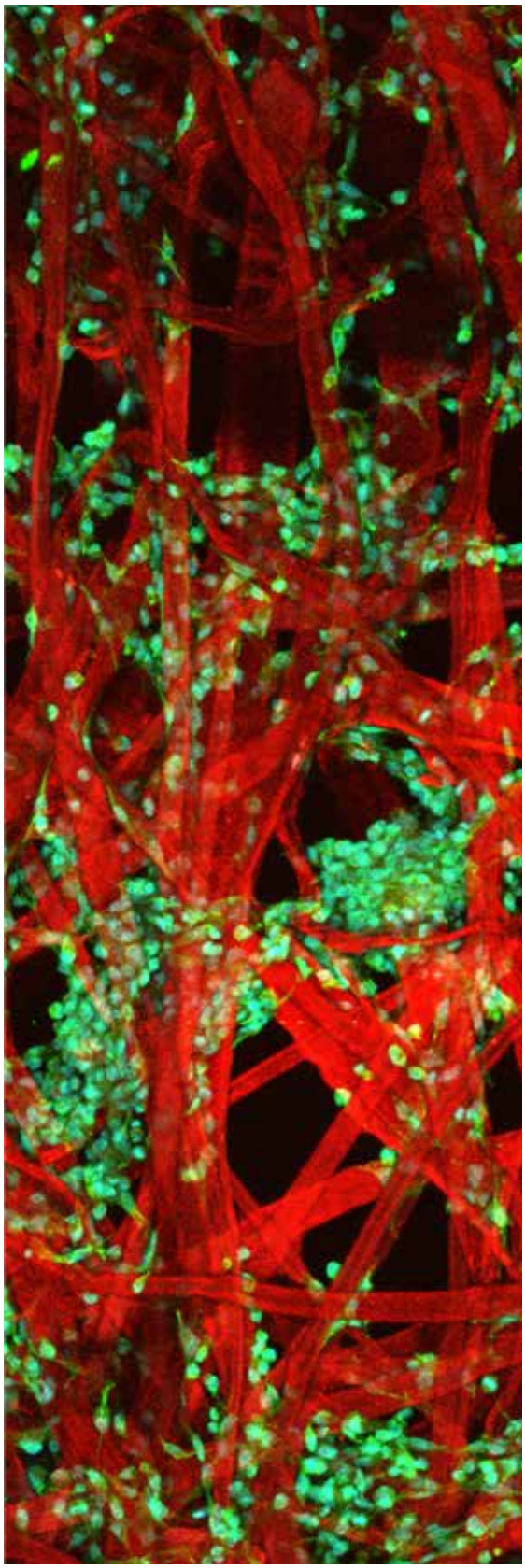
CHRISTINA MEI, KEVIN MIDDLETON, YOU LAB

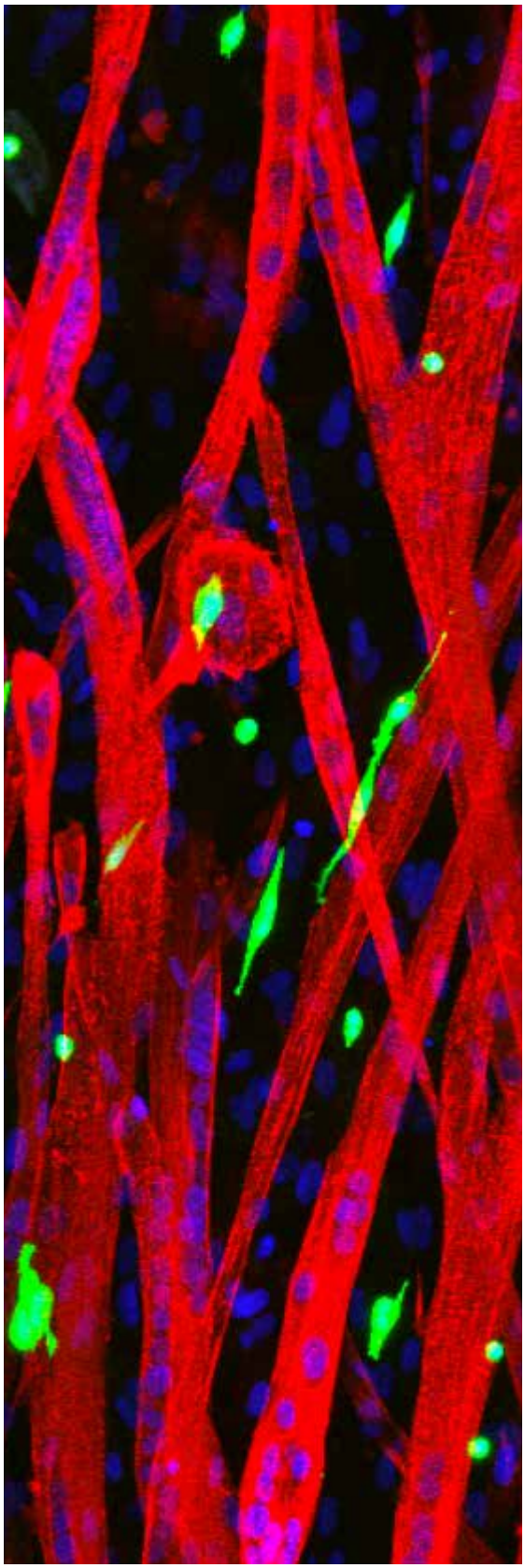
This is a microfluidic cancer extravasation tissue platform that integrates stimulatory bone fluid flow and real-time bi-directional signaling between multiple cell populations, as to investigate the role of osteocytes in the mechanical regulation of breast cancer bone metastasis.

HERO Gloves

AARON YURKEWICH, ILLYA KOZAK, ANDREI IVANOVIC, MIHAILIDIS LAB

The HERO Glove assists stroke and spinal cord injury survivors to extend their hand and grasp with more force. The HERO Glove enables people to perform activities of daily living like opening water bottles, cutting food and writing independently at home.





←Cancer cells on paper (Left)

SIMON LATOUR, MCGUIGAN LAB

The picture represent cancer cells growing in a paper based 3D environment.

←Skeletal muscles (Right)

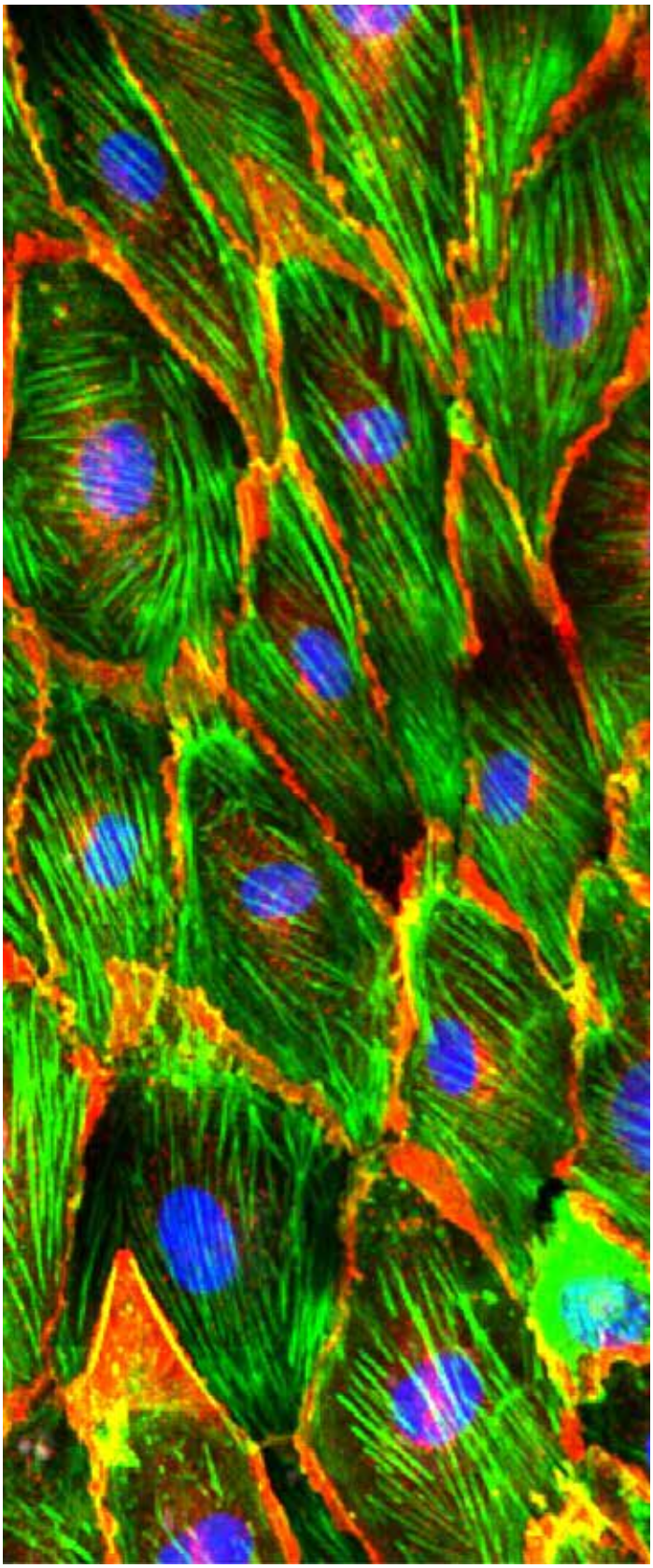
BELLA XU, GILBERT LAB & MCGUIGAN LAB

The mouse skeletal muscle stem cells (green) associate with human skeletal muscle fibres (red) 24 hours after the incorporation of GFP muscle stem cells in 3D human muscle tissue (MEndR).

→Modeling the blood vessels

YIH YANG CHEN, CHAN LAB

Human Umbilical Vein Endothelial Cells (nuclei stained in blue) are grown within a microfluidic channel and subjected to flow shear in order to align their actin fibres (green) in the direction of flow. VE-Cadherin protein expression (red) shows the cell membranes are cross-linked to each other, allowing all of the individual cells to resist being washed away.



Using 3D printed device for surgery

SHAURYA GUPTA, YEE LAB & YANG LAB

This 3D printed device can be used for high-frequency ultrasound in neurosurgeries. This device allows for accurate tracking of the ultrasound probe (and by extension - ultrasound scans) in 3D space and in relation to the patient's preoperative CT/MRI scans.

Rehab using augmented reality

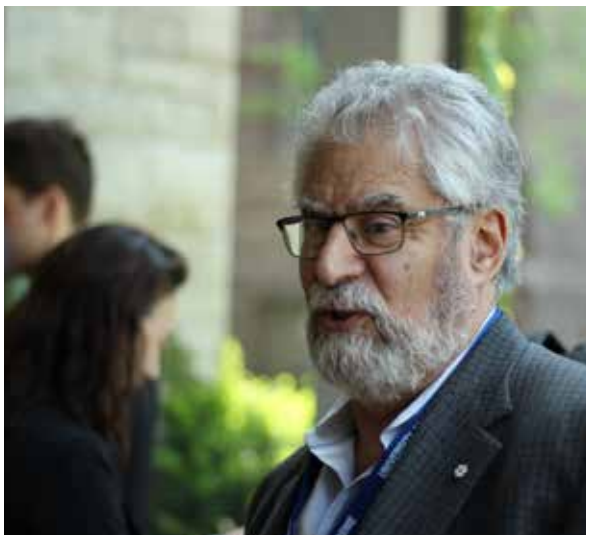
MEHDY DOUSTY, ZARIFFA LAB

Zariffa and colleagues are applying computer vision algorithms on videos captured from wearable camera to monitor patient hand recovery after spinal cord injury. This can provide more effective clinical evaluations of new interventions through precise outcome measurements.

YEAR IN PICTURES

IBBME SUMMER BARBEQUE

The IBBME annual barbeque is a tradition that introduces new faculty members, graduate students, and staff members to the Biomedical Engineering community at the University of Toronto.




IARC
Institute of Biomaterials and Biomedical Engineering
Annual Research Conference

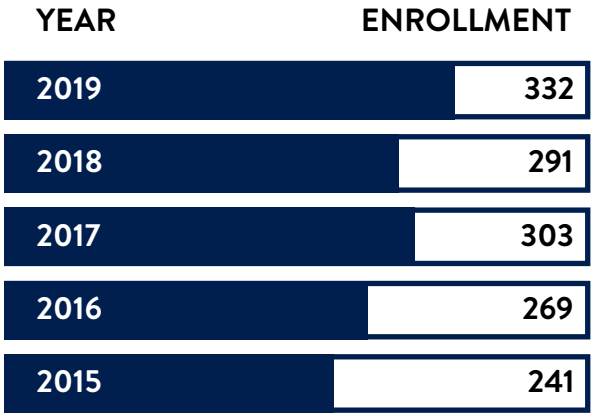
ANNUAL RESEARCH CONFERENCE

The IBBME Annual Research Conference is a student-organized conference that celebrates biomedical engineering research and achievements by our student and faculty members.

YEAR IN NUMBERS

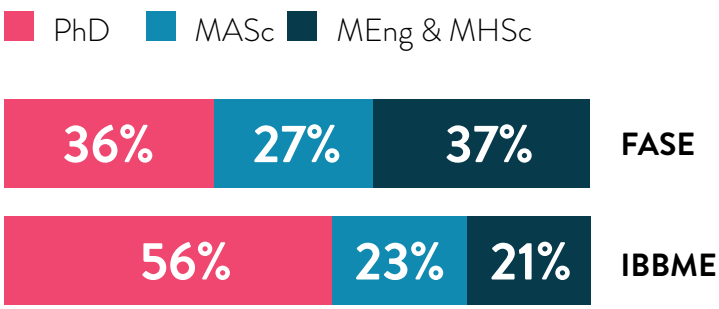
Enrollment Trend

IBBME graduate student body has been experiencing steady growth in the past 5 years. At the beginning of 2019 academic year, the graduate body experienced a 14% growth compared to last year. The numbers shown were the student numbers in September of every year. The numbers were collected on September 18, 2019.



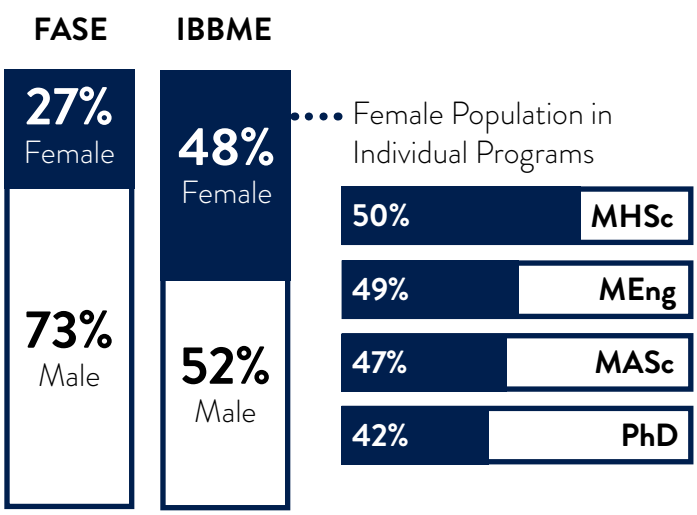
Enrollment Breakdown

IBBME is one of the leading research intensive units within Engineering. Approximately 56% of its graduate population consists of PhD students in 2019. Comparatively, FASE averages 36%. The IBBME numbers were collected on September 18, 2019.



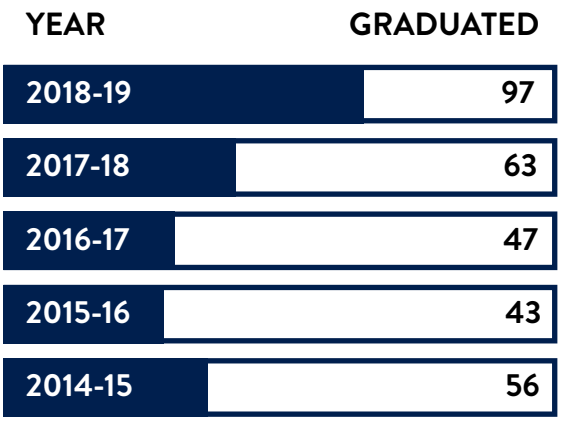
Gender Distribution

IBBME has a balanced female to male graduate student body ratio. The numbers from IBBME was collected on September 18, 2019.



Graduation Summary

There is a drastic increase in IBBME graduates in the 2018-2019 academic year. The numbers on the right of the bar graph indicate the number of graduates who have successfully defended their thesis in the academic year. The numbers from the 2018-2019 academic year was calculated from adding 2018 September, 2019 January, and 2019 May sessions. The numbers were collected on September 24th, 2019.

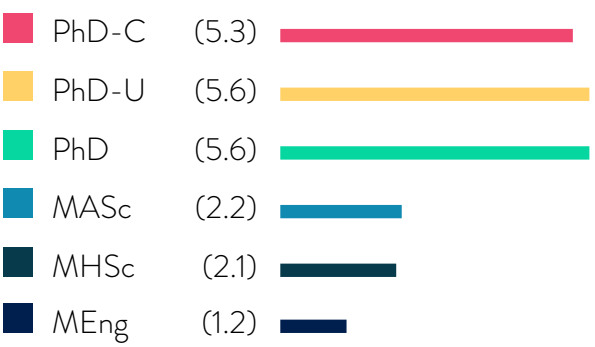


Graduation Breakdown

Graduate proportion is similar to the current student body breakdown, indicating a balanced exit rate amongst students within each program. Bracketed percentages indicate the proportion of students out of 97 total graduates in 2018-19. The numbers were collected on September 24th, 2019.

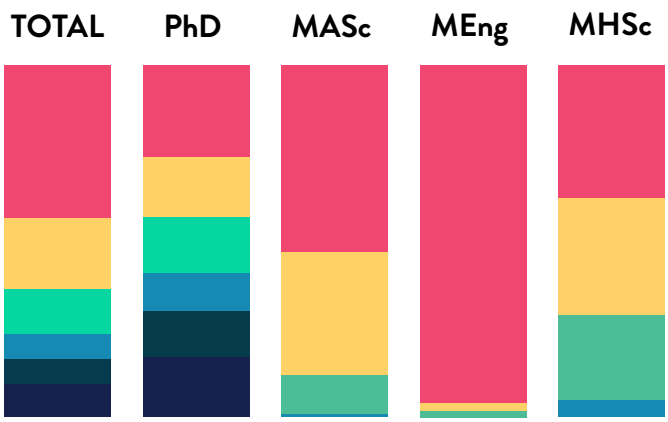
Graduation Time

Graduation time is dictated by degree type. PhD-C: Clinical Specialization. PhD-U: Direct-entry. PhD: students who had previously obtained a masters. The number of years was calculated as an average. The numbers were collected on September 24th, 2019.



Year Distribution

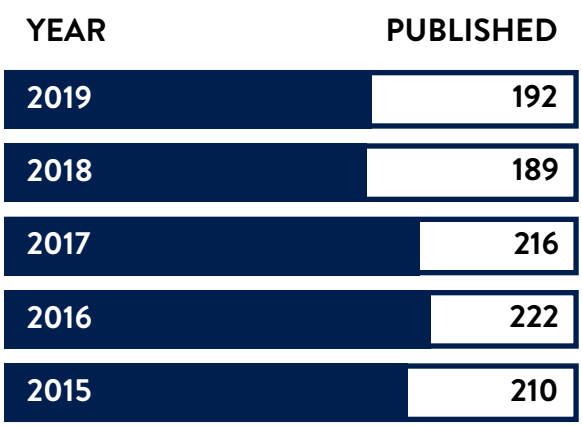
First year students are the most prevalent in the student body. Within the 332 students registered, 142 are first year students. While the student distribution is balanced in PhD, MASc, and MHSc programs, MEng had the highest proportion of first year students. Since this is one year program, the proportion of second year and above is expected to be low. The numbers from IBBME was collected on September 18, 2019.



LEGEND	TOTAL	PhD	MASc	MEng	MHSc
Year 1	43%	26%	53%	96%	38%
Year 2	20%	17%	35%	2%	33%
Year 3	13%	16%	12%	2%	24%
Year 4	7%	11%	1%		5%
Year 5	7%	13%			
Year 6+	10%	17%			

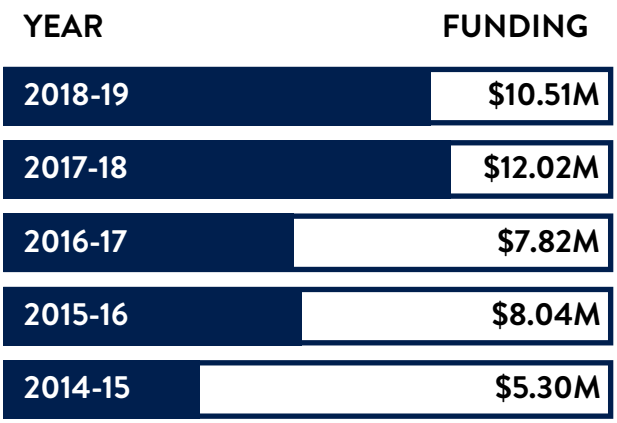
Publication Record

IBBME has published 192 peer-reviewed papers in 2019 from our core faculty members. The data on the right was aggregated via SciVal, an Elsevier subsidiary. The data was collected on December 30, 2019.



Funding Trend

IBBME have received $10.51 million in research funding amongst 35 core faculty members. On average, funding per faculty member was approximately $0.3 million in 2019. The numbers shown on the right hand side of the bar graph is the total funding package that is active during September 2018 - August 2019.



Grant Distribution

IBBME continues to thrive with research funding from all sectors. Amongst all funding packages, approximately 43% are new funding initiatives. Majority of the funding are operating grants. The numbers represent the September 2018 - August 2019 period.

43
New

58
Ongoing

Selected Grants

Milica Radisic
NIH: Engineering Vascularized Myocardium

Elaine Biddiss
CIHR: The Virtual Music Teacher

Jan Andrysek
NSERC: Biomechanical Biofeedback

Funding Breakdown

Majority of the research, equipment, and personnel funding originate from the federal government of Canada. 'Other Sponsors' are categorized as fundings from education bodies, foundations, hospitals, international organizations, and societies. The numbers represent the September 2018 - August 2019 period.

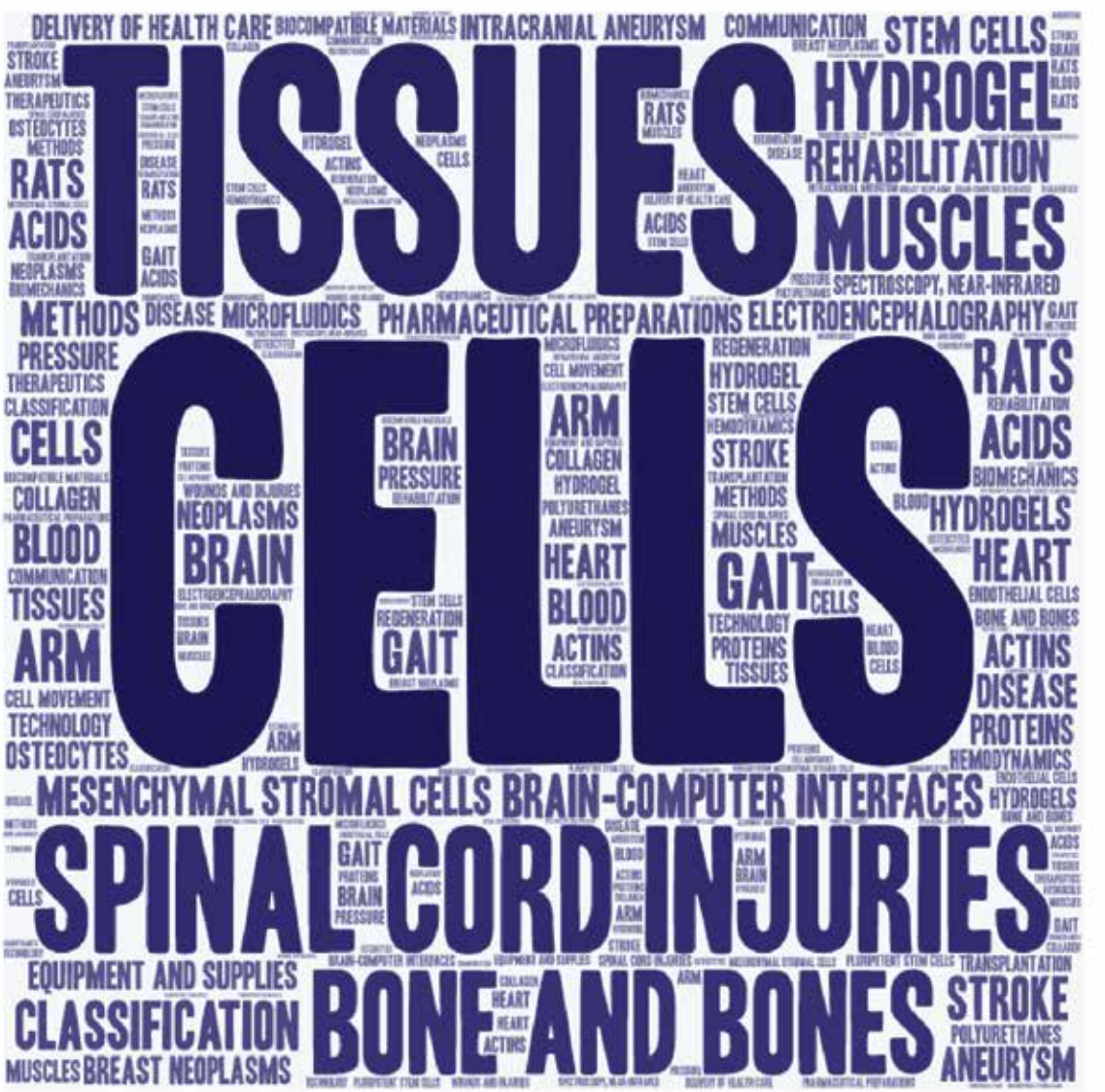
Federal Grants **$7,310,086**

Provincial Grants **$2,535,723**

Other Sponsors **$659,375**

Keyword Identifiers

IBBME has a diverse set of research topics. Publications produced by IBBME core faculty members from 2019 were aggregated and the frequency of recurring keyphrases was captured. The size of the font refers to the relative frequency in which the phrase occurs in publications. The following keyphrases were generated by SciVal.



YEAR IN PEOPLE

CORE FACULTY

JULIE AUDET | PhD, PEng | Cell & Tissue

Professor (IBBME) | Vice Dean, Graduate Studies, Faculty of Applied Sciences & Engineering
Email: julie.audet@utoronto.ca

JAN ANDRYSEK | PhD, PEng | Clinical

Associate Professor (IBBME) | Senior Scientist, Holland Bloorview | Associate Director, Professional Programs, IBBME
Email: jan.andrysek@utoronto.ca

BERJ L. BARDAKJIAN | PhD, PEng | Clinical

Professor (ECE, IBBME) | Investigator, Toronto Western Hospital
Email: berj.bardakjian@utoronto.ca

ELAINE A. BIDDISS | PhD | Clinical

Assistant Professor (IBBME, Rehabilitation Sciences Institute) | Scientist, Holland Bloorview
Email: ebiddiss@hollandbloorview.ca

CHRIS BOUWMEESTER | PhD, PEng | Clinical

Assistant Professor, Teaching Stream (IBBME)
Email: chris.bouwmeester@utoronto.ca

WARREN C. W. CHAN | PhD, FAIMBE | Molecular

Professor (IBBME, ChemE, CHM, MSE, DC) | Director, IBBME
Email: warren.chan@utoronto.ca

TOM CHAU | PhD, FAIMBE, FCAE, Peng | Clinical

Professor (IBBME, ECE, RSI) | Vice President of Research, Director & Senior Scientist, Holland Bloorview
Email: tom.chau@utoronto.ca

HAI-LING (MARGARET) CHENG | PhD, PEng | Cell & Tissue

Associate Professor (IBBME, ECE) | Adjunct Scientist, Sick Kids
Email: hailing.cheng@utoronto.ca

LEO CHOU | PhD | Molecular

Assistant Professor (IBBME) | Investigator, Medicine by Design
Email: leo.chou@utoronto.ca

JOHN E. (JED) DAVIES | PhD, DSc, FSBE | Cell & Tissue

Professor (Dentistry, IBBME) | Associate Director, Graduate Programs, IBBME
Email: jed.davies@utoronto.ca

RODRIGO FERNANDEZ-GONZALEZ | PhD | Cell & Tissue

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