BIOMEDICAL ENGINEERING

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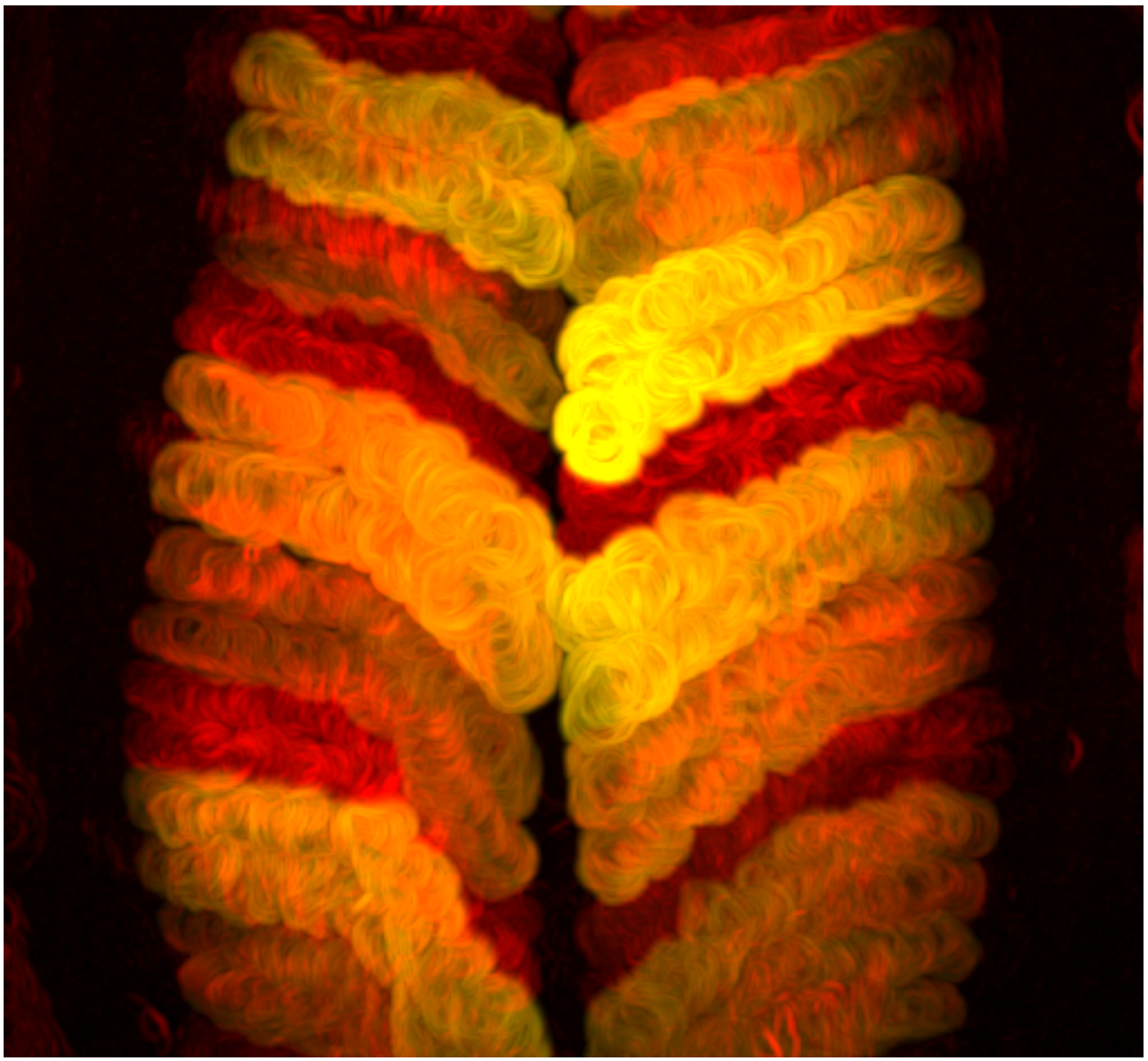

Institute of Biomedical Engineering
UNIVERSITY OF TORONTO

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Negar Balaghi, PhD Candidate

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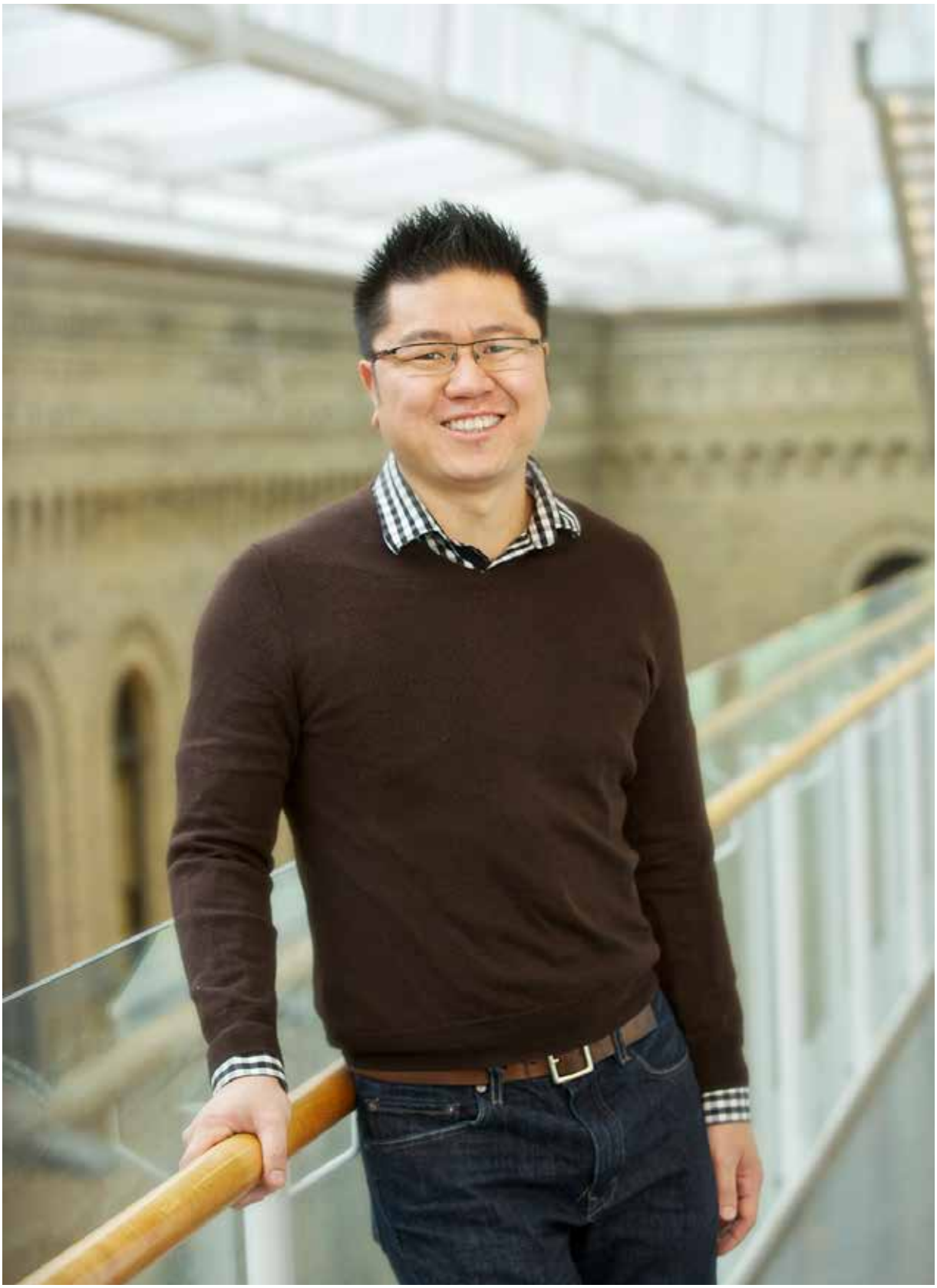


NOTE FROM THE DIRECTOR

Welcome to the fifth edition of the Institute of Biomedical Engineering (BME) annual magazine. Every year we want to capture the spirit of our Institute by highlighting some of our research stories, alumni updates, and student life experiences.

The people in the Institute are the major drivers of our success. Faculty members are driving innovative research and forming impactful partnerships with major industry partners. Read about their achievement in the coming pages.

Our trainees continue to succeed in their endeavors even after finishing their study at BME. In this issue we featured alumni from various industries, from multi-million dollar startups, to working on transforming the healthcare industry. Although their roles are different from one another, they leveraged the skillset gained during their studies in BME to further their career. We are ecstatic to reconnect with them again.

At BME, we value inclusivity and support for all members of our community. One way we strive to foster this environment is by showcasing the experiences and perspectives of our diverse student body. By sharing their stories and highlighting their unique talents and contributions, we aim to create a better understanding of our community. We encourage all members of our community to read about their experiences in the 'Faces of BME' and 'Incoming students' features.

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

Warren C.W. Chan
Professor and Director

PAGE CONTENT

Facilitating pediatric rehabilitation through interactive technologies

Learning (or relearning) motor skills is hard work. Time, commitment, and access to services are key ingredients on the rehabilitation journey, but they are not always enough – it's also essential that kids are motivated to engage in the process. Can gamifying the rehabilitation experience lead to better outcomes for kids and their families? This is the question Dr. Elaine Biddiss is trying to address at the Holland Bloorview Kids Rehabilitation Hospital.

"We design and test interactive technologies – largely games and apps – for kids with disabilities," said Dr. Elaine Biddiss, an associate professor at the Institute of Biomedical Engineering and senior scientist at Holland Bloorview Kids Rehabilitation Hospital. "We recognize that kids come into and progress through life with different physical and cognitive abilities, and we try to create games and apps that support them in their therapies, but also supports them in participation – playing with friends and families, learning something new and meaningful, having fun."

There is no one-size-fits-all solution for children going through their life experiences, and Biddiss aims to address a diverse set of challenges faced by children from all backgrounds, with solutions that can be tailored to each child's needs. To design these solutions, her team works closely with healthcare professionals as well as children and their family members to clearly identify the problem. Understanding the problem from multiple perspectives is the first step to coming up with the right solution.

"The technology is there to help our kids in meeting their individualized therapy goals while participating in an activity that can be fun and meaningful," said Biddiss, who holds the Bloorview Children's Hospital Foundation Chair in Pediatric Rehabilitation.

A key parameter to success in rehabilitation is motivation. What motivates kids is sometimes quite different from what might keep an adult engaged in the work of rehabilitation and this can present some unique challenges.

"When you design a therapy game for kids, they first and foremost are expecting a good video game – something that is fun, engaging, multiplayer, with great graphics and a cool story," explained Biddiss. "While an adult is more likely to be ok with performing the same motion without engaging stimuli, the same can't be said for children."

This requires the researchers to step beyond the clinical and technical aspects and understand the human components that go into both the rehabilitation process and good gameplay. It's also not only the child that needs to be considered, but the entire family unit and how the technology can fit in.

"We have to look at what the parent's needs are, whether they have siblings, what time of the day they can use the interactive technology, how much time can they dedicate to rehabilitation daily – there are numerous parameters that go beyond just the development of the technologies," said Biddiss.

Designing technologies is one part of Biddiss' research, but she also designs studies and measures to evaluate if they are effective and can monitor a child's progress in rehabilitation. She is also committed to the commercialization of the technology impact through her team's start-up enterprise, Pearl Interactives, to hospitals, clinics, and other healthcare settings to maximize positive impact for children and youth living with disabilities.

Gamifying the rehab experience

A centre piece of the Biddiss lab is Bootle Blast, a movement-tracking game aimed specifically at engaging kids in their rehabilitation. Developed by Biddiss and her colleagues at PEARL lab, this game uses Orbbec Persee+, a 3D camera to track the movements of children as they perform exercises and manipulate real-life objects to complete game missions, collect points, and unlock new games. In-game characters provide instructions and feedback along the way serving as both "coach" and "cheerleader."

The hope is that by repeatedly playing this game, children can improve their motor skills and make gains in real-world function. While the game was originally designed for individuals with cerebral palsy, it has been used with children with diverse disabilities including stroke, acquired brain injury and spinal cord injury, to name a few.

Pilot study in Costa Rica

"A lot of families in Costa Rica do not have access to rehabilitation: some simply cannot afford it, and others live too far away from a specialized hospital to receive support. Parents in some families work long hours, and there is not much time to "spare" for rehabilitation. These are very important reasons to bring Bootle Blast to my home country," said Daniela Chan-Viquez, a PhD candidate at University of Toronto's Rehabilitation Sciences Institute and one of Biddiss's research trainees.

Each child participating in the study receives their own Bootle Blast game and the technology needed to play it. The study has a family-centred approach where participants can set their own weekly playtime goals. Data collection is ongoing and 15 families are expected to complete the trial by January 2023.

"We have received so many heartwarming stories from participating families," said Chan-Viquez, who is running the study. "One girl who came into the study was unable to button up her school shirt. By the end of the eight-week program, she was able to do one button. Two months later, the parents sent me a text message saying that morning, their daughter was able to do all the buttons on her shirt, and that they were really grateful for being part of the study. The child had kept playing Bootle Blast, as participants are able to keep the system after completing the study." said Chan-Viquez.

Enhancing tracking accuracy and accessibility

Biddiss and her team are also interested in understanding how & if Bootle Blast can be used to assess and monitor changes in a child's movement abilities over time. Soowan Choi, a biomedical engineering

← Dr. Elaine Biddiss, the Principle Investigator at the PEARL lab holding an interactive component of Bootle Blast. This program aims to engage movement in kids seeking rehabilitation.

→ Soowan Choi, a MASc graduate student in Dr. Elaine Biddiss' lab.

↓ Daniela Chan-Viquez, a Ph.D. graduate candidate in Dr. Elaine Biddiss' lab.

MASc student, is looking to validate the tracking accuracy of the 3D camera to support these efforts.

"Right now, children have to come into clinics for their movement abilities to be assessed in-person by a trained clinician," said Choi. "If we can make the technology robust enough that some of these assessments can be done from the comfort of home with data transmitted securely to clinicians, it would remove geographical barriers and save the patients and the clinicians a lot of time. The first step towards this is to understand how accurately the camera can track movement."

To evaluate the accuracy of the 3D camera, Choi asks participants to perform various mini-games within Bootle Blast, such as shoulder abduction, bilateral movements, etc. He captures movement data over multiple locations at the wrist, elbow, shoulder, hips, knee, and ankle. Clinically relevant metrics can be derived from these joint data such as smoothness of movement or reach envelope, which is essential when quantifying a client's functional abilities with Cerebral Palsy.

The data is then compared against a gold standard motion-capture system – like those used in Hollywood films – where reflective markers are placed on various parts of the body.

"The goal is to establish the accuracy of the Orbbec Persee+ as a sensor for tracking movement and completion of therapy exercises during gameplay," said Choi.

Commercialization with accessibility in mind

Biddiss is committed to making the interactive rehabilitation technologies her team creates available, affordable and accessible to all families.

"Our hope is that we can provide support and technologies to supplement children's rehabilitation, especially for families who might not have the means to access these types of interventions," said Biddiss.

Aside from accessibility, there are many other real-life considerations that must be considered when designing rehabilitation interventions and technologies for children such as technology-family-child fit and sustaining engagement.

"As adults we may have a different lens to rehabilitation. But kids want to have fun, with their friends and family. Let us give them really good games to play and at the same time we can try to address some of these really important participation goals. So that is the long-term vision, really good, inclusive, video games that support kids in reaching their play, learning, and wellness goals." said Biddiss. ■

U of T Engineering lab partners with Moderna to develop RNA-based tools to treat and prevent disease

BY: SAFA JINJE

A team of U of T Engineering researchers, led by Professor Omar F. Khan (BME), has partnered with biotechnology company Moderna to develop next-generation RNA platform technologies. This industry-university strategic research agreement is the first academic partnership under the University of Toronto and Moderna's collaborative partnership framework agreement.

"We are making new kinds of nanotechnology and RNA to help prevent and cure diseases. Together, we're driving new technological innovations to provide patients with even more options for highly efficacious RNA-based medicines," says Khan, who holds the Canada Research Chair in Nucleic Acid Therapeutics.

"Moderna has an incredible track record of taking research from idea to clinic. This partnership is a great opportunity for us to reach our collective goal of efficiently engaging the body to treat and prevent diseases."

As demonstrated by the success of its COVID-19 vaccine, Moderna is an established name in messenger

← Professor Omar F. Khan (BME, back row, second from left) and his lab group, OFK Lab Blue Coats, focus on tackling diseases that are currently incurable and untreatable. (Photo: Safa Jinje)

RNA (mRNA) science. Now, Moderna and Khan's lab group are leveraging fundamental knowledge of chemistry, engineering, biology and immunology to design new types of RNA and their safe, effective delivery to the body.

"We believe mRNA is a platform that could significantly improve the way treatments and vaccines are discovered, developed and produced," says Shehzad Iqbal, country medical director at Moderna Canada.

"It's critical for the next generation of mRNA medicine to be fully controllable — we need both the understanding and ability to optimize delivery systems and their payloads to maximize the benefits of mRNA medicine while minimizing unwanted side effects."

Ribonucleic acid, most commonly referred to as RNA, is a nucleic acid in the same chemical family as DNA, and it is found naturally in the body. While DNA encodes all human genes, RNA is involved in the expression and regulation of those genes, including their translation into proteins. Certain viruses also use RNA as its genomic material, including SARS-CoV-2.

Delivering customized RNA sequences into the body could offer a way to inhibit undesirable processes, as well as stimulating beneficial ones. For example, researchers could use RNA constructs to block biochemical processes that enable cancer tumours to grow and metastasize, or to help the body's immune system fight off infections.

RNA-based therapeutics have the potential to treat many diseases — from diabetes to cancer to musculoskeletal diseases — through targeted approaches that focus on the biochemical pathways those diseases exploit. RNA molecules could be used to combat genetic diseases, by either silencing some genes or enhancing the expression of others, all without genome editing or the use of small-molecule drugs.

Despite all this potential, RNA is a comparatively fragile molecule. In order to do its job, it needs to be delivered in a package that protects the material from damage and preserves its potency as it is delivered and stored around the world. The packaging also enables cells to take up the RNA sequence and read its instructions. The new partnership will design both those delivery vehicles, and the customized RNA sequences they will contain.

"On the nanotechnology side, we are working on delivery molecules," says Khan. "On the RNA side, we are working with mRNA, which people are familiar with. We're also going beyond mRNA to create new and advanced technology that can prevent and treat diseases."

Khan brings an effective blend of academic and industry experience to the Moderna partnership. His research was recently supported by Medicine by Design's Pivotal Experiment Fund — a program that backs a pre-clinical pipeline of regenerative medicine-based therapies that have a strong potential for clinical and/or commercial impact.

"The Khan lab has deep expertise in identifying 'what comes next' and Moderna brings significant manufacturing and development experience to help realize that next big thing Dr. Khan and his team are dreaming up," says Iqbal.

"Working with Moderna, a leader in RNA medicine that has helped countless lives, is a wonderful opportunity for all my trainees," adds Khan. "My team can showcase their innovative talent and work toward our mutual goal of using science and engineering to improve the health of people across the world. The global health impact is very tangible."

"Together, we're looking ahead, and we're foreseeing the true value of nanotechnology and RNA in its many forms." ■

New academic-industry partnership aims to lower the cost of cultivated meat

BY: TYLER IRVING

When Professor Michael Garton (BME) got a call from Myo Palate, a company that is producing meat without raising whole animals, he knew it was the opportunity he'd been waiting for.

"My research has always been focused on healthcare and medical applications," says Garton.

"But environmental issues are something I really care about, something we all care about. Given the impact that agriculture has on the environment, I knew this would be a great way to make a difference."

Garton and his team are experts in synthetic biology. In their lab, they are designing customized stem cells, derived from a patient's own tissues, that could be used to treat certain diseases or conditions.

"For example, one challenge we are interested in is neurological diseases, such as multiple sclerosis or ALS, which are caused or amplified by chronic inflammation of nerve tissue," says Garton.

"We can take stem cells from a patient and program them to specifically detect chronic inflammation and to release anti-inflammatory molecules in response.

← A mixed filling dumpling with Myo Palate's cultivated pork and store-bought vegetable ingredients. The company has partnered with U of T Engineering professor Michael Garton (BME) on a project to further advance their technology. (Photo: Joanna Wojewoda, courtesy Myo Palate)

We could then re-implant those cells back into the body."

Because the anti-inflammatory molecules are released only where and when they are needed, this approach — known as ex vivo gene therapy — could reduce the side effects associated with treatment via traditional drugs.

Using this knowledge to create cultivated meat — that is, animal cells grown outside of a living animal — may not seem like an intuitive leap to make, but Garton says that there are plenty of parallels.

"In our work, we face the challenge of getting our stem cells to grow and differentiate into the types of tissues we want to make," he says.

"Producers of cultivated meat will be doing much of the same thing. And because their cells will be consumed as food, rather than implanted into a patient, there are fewer obstacles in the overall process, which in a way makes it slightly easier."

But the challenges of creating cultivated meat go well beyond whether or not it is technically possible — economics are also critically important. Cultivated meat is not yet cost-competitive with raising whole animals, which is one of the major factors limiting its widespread adoption.

"Unless we can get the cost down, it's just not going to fly," says Garton. "What we're hoping is that our expertise in synthetic biology can reduce or even remove the need for some of the more costly inputs."

One example is growth factors, which are specialized biochemicals that signal what kind of environment a given cell is growing in. Their presence or absence determines what type of tissue a stem cell will grow into: for example, skin, nerves or muscle.

In the case of cultivated meat, the goal is typically to produce myocytes, or large muscle cells. While growth factors that result in this type of tissue can be readily purchased, their relatively high cost is a major hurdle to producing cultivated meat at a competitive price.

Garton and his team hope that their research can result in stem cells that require lower amounts of these growth factors, or even none at all.

"We're testing lots of different ways of approaching this challenge, and we're also automating the process so we can do it in a high-throughput way," says Garton.

"We're developing machine learning methods that can sort through the data to find out what's working and what's not, and what will most likely be successful in the next iteration."

The collaboration between Myo Palate and Garton's group is funded by a grant provided jointly by Genome Ontario and the Canadian Food Innovation Network.

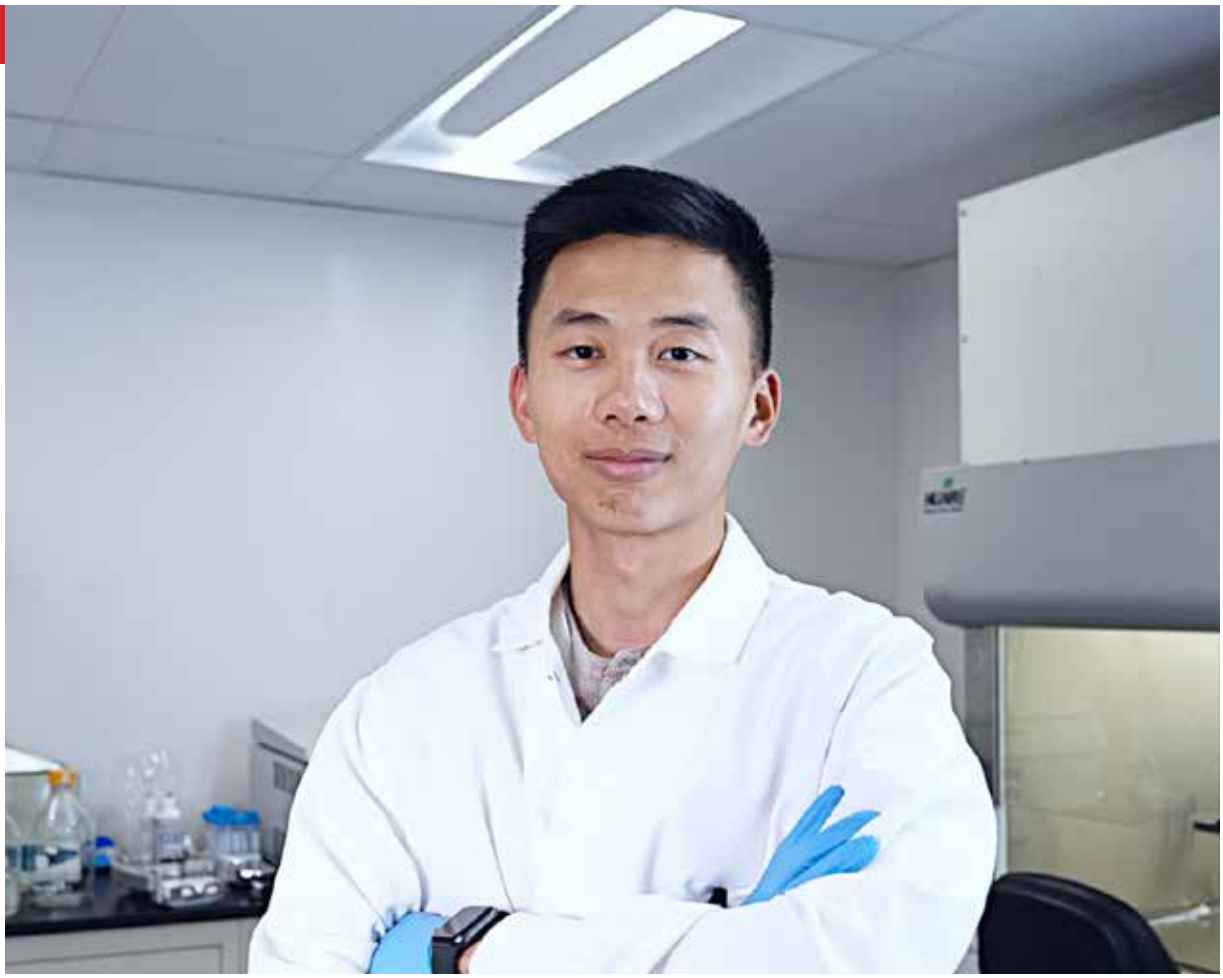
"This is an exciting opportunity to collaborate with Dr. Garton and utilize cutting-edge synthetic biology techniques to reduce the cost of growing muscle cells," says Frank Yu, co-founder of Myo Palate.

"While our initial products will not contain genetic modifications, we think that this will be a game changer for the future."

For his part, Garton is excited about the ability to make an impact in a fast-growing field.

"It's going to be a very long time before we have a stem cell that automatically grows into a real muscle in the lab with minimal inputs," he says.

"But in terms of putting the foundational pieces and core building blocks in place to achieve that, I think we're going to be able to deliver some real insights relatively quickly." ■



Applying scientific rigor in the beauty and wellness industry

David Zhang graduated with a MASc from the Institute of Biomedical Engineering in 2016. Inspired by utilizing biomaterials to regenerate and recover healthy cell functions for his MASc project in Dr. Michael Sefton's lab, David continued his journey as a PhD student at Harvard University working with Dr. David Mooney on next generation cancer therapeutics. In 2021, David and his colleagues founded Revela, a startup company that aims to use the latest advances in Artificial Intelligence (AI) and biotechnology to create better consumer products. Based near Boston, his company recently received $6.5 million seed funding from various top venture capital firms. As Chief Scientific Officer, David aims to challenge the beauty and wellness industry by uncovering new ingredients through rigorous scientific innovation.

What does your company Revela specialize in?

For years now, most products have been made using extremely old stuff. Just old ingredients remixed and remarketed in the most creative and innovative ways to sell to consumers. But when you take that all away, what truly determines any product's effectiveness are its ingredients. So shouldn't true innovation focus on finding better ingredients instead of the aesthetic of the exterior packaging? We founded Revela to do exactly that – to discovery the best ingredients to make more effective products. Intentional solutions for everyday problems.

What do you mean by "waking up the follicles"? What is it really doing to your scalp?

By "waking up the follicles" what ProCelinyl does is push the hair follicle towards a healthier state. We've seen that in vitro and in ex vivo models, and the clinical evidence suggests that's what's happening in vivo as well. ProCelinyl is able to potently, and selectively promote the proliferation of follicle dermal papilla cells, which are the key cells involved in hair cycling. We are currently doing a bunch of follow up studies on this, such as next-generation sequencing to really tease out the deeper level pathways that are being engaged.

Why is the science important? And why is that a big part of your selling point?

Science is important because at its core, it's what determines if an ingredient will work or not. In the field of beauty, wellness, and cosmetics, science especially research and development, is often put on the back-burner. I've heard some people say, that "beauty is where science goes to die".

That's incredibly unfortunate, and wrong. The reality is that the dominant companies in this space know that scientific innovation doesn't matter when it comes to sales. They know that they can probably invest the same amount money in marketing and get the same, probably better returns, rather than investing in what we, at Revela, believe is the most important thing – the science.

What does the molecule discovery process look like?

For hair, we're focused on the follicle papilla cells at the base of the hair follicle. Decades of research have shown that these cells are like the "roots" of your hair. When they're healthy, it directly impacts your hair shaft – making your hair healthier, thicker, and fuller.

We take no assumptions in our discovery approach. We like functional responses – like follicle papilla cell proliferation. Our goal is to find compounds that can improve their proliferation. We start by curating a small-molecule library of ~10,000 compounds from existing chemical databases. These compounds are selected to have the desired properties for something that can be used topically (aka directly on the skin).

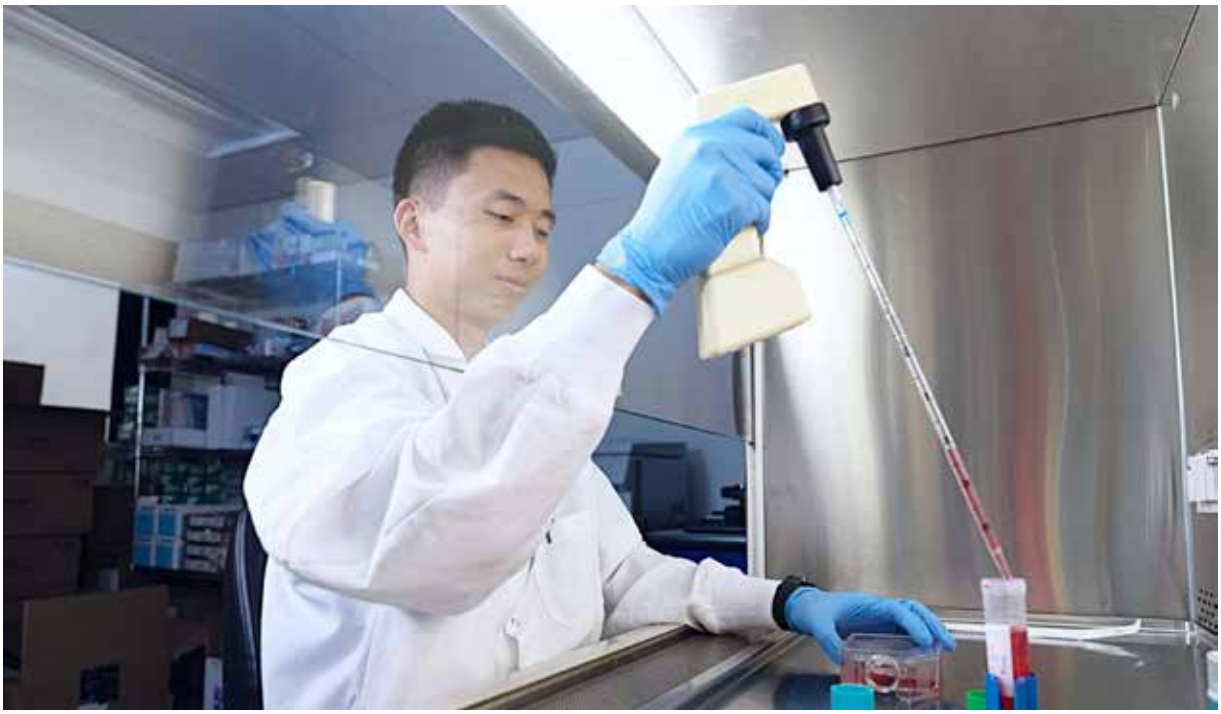
Using these compounds, we perform a small-molecule chemical screen. The result is a rich dataset that describes follicle papilla cell proliferation as an output to a specific compound structure. We next plug in that dataset into our ensemble of machine learning models and train the models to learn the relationship between a specific compound's structure and follicle papilla cell proliferation activity.

What this does is allow our models to search through much, much bigger chemical spaces and find the most potent compounds that have the desired activity we want. In this way, we can virtually screen millions of compounds rather than manually screening them ourselves in well plates to find the best possible compounds for really any given condition.

What is your testing process like?

Our bar for science is higher than most beauty and wellness brands. Our ingredients are rigorously tested, in the lab, then in the clinic, to make sure they are both safe and effective.

Once we have the top AI-predicted compounds, we re-test them, over and over. Then, we take the best of the best and test them on other cells on the scalp, like fibroblasts, muscle cells, endothelial cells, fat cells, keratinocytes, etc. The reason we do that is to make sure that the compounds are specific for the follicle papilla cells. We also do an extensive series of in vitro assays looking at cellular toxicity, immunogenicity, and skin sensitization to ensure that the compounds are safe to use.



Once we've gone through this validation process, we're left with just a handful of compounds that are both highly effective and highly safe. This is when we test them on ex vivo skin models, which are biopsy punches from leftover tissue from people who have received cosmetic surgery, further validating the compounds' safety.

From there we'll move onto clinical testing – we'll first do a repeat insult patch test which looks at irritation over a period of time, to see if there's any contact dermatitis, or allergic reactions, etc. Once that's good, we start more extensive clinical testing. At this point, the compound would be formulated into a product that people can use every day. The clinical tests evaluate the real safety and efficacy of our ingredients and products.

How are your products perceived by early testers?

We always say: "the results speak for themselves". That's the way it should be. Based on the thousands of people who have used our hair revival serum, the feedback has been very positive, and users were able to see amazing hair recovery results, much faster. It's makes me excited when I hear that our product exceeded a customer's expectations or that it worked when nothing else did. It's the reason we're here in the first place – good people deserve the best, and everyone should have higher expectations for the products they use every day.

Revela had recently secured $6.5million in series a seed fund, can you explain what that process has been like?

The seed round is generally the first large funding round in the lifetime of a company. It's a lot different now than it used to be like even five years ago. There used to be much fewer funding mechanisms, fewer venture capital firms. Now it's all changed, there's a ton of micro funds that will give cheque sizes of like $50,000 to like $100,000. The seed round is often broken up into several smaller rounds. While the early-startup funding environment remains favourable, what investors are looking for are constantly changing. It's important to always keep a pulse on current market conditions and modify your fundraising strategy as needed.

What made Revela stand out to the investors?

One thing that makes us unique, is that we are one of the first and only consumer companies that focuses on science like a biotech company would. We're also selling to consumers and there aren't really a lot of companies that navigate that space.

In our very first set of conversations, potential investors were confused. They couldn't quite figure out if we were a biotech company or a consumer goods company. But we're a combination of both. We take biotech approaches to make better things in consumer goods. Our earliest investors were a very selective, small set of people that truly understood our vision and why we're taking the longer, arguably tougher road.

Timing is everything. COVID changed a lot of things. People are questioning fluffy products and are starting to demand more. That's where we fit in. We strongly believe that if we want to build a successful biotechnology company that provides amazing products to people, we first need to build a brand that people can trust. I think that's a fundamental thing that a lot of biotech folks don't fully appreciate because they don't care as much about the end user. It's something that consumer funds understand because that's what they're extremely good at (marketing), but the science for them is still something more of a hypothesis. This is, of course, all changing fast.

What is the next step for your company?

During the COVID pandemic, my mom was introducing me to a bunch of supplements that claimed to fight COVID (this was way before vaccines). When I looked at the active ingredients in those supplements, I was like: 'Mom, this is literally just vitamin C, there's nothing else in here that is going to help. The fact that my mom was able to be convinced by the false promises of these products got me thinking what a strange world that we live in. Why is there so much stuff out there that don't work? It's wrong.

Revela was built on stories like this. Our vision is for a world where folks don't settle for less, where expectations for consumer products are extremely high, and where customers demand more from brands. And we plan to get there by delivering solutions. More importantly, I'm hoping the impact we can make will let someone like my mom to be able to pick up one of our products, look at the label, and immediately understand exactly what the active ingredients can do.

A key challenge for us is really bridging science and the consumer. Surrounding that, an important piece of the puzzle is setting up the right company values, because at the end of the day, it starts with us. It's so tied into success. We've actively taken steps towards this: every scientist we hire does customer service for a month. Every marketer we hire does "journal clubs". It's really from these cross-disciplinary environments where the best ideas are born. ■

Transforming healthcare digital data with a focus on accessibility

An alumnus of Engineering Science (2007) and Biomedical Engineering (2009), **Melanie Yeung** has witnessed the digital transformation of health data – from pen and paper to digital records. Having worked in the University Health Network for more than 10 years, she recently started her role as the Director of Digital Products at Medavie. Now, Melanie is planning to create a digital health ecosystem that incorporates patients, healthcare providers, and new technologies to better understand and engage patients about their health and wellness.

Can you briefly describe your background and how you got into your current role at Medavie?

My background is deep-rooted in clinical settings. I graduated in Engineering Science at the University of Toronto in 2007, with a focus on biomedical options. Soon after that, I completed my master's in clinical engineering through BME with Dr. Joseph Cafazzo at the University Health Network (UHN). My project was to design and develop an iPhone app to assist nurses in collecting vital signs for early warning systems and critical care response teams.

I also did an internship at Mass General Brigham, looking at how to integrate medical devices into their networks so clinicians could draw that data into a centralized record. I did a lot of interoperability work on connecting standalone medical devices, such as ICU monitoring devices and ventilators, into computer networks.

When I went back to work at UHN in 2012, mobile hardware and application development became more mature and were starting to be integrated into the health care system. At the time, my primary goal was to develop self-management applications for patients with chronic diseases. I focused on creating health apps and digital therapeutics for smartphone devices, bringing what was traditionally recorded on pen and paper by patients and providers into the digital world.

In terms of medical applications, we were enabling the tracking of symptoms, medication, vital signs and observations collected through wireless medical devices such as glucose meters, blood pressure monitors and weight scales. We developed products that were for heart failure, diabetes, asthma, COPD, cancer, and pain management. At the end of my tenure at UHN, I was managing a development team composed of about 30 developers, quality assurance testers, product managers, and product owners. Together, we were creating a variety of patient applications.

After that experience, I decided to venture out of academia and investigate how to scale digital products in the marketplace. Medavie, a health solutions partner that oversees Medavie Blue Cross and Medavie Health Services, had an opportunity for a director of digital products to help start a new line of business to further support the health and wellness of Canadians. That brought me to where I am now.

How has the field of digital medicine changed in the last decade?

Over the last decade, people started seeing the benefits of mobile and digital technology, and access at the point of care. It goes hand in hand with evolving hardware capabilities on mobile devices and it being more amendable to the healthcare environment.

In 2022, it's common to see healthcare professionals and patients using apps to record health-related data, which has evolved immensely since I started working in this field more than a decade ago. When I shadowed nurses back in 2009, much of the documentation was still done using pen and paper. We have come a long way since then and have surpassed the time when disinfecting digital devices was the primary challenge and major barrier in a clinical setting. Now, it is determining which application works best for the clinician's workflow and use cases. Without applications, I believe digital technology would not have accelerated to the place we see it in today in the healthcare settings.

At the end of my graduate studies, there were multiple different career paths I could have taken. But something that's always been important to me is how I can interact with people in a way that pushes a community of practice forward. I really enjoy the practice of mentorship, whether that's in the context of teaching, research in supervision, or talking to people. Mentorship has always been important to me, and I just didn't see a better way to do that than as a faculty member.

I continued down that research path and started as a professor in the summer of 2021 at Dalhousie University. I completed a postdoctoral fellowship at Johns Hopkins University because I think it's important in an academic career to get more experience in different research areas and in different labs. My post-doctoral research interests include investigating the mechanisms behind foreign body reaction and designing biomaterials that work synergistically with microenvironments in the immune system to reduce inflammation. Now, I'm looking forward to balancing the importance of teaching and of research accordingly in a faculty position.

↑ Illustration by sbonaart. (Songyi Choi)

What are some of the challenges and barriers present now in the field of digital medicine?

I believe that healthcare should be equitable across any demographic, population, and economic status. We need to all work on building infrastructure and provide everyone with an equal opportunity to connect with their healthcare provider through digital health.

That could include subsidized or lower-cost devices that Canadians can purchase or working with the government and telecommunication companies to create device access points. Increasing access to devices can ensure digital health is available to all Canadians.

What is the goal of Medavie?

At Medavie, we are on a mission to improve the well-being of Canadians. For my team, this would be in the form of creating digital innovations by partnering with technology companies, development groups, and other service providers to create an ecosystem where we can offer something tangible to Canadians. For us, we must learn and understand the needs of the end-user and the environment around them. This includes things like legacy systems, emerging technology companies, and their roadmaps. Together, we can work to create a solution to a challenge we are facing or seize an opportunity to address gaps in care. Importantly, it's about understanding the patient's unique needs and creating products and services that best support their healthcare journey.

What is your day-to-day like? What do you do as the Director of Digital Products?

As the Director of Digital Products, I communicate with a variety of departments and stakeholders. Each of these groups has different needs, so I find myself wearing many hats.

If it involves our development team, for example, I'd be getting status updates on how the product is developing, driving the requirements, and designing with the team.

I may have conversations with end users, where I'm learning about current user experiences, identifying opportunities, and how to avoid barriers. Those meaningful conversations with end users and clients help me define the product requirements and specifications.

Legal, privacy and security also play an important role in what we do. We are developing products that have personal health information so it's paramount that while we are creating our products, we build privacy and security into the architecture of the app. We ensure our end users understand our privacy policy, terms and conditions, and how the information is used.

Lastly, I have meaningful conversations with leaders in my organization about our value proposition, how it relates to our business, how we can accelerate Medavie's mission, and what type of resources we might need to launch or enhance products and services. We are a not-for-profit organization and have a board of directors who set the strategic direction for the organization. I ensure that the work my team is doing aligns with the strategic direction set for the business.

What would be the next step for digital healthcare?

I think at the root of it is the patient – making their experiences in healthcare seamless and enjoyable while supporting positive health outcomes.

A digital journey starts with the ability to access an app, use the app, and communicate and send data to a healthcare provider. Healthcare providers can leverage the information available to help prevent disease, diagnose or treat the patient. If anything goes wrong in this pipeline, then we've failed.

All those transactions and those interactions need to be done in a very purposeful and seamless way for the best user experience. So, it all comes down to how that patient's journey is, and how the experiences around that journey lead to the best outcomes. ■

Making academic articles more accessible

Originally from Belgrade, Serbia, Dr. **Lazar Jovanovic** developed an early interest in human-machine interfacing. Graduated from biomedical engineering in 2021 under the supervision of Drs. Milos Popovic and César Márquez-Chin, Lazar worked on brain-computer interface-controlled stimulation therapy to help individuals who have suffered a stroke or spinal cord injury recover arm and hand movements. Now, Lazar is developing a platform, Summations, which allows researchers to efficiently communicate their work with large and broad audiences by enhancing the reader's understanding of academic articles.

What is the goal of your company, Summations?

Summations is a research portal focused on accessibility. It enables improved comprehension of the content through summaries and definitions, and in the future, by breaking down language barriers.

This goes back to my experience as an undergraduate student in Serbia, unfamiliar with what was going on in the field, and then doing graduate school abroad where English was my second language.

Through Summations, we want anyone who visits our platform to be able to access academic resources and be able to understand the content and how it is relevant to our lives.

Once that information is on our platform, we can employ it in many different ways. Our current focus is on bringing the platform to undergraduate students and universities to improve the comprehension of scientific content taught in classrooms.

The insights we want the readers to take away are the main findings of the research, the motivation leading to the study, and the impact this work will have on the field or, when applicable, more broadly on our infrastructures, such as the healthcare system, or the world.

How does the summarization process work?

The summarization process currently consists of two steps: drafting and editing. To assist with drafting, we have implemented a series of questions we ask the authors as they start to work on their summaries. The answers to these questions are used to generate a draft, which the researchers review and edit.

At the same time, we are developing a natural language processing (NLP) algorithm that leverages artificial intelligence. This will allow the users to input the identifier for their article or to upload a PDF containing the paper and have the draft of the summary generated for them.

The first step before we get to NLP is extracting the text from the PDF file. To achieve this, we can use off-the-shelf tools offered through Amazon Web Services, and Google Cloud platforms, or build our algorithm to extract text from PDF using Python, a programming language I used throughout my Ph.D.

The second step is applying the NLP algorithm to process the text and extract the summary. This is something we are developing now. This work is new to me and quite exciting. I had exposure to elementary machine learning algorithms during my time at the University of Toronto through coursework and a little bit through my research. However, as I have not worked with text and language models before, I am now learning about it on my own, talking to experts in this field, and actively recruiting individuals who can join us and help us build this more quickly.

Who will be your target audience?

Right now, we are building an active community of researchers that will use Summations for knowledge translation in the university setting. We are also developing tools to assist the same researchers in growing their audience and getting exposure to their work.

By working with teaching stream professors to help them incorporate academic papers into their curriculums, we believe the summaries will give readers an in-depth comprehension of the content and support undergraduate students build their scientific literacy, thus helping universities achieve one of their goals.

What is the future for Summations?

One of the first barriers is getting access to peer-reviewed papers. The open-access movement is working to remove some of these barriers, and many universities are joining to support these initiatives. Right now, we are focused on summarizing peer-reviewed publications, and over time we want to expand into book chapters, conference papers, and preprints.

The primary challenge would be widespread adoption to the point where the general reader would benefit from it. We want our library to be accessible to many people, so we must ensure that we have content on various subjects. We want regularly updated content, with the newest publications being summarized immediately.

A higher-level challenge is the speed of acquiring new content. Our goal is to increase the rate of getting new summaries so that we can address the needs of professors who want to update their curriculum, as well as individuals among the public who wish to stay up to date on the latest research. In 5 years, I imagine Summations will be the gateway to comprehensible and accessible academic knowledge. Anyone interested in the latest developments in sciences and humanities would log onto our platform, look for a topic or a publication, find it, and understand the gist of the paper, all in 2 to 3 minutes. ■

Solving healthcare problems through strategic consulting

Completed her Ph.D. in Dr. Paul Santerre's lab in 2019, Dr. **Meghan Wright** always had a passion for entrepreneurship, business, and science. After graduating, Meghan interned briefly with the life sciences investment firm Bloom Burton & Co. as a consultant before joining Shift Health, a life sciences and healthcare strategy consulting firm located in Toronto. Now Meghan is working on projects across a wide range of areas – from the private sector to academia, to help transform healthcare.

What kind of consulting takes place at Shift Health?

We primarily focus on strategy consulting related to life sciences and healthcare research and innovation. We focus on improving or advising research programs and partnerships, whether it's the academic or private sector, healthcare policy strategy, and earlier stage R&D programs. I'd say it's more science-heavy and focused on R&D relative to management consulting. We focus less on the commercial or corporate operational aspects of things.

What kind of projects are you working on?

Right now, I'm working on a set of projects for the International Vaccine Institute, a nonprofit organization dedicated to delivering public health vaccines to the world. We are doing vaccine candidate landscape assessments and building business models for vaccines for two different infectious diseases: Strep A and salmonella.

Another project that I'm working on is an engagement with the Canadian Partnership Against Cancer,

a nonprofit aimed at improving cancer care. We're helping them develop solutions to drive equity-based cancer health services and policy research in Canada.

What are some of the challenges that you face as a consultant?

Time management is one of the first things that come to mind. As a consultant, you must be mindful of how much time each project takes and prioritize them accordingly based on urgency and client need. Right now, as a Senior Consultant at Shift Health, I typically act as the project manager on my projects. Sometimes we could be managing as many as 5 or 6 projects, so it's very important to have excellent time management and be able to multitask and compartmentalize. My Ph.D. involved managing lots of different projects and workstreams, so I'd say graduate school really prepared me for this aspect of my work.

Another thing that I don't hear people talk enough about when they're talking about the consulting industry to students is client relationship management. This is such a critical part of any project, and I'd say it's very different from anything we do in our Ph.D. work. In graduate school, we're often working super independently. This is obviously different in consulting. Having an emotional awareness is critical when it comes to client relationship management. It's not just about finishing the project, it's about developing a work process that allows us to engage with the client in collaborative and cooperative ways. By watching my peers and senior team members here at Shift Health, I was able to learn a lot.

What is your general approach when working with clients?

At Shift Health, we have a company philosophy that I really like: we bring a science mindset to strategy consulting for the health research and innovation ecosystem. Having that science background allows our teams to quickly learn new technical subjects, which is so critical in our job when establishing credibility with our clients.

A typical workflow would follow the same 3 or 4 high level steps. We first establish a very clear understanding of the client's needs. This would involve things like a kickoff meeting and reviewing internal documents. The next step is usually information gathering. This is a mix of both primary and secondary research. We do a lot of expert interviews here, which I really enjoy. In these interviews, we are trying to derive insights from key opinion leaders in the field, and they can take place as one-on-one interviews, workshops or focus groups.

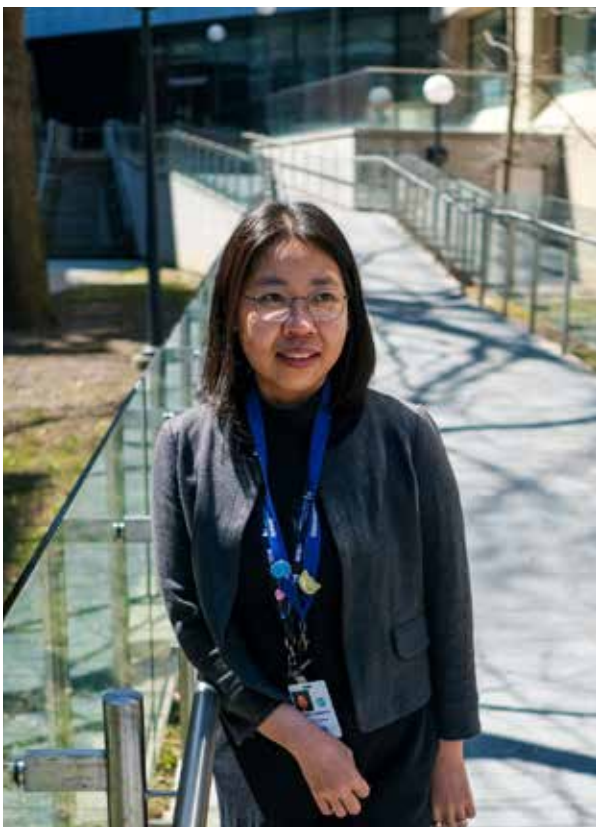
After that, we synthesize what we've learned from our sources into a series of very clean, well-formulated insights or recommendations, and present them in a clear story to our clients. Usually, we'd be using a slide deck. The typical last step is to gather recommendations from clients or other stakeholders to validate and potentially incorporate their feedback. Then it's finalized! A beautiful word in our world.

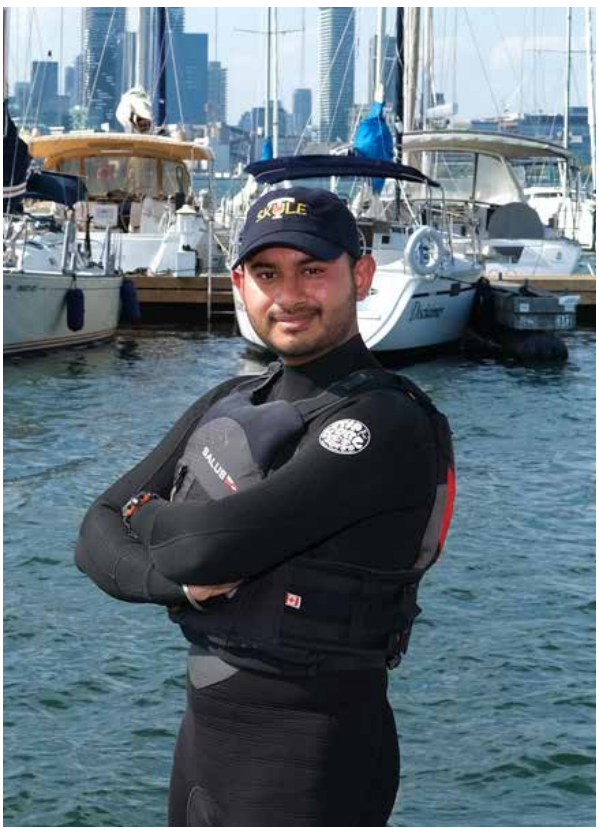
What is a trend you are seeing in healthcare through consulting projects?

From the projects I've worked on, I'd say there's a couple trends worth noting: 1) a growing recognition of the urgent need to embed equity in the healthcare innovation ecosystem and 2) the need for multi-sector collaboration to enable data-driven healthcare.

There is definitely a big interest across stakeholders in improving equity in health innovation. This involves reducing barriers certain communities face when it comes to accessing treatment, enrollment in clinical studies, etc. The question here is how can we reduce these gaps? This is obviously a multifaceted problem and also requires a lot of collaboration and coordination across sectors before we can adequately address inequities.

And, as populations grow and age, the healthcare system is getting stretched, and there need to be ways to ensure accessible quality care across the population. Through our work, we have shepherded what's called the Personalized Health Care Collaboration (PHCC), and the idea here is to foster dialogue across multiple sectors and enable collaboration that informs policy changes and activities within the space of health data. If done properly, data-driven healthcare has great potential for better and more universal care. ■





FACES OF BME

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

Lily Takeuchi | PhD Candidate | Craig Simmons Lab

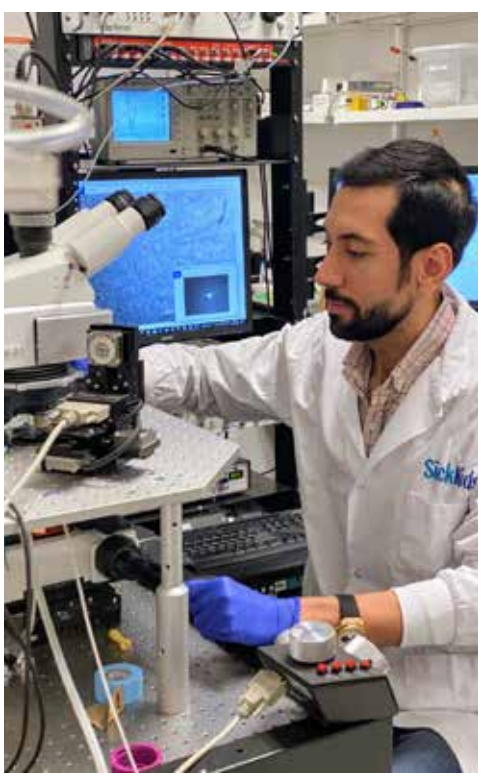
I am working in Craig Simmon's lab, renowned in the field for cardiology research but I'm working on a new branch of research dealing with barrier modeling. Specifically, I am working towards developing stem cell derived models of the blood brain barrier to integrate into microfluidic platforms. My goal is to be able to create relevant disease models specifically for Alzheimer's.

The blood brain barrier is responsible for ensuring that we have this highly selective, robust barrier to prevent pathogens and foreign substances from entering the brain, as well as being able to exchange the necessary nutrients that we need. Once it starts to deteriorate, it can exacerbate disease conditions because of the lack of a protective barrier. Not only has it been suggested to propagate Alzheimer's (pathogenesis and disease severity), but it is also one of the first signs of the disease, and the reason why is largely unknown. Part of my project will be to see what factors might be driving this damage.

With the Student Biotechnology Network, I served as the Director of Corporate Affairs. Last year, the Discovery Foundation, which is one of the organizations on our board, put out a call for a technology education program grant. We thought that this would be a great opportunity to create a business mentorship program, aimed at educating and empowering for folks from underrepresented communities, (BIPOC, women, LGBTQ+) to enter into biotech entrepreneurship and leadership. We created this program as a pilot to serve as a pipeline for increasing representation in the industry. Right now we partnered with the Society for Canadian Women in Science and Technology (SCWIST) for the initiative where I'm still currently a Board of Director.

I think biomedical engineering as a discipline, is moving towards being much more fluid, collaborative and interdisciplinary, which is an incredible asset. It makes the work that we're doing just so much more valuable to the kind of end user and the communities that we want to impact because through collaboration, and through having folks with different perspectives and backgrounds, you're just able to see so many more potential gaps in translation.

← All photos courtesy of Amin Kamaleddin Ezabadi.



Amin Kamaleddin Ezabadi | PhD | Steve Prescott Lab

I was born in Yazd, Iran, a historic city known as one of the oldest cities in the world. Given its hot and dry desert climate, it was always surprising to me how such an ancient civilization could form there. Yazd is known for its highly efficient water transpiration system called qanat, which can supply the surface water from the underground aqueduct. Since childhood, I was inspired by such cultural perseverance and adaptability to take initiative and be flexible in circumstances of all stripes. Nothing seems impossible to me when thinking about how my ancestors built one of the oldest civilizations in a desert.

I want not only to be a part of the existing race to create a more scientifically advanced tomorrow but also to be the coach of our science community, where individuals advocate for evidence-based decision-making. I know I have found my passion and I feel joy and enthusiasm when I consider myself a neuroscientist, committing myself to lifelong learning, trying to solve crucial problems of humankind, and shaping the cutting-edge research in the world.

Biomedical engineering entails combining different scientific and engineering fields and harnessing the power of new technologies to solve medical problems. By definition, biomedical engineering necessitates taking a multi-faceted approach to answer the questions that nature posed for us and to push our future forward. During my graduate studies, I combine animal experiments with computational modeling and machine learning to understand how the nervous system processes information, aiming to find more effective therapeutics for neurological diseases such as epilepsy and chronic pain.

As a Graduate Student Governor at the University of Toronto, I monitor the quality and substance of institutional leadership and decision-making and provide input on proposed policies at various stages of development. I also establish partnerships and collaborations with both the administration and student societies, aiming to bring students' perspectives to the table. One recent example is to develop the institutional guidelines for restarting research during the COVID-19 pandemic in consultation with community members to ensure safe recovery and adaption of research operations.

Within U of T, we are surrounded by boundless innovation, curiosity, and passion. But, of course, we can always be better and do better, and there is always some room for improvement and change. If you want to change a system, you should be a part of it. So, I garnered the opportunity and am truly honored to serve on Governing Council, the highest governance body at U of T. I envision committing myself to lifelong learning and shaping the cutting-edge research in the world as a university professor and administrator. I also hope to harness the best leadership opportunities at the university to grow research quality undergirded by inclusion and diversity. Like research, teamwork and collaboration are keys to good governance. Every initiative involves multiple stakeholders, and our goals can be achieved only once all different opinions are heard and all stakeholders are engaged with the decision-making process.

Amber Xue | PhD Candidate | Molly Shoichet Lab

My interest in biomedical sciences began at a young age as I grew up surrounded by physicians. I was inspired by my relatives who worked in different departments at hospitals. Driven by my strong desire to help others, I attended Harbin Medical University to become a medical doctor. During my undergraduate degree, I also trained in a pharmacological lab where I was responsible for testing a drug that was developed.

My research is focusing on a rare disease called lymphangioleiomyomatosis (LAM) that only impacts women of childbearing age. By investigating immune response to LAM cells in vitro, we analyzed the phenotype change of T cells and LAM cells over time. Additionally, by sequencing lung tissues from LAM patients and healthy people, we aim to target the transcriptome difference in LAM patients and further translate it into clinical.

I joined a non-profit organization named Podan Innovation Plan, which aims to transfer academic discoveries to industry by helping researchers and industrial actors to break the interdisciplinary barriers. The areas that I covered during my work for this organization range from CRISPR technology to AI diagnosis; from wearable medical devices to injectable materials; from single-cell analysis to blockchain application to medical science and marketing strategy. From the interactions with engineers, physicians, and researchers I have come to understand different perspectives and think more broadly.

Shaurya Gupta | PhD Candidate | Albert Yee Lab

Spinal cord injury is a debilitating condition without a cure. The central problem of addressing human injury lies in solving issues around blunt injury inflicted by bone fragments, leaving centimetre long cavities. The goal of my research is to develop imaging and robotic technology to facilitate the injection of a novel biomaterial bridge, 'magic goo', to fill the cavities and guide the regeneration of severed nerve fibres. Using the technology developed during my doctoral studies, the bridge materials will be injected with minimal damage to the injured spinal cord, promoting nerve regeneration and increasing the probability of repair.

My father was a captain on merchant navy ships, and so I grew up in and around boats. I got into competitive sailing during the start of my MASc at BME. Toronto has an excellent harbour with a vibrant sailing community. The people are welcoming and there are a variety of boats you can sail on. I started sailing on smaller boats called 'dinghies', crewing for people with more experience than me. Eventually, I moved my way up to the position of skipper (captain) and started racing competitively.

In sailing, you are at the mercy of nature. You constantly have to adapt to changing wind and sea conditions. In a typical race, you are competing against other sailors on a long course across several laps. In order to do well, you have to sail the shortest distance with the maximum possible speed. This requires great a deal of skill and years of experience to perfect.

If you want to compete at the highest level, you have to pay attention to the details. Things like sail trim, steering, boat/sail maintenance, nutrition, strength are some of the important factors to consider. For instance, there are over five different parameters that I can change to affect the sail shape (trim) when sailing. These parameters are changed by tightening or loosening different ropes (sheets) on the sailboat. Moreover, these parameters change based on the wind and sea conditions and whether I'm sailing upwind or downwind. This detail-oriented approach has attracted me to the sport. I'm excited for the lifelong learning opportunity that is sailing and honoured to be part of something that our ancestors have been doing for centuries!

There are several similarities between sailing and research. One that is most evident to me is that of constantly having to adapt to whatever nature throws at you. In sailing, one is constantly adapting to changing wind and sea conditions to maximize boat speed for a desired heading. Similarly in research, one constantly has to adapt to information gathered during experiments – be it adapting the design, protocol, or sometimes even the research hypothesis. This constant interaction with nature is deep-rooted both in sailing and in science.

INCOMING CLASS OF **2022**

In September, BME welcomed 100+ students into our graduate programs. We asked some of these students why they chose our programs, and what they are looking forward to in this year. Here's what they have to say.

Amel Sassi, MASc Program

Having completed an undergraduate degree in Medical Sciences, I knew there was so much more to learn about the world of technology and engineering. Inspired by the various research facilities and experiences of alumni, I was drawn to Biomedical Engineering at the University of Toronto as I knew it would be the perfect place to develop crucial problem-solving and innovative skills. Above all, the opportunities and support for entrepreneurship seemed endless, which would allow me to take advantage of UofT's environment that is truly conducive to growth.

I am looking forward to becoming an active member of the discourse surrounding my field of interest. Specifically, as a MASc student, I now have the opportunity to work with and learn from many individuals in the industry, and in academia that I have looked up to for many years. Having the chance to now be able to sit at the table and take part in these discussions alongside like-minded peers is truly a once-in-a-lifetime experience!

Chayapol Kulatumyotin, MEng Program

BME at the University of Toronto offers a variety of different courses, and it gave me the opportunity to choose topics I wanted to further explore. People from around the world come here to learn which makes it an excellent opportunity to network and meet new people.

I look forward to learning, engaging with my peers, making new experiences, and exploring the world around me!

Gloria-Edith Boudreault-Morales, MASc Program

My goal in life is to help others, and I feel this program is a step in the right direction for that. During my MASc degree, I look forward to further developing my research skills!

Hugo Higuero, PhD Program

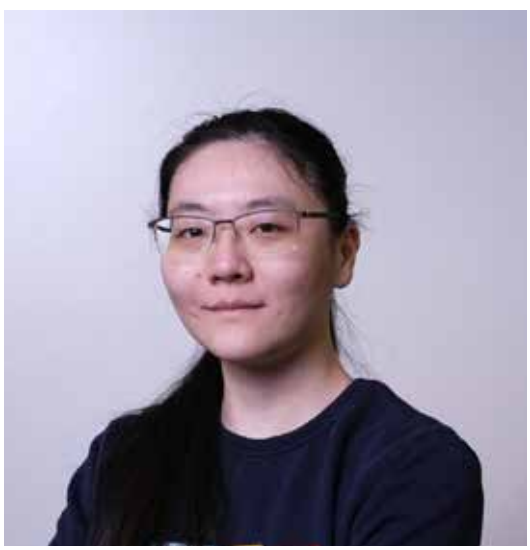
I chose to study Biomedical Engineering at UofT because the department possesses one-of-a-kind advantages that allow students to maximize their learning and expertise. The option for a custom-tailored curriculum, as well as its mix-and-match options for electives makes it an excellent choice for developing one's knowledge and skills to their fullest potential. This is paired well with the constant collaboration with renowned healthcare institutions such as the University Hospital Network, the Ted Rogers Centre for Heart Research, and The Hospital for Sick Children.

I am looking forward to learning as much as possible, developing effective technologies that empower people and their health, and making life-long friends along the way.

Paarsa Salman, MEng Program

I chose this program because I was inspired by the potential for empathetic and scalable medical solutions to transform pressing local and global needs. The MEng program at UofT offers both academic and industry perspectives approaching technical projects with a spirit of collaboration. This program provides the skillset, support, and strategies that can transform a vision into reality.

I am most excited to connect with my peers and professors through meaningful projects and research. I am also looking forward to strengthening the bridge between research & clinical impact by engaging directly with communities, professionals, & patients. Lastly, I can't wait to explore the city and try out new food!



Ruiwen Xian, MEng Program

I had done some research projects in biomedical devices during my undergraduate studies, and I love the feeling of being able to apply the latest research in the medical device industry. As a MEng student, I want to learn more about biomedical industries and looking forward to participating in internships and lab activities.

Griffin Copp, MASc Program

The Biomedical Engineering graduate program at the University of Toronto attracted me because of its unique ties with hospitals and innovators both in the city and internationally.

During my time pursuing a MASc I look forward to meeting like-minded people that are working to tackle the most pressing problems in healthcare.

Zach Frangos, MEng Program

As a UofT alumnus, there is nowhere I'd rather further my education. I am looking forward to narrowing my focus and learning more about cutting-edge topics regarding biomedical devices.

Seyedmohammadsaleh Mirzatabatabaei, PhD Program

I chose biomedical engineering because of its highly professional resources, professors and facilities. I look forward to making international progress in the field of my research.

Vrushali Guruji, PhD Program

I chose the biomedical engineering program at the University of Toronto because of its innovative and collaborative atmosphere. As a student joining the Ted Rogers Centre for Heart Research, I am incredibly appreciative of the opportunity to collaborate with some of the most prominent professors and clinicians in the world to address pressing medical issues.

I look forward to networking with like-minded academics and contributing to the rapidly evolving field of biomedical engineering!

Ivan Napoles, MEng Program

I chose BME at UofT for multiple reasons. I had already developed a great interest in the field since my undergrad and wished to develop my theoretical knowledge within it. Many of the courses offered by the University caught my attention and having the possibility to add the ELITE emphasis to give an important edge to the MEng degree truly made it my top choice.

I look forward to enriching my theoretical knowledge of this field of engineering and learning how to apply it to real-world challenges. I am also excited to connect with fellow graduate students and professors as I take great interest in upcoming research and projects. Finally, I also look forward to the internship where I seek to gain valuable work experience in the biomedical engineering realm.

Raymond Hawkins, MASc Program

During my undergraduate studies in the Biomedical Systems Engineering major of Engineering Science at UofT I was introduced to many Profs in BME with interesting and applicable research. The collaborative environment within and between the faculties constantly inspires new research ideas. I knew that a MASc in BME would allow me to apply my technical skills to many exciting biological applications.

I'm looking forward to the chance to dive fully into my research and have the freedom of steering my thesis in the direction of my interests. I am also very excited to both use and develop new tools for foundational biology research.

Rawad Alkallas, MASc Program

The University of Toronto offers a high level of education and research. It would be an honour to contribute my own skills and talents to the university to further pioneer technological advancements in Canada.

I strive to make innovative strides in my field and ultimately provide support and healing to all whom my research can affect.

Vanessa Parayaoan, MEng Program

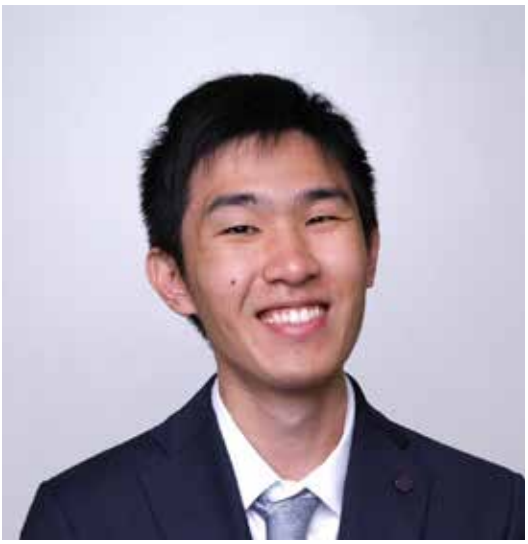
I chose Biomedical Engineering at the University of Toronto because it offers a unique opportunity to study at the intersection of engineering and medicine through both coursework and hands-on practical experience. The university allows me to learn from the best while also providing endless opportunities to embark on entrepreneurial ventures within the institute.

I'm looking forward to building on my undergraduate engineering knowledge and learning more about the unique specialized fields within Biomedical Engineering. I'm also excited to meet like-minded people and make meaningful networking connections.

Nai-Lun Ko, MEng Program

As a student of BME at the University of Toronto, I will be able to gain valuable professional skills for my future career. I selected the program because of its unique curriculum and the opportunity to gain more professional skills in my field. Also, this is a city I feel at home as I have lived here for my undergraduate time.

I look forward to making good friends and learning more real-world skills to apply in my future as a biomedical engineer.



Jonathan Lu Duong, MEng Program

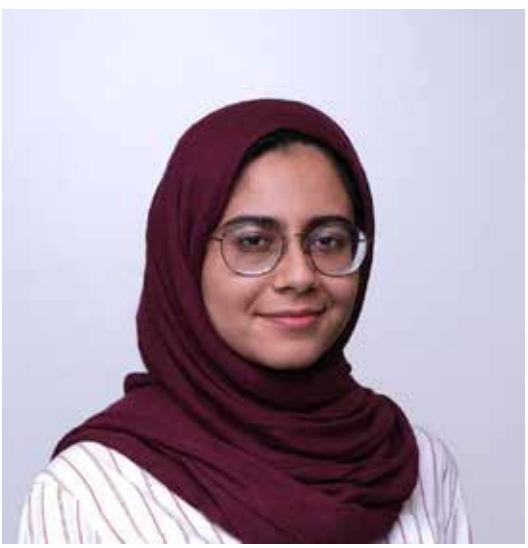
I chose to study Biomedical Engineering at the University of Toronto for its world-class professors, its fascinating and in-depth curriculum, and the incredibly capable peers I will be studying and eventually working alongside. There are also so many amazing opportunities to work in the biomedical field in Toronto, and I can see myself growing immensely both in skill and knowledge while studying and working here.

I look forward to learning about the many different fields within biomedical engineering! There are many interesting topics such as regenerative medicine, biomaterials, and medical imaging to learn. Along with that, I am looking forward to connect with students and faculty alike to establish a strong network within the biomedical engineering field.

Alyssia Sanchez, MASc Program

I chose to study BME at the University of Toronto because of the unparalleled network of scientists and clinicians conducting cutting-edge research. The university also has close relations with many hospitals and companies, which provides students with endless opportunities to problem-solve and apply meaningful research in real-world settings. My experiences in the biotech industry have really solidified my interests in biomedical engineering and my desire to drive innovation in this field, which led to my decision to pursue graduate studies.

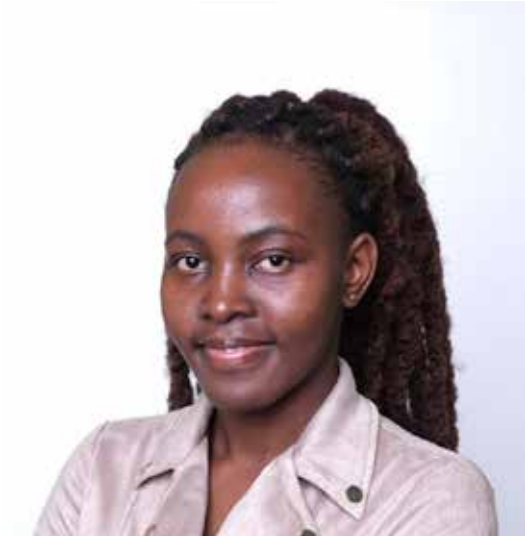
There is so much that I'm looking forward to this year! I'm excited to connect with like-minded individuals, to further develop my professional skills, and make significant contributions to the scientific community. Ultimately, I aspire to make a positive impact on patients and improve their overall quality of life.



Yumna Irfan, MEng Program

The MEng program at UofT offered a unique opportunity to learn about biomedical product development and gain industry experience through an internship.

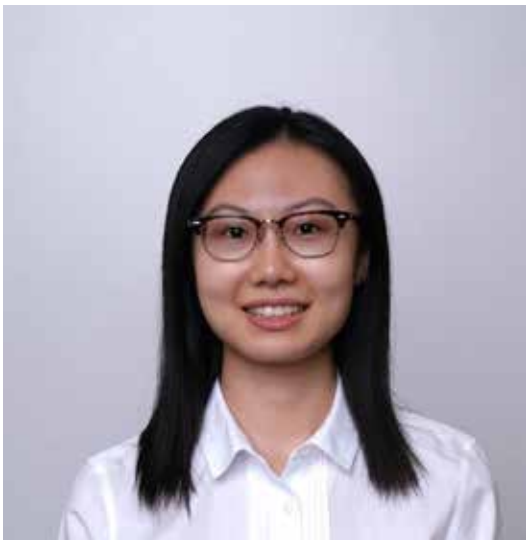
I am looking forward to exploring new topics and meeting my peers!



Isdora Msigwa, MEng Program

I chose the University of Toronto because the areas of my interest in the field of biomedical engineering align with the major areas of coursework and research focus at the Institute of Biomedical Engineering.

As a graduate student, I intend to capitalize on opportunities to work on complex problems in biomedical engineering, network with a community of like-minded individuals and interact with world-class faculty members.



Weiqi Han, MEng Program

The program would advance my critical and creative skills for working in the field of medical device design & manufacturing.

I'm looking forward to making new connections and further developing my skills in the biomedical engineering field.

Sara Alatrash, MASc Program

I found a true passion in the areas of research available at the Institute of Biomedical Engineering at the University of Toronto.

I am eager to develop myself in research and academia, and I am motivated to begin this experience that aligns with my career goal of being a researcher in the biomedical engineering field. Starting my Master in Applied Science degree in Biomedical Engineering at the University of Toronto is one of the most important goals on my path.

Hannah Smegal, MASc Program

I chose Biomedical Engineering because it integrates the application of technical skills with problem-solving in medicine and health care. Studying at the University of Toronto enables me to be exposed to various hospital partners and leaders in the biotechnology industry.

I am excited to collaborate with the U of T community and its research network to contribute toward knowledge advancements and innovation. I am also looking forward to making new friends and developing my skills in AI and robotics!

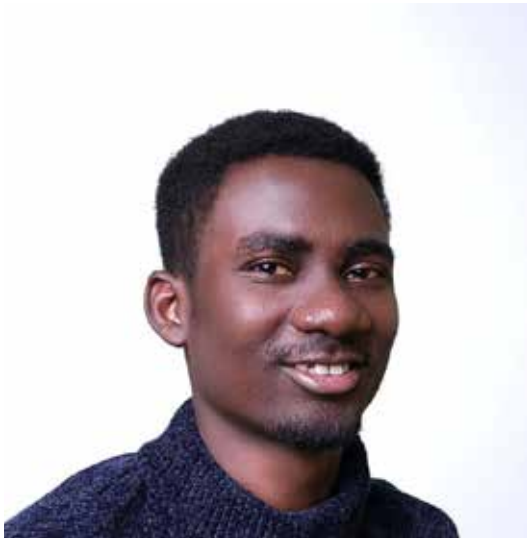
Sophia Farcas, MEng Program

Biomedical engineers are at the forefront of the medical technology industry; they participate in innovations that can leave significant impacts on whole population. I aspire to be a part of this community and contribute to the advancement of medicine through pursuing my degree in biomedical engineering. I chose UofT particularly due to its extensive network and connections to a plethora of biotechnology companies and hospitals ,as well as the unique opportunity it provides students to take courses under the ELITE emphasis that prepares them with the practical skills needed to succeed in the real world.

I am looking forward to creating a community with like-minded individuals and enriching myself in as many learning opportunities I can get my hands on, so that one day, I contribute something meaningful to the medical community.

Bright Li, MEng Program

I chose BME because of the internship opportunities, and I look forward to learning transferable skills during my time here.



Famous Ghanyo Tay, MEng Program

My interest in biomedical engineering is birthed out of my childhood experiences as one of my closest friends, Michael, suffered from a car accident, which left him bedridden for almost a year. We usually visited a physiotherapist through his recovery process, where I was exposed to rehabilitation science. I became curious about the assistive technologies used to help people recover and developed a mentoring relationship with the physiotherapist who treated him. Through BME, I hope to learn innovative and engineering ways of improving the quality of life of people through assistive technology.

I am looking forward to carrying out scientific research on how neural circuits can be utilized to address neurological disorders. Also, I look forward to collaborating with other students on research and also, making meaningful networks.

Neha Sam, MEng Program

After working in medical development for three years, I chose to go back to school to upgrade my technical and clinical skills. UofT had all the courses I was looking for – from AI and machine learning to business and project management.

I'm excited to be learning again and I'm looking forward to meeting like-minded people.

Maisha Chowdhury, MEng Program

I am passionate about working with medical devices to advance our healthcare. I chose BME at the University of Toronto because I wish to dig deeper into my passion and learn more about the product development process, from the initial brainstorm to the product launch.

I look forward to embracing new opportunities, expanding my skill-set, making new friends and being challenged to grow and be the best engineer that I can be.

Yasser Karam, MASc Program

The university has leaders in the field and ample opportunity to pursue all sorts of streams in Biomedical Engineering. I look forward to learning different perspectives from friends and through my research about Biomedical Engineering.

Sheldon Mei, MASc Program

I chose Biomedical Engineering at the University of Toronto because I hope to pursue a career in the industries of pharmaceuticals or biotechnology. Obtaining a graduate degree from this program will allow me to hone my skills and knowledge as a researcher to pursue my career goals, but also explore other interesting opportunities. Having also obtained my bachelor's degree from the University of Toronto, I understand that this institution has an outstanding reputation in the fields of life sciences, engineering, and technology

I look forward to not only being a student and researcher but to also becoming a professional in the workforce. I am also interested in networking with other like-minded individuals who share an interest in life sciences and technology.

Tenzin Yangzom, MASc Program

I chose Biomedical Engineering at the U of T specifically because of how well-established the program is. U of T is a pioneer in the biomedical engineering space, with great faculty members and a network across multiple disciplines and hospitals – all very exciting to me!

I am looking forward to collaborating with smart and innovative individuals, as we break new ground, all while developing new technologies and research skills.

Julia Handfield, MASc Program

A mix of the exciting research conducted within this department and at the university as a whole, the interesting and enriching courses offered, and the interdisciplinary nature of the program. Coming from a degree in physiology and wanting to pursue stem cell research, I was looking for a Master's program that would allow me to expand my knowledge in biomedical sciences through the lens of cell and tissue engineering, and UofT's Biomedical Engineering provides exactly that, in the heart of a city known for its collaborative and first-class research and clinical institutions

I am looking forward to exploring how the learning process will be for me and finding ways to enrich my learning and research. Feeling really connected to my work, and having pride in and ownership over it feels like a big responsibility that I'm excited to undertake and explore. I'm also intrigued by the endless opportunities for collaboration and discussion with like-minded individuals.

Fei Li, MASc Program

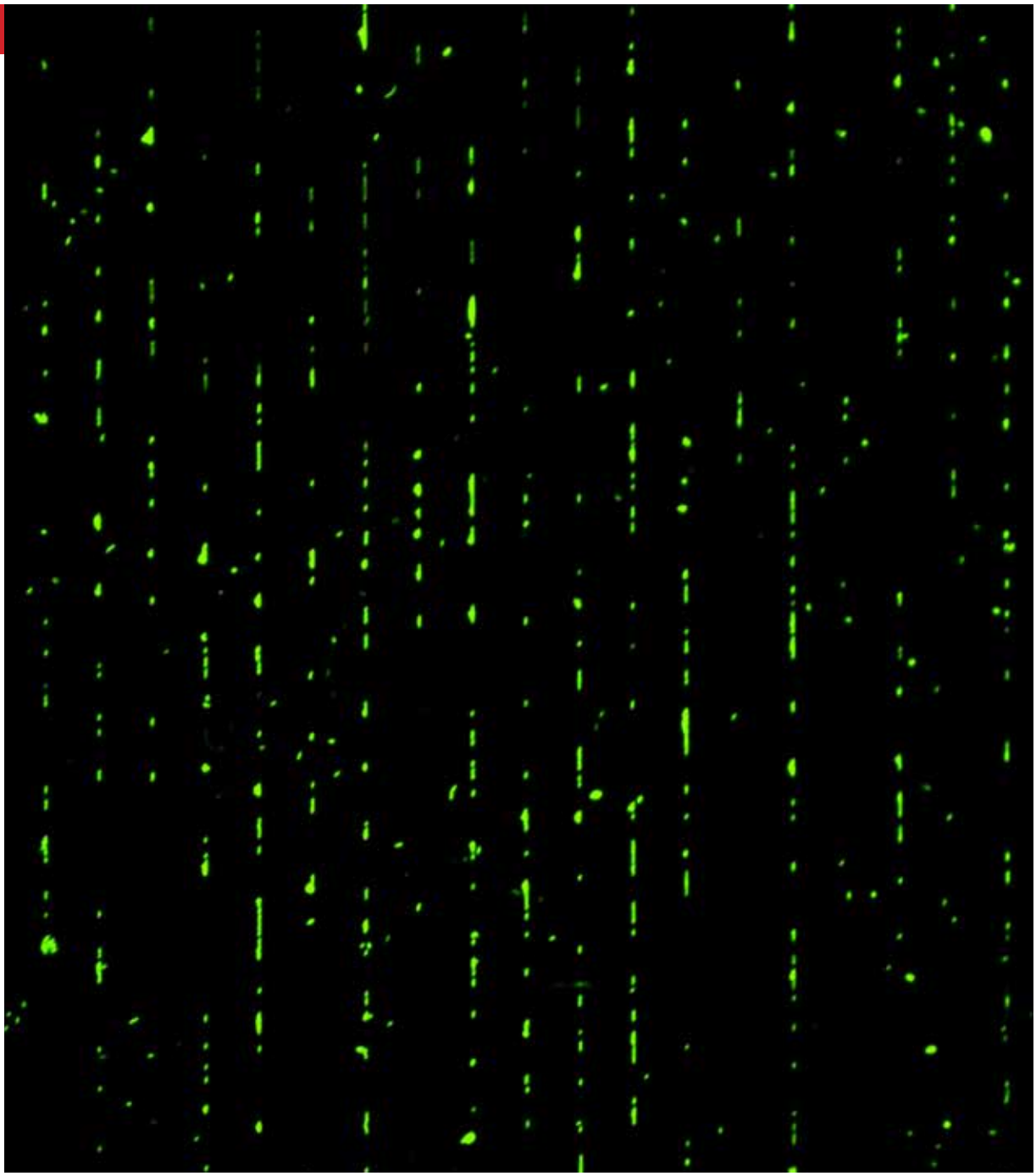
I chose BME because I wanted to explore its multidisciplinary network and also take a look at science through a more technological lens. I want to see how research conducted in the lab can be incorporated into medicine and used by patients.

I am looking forward to collaborating with many different individuals and learning about their diverse research ideas and techniques. Overall, I am excited to contribute to research!

Alireza Ettefagh, PhD Program

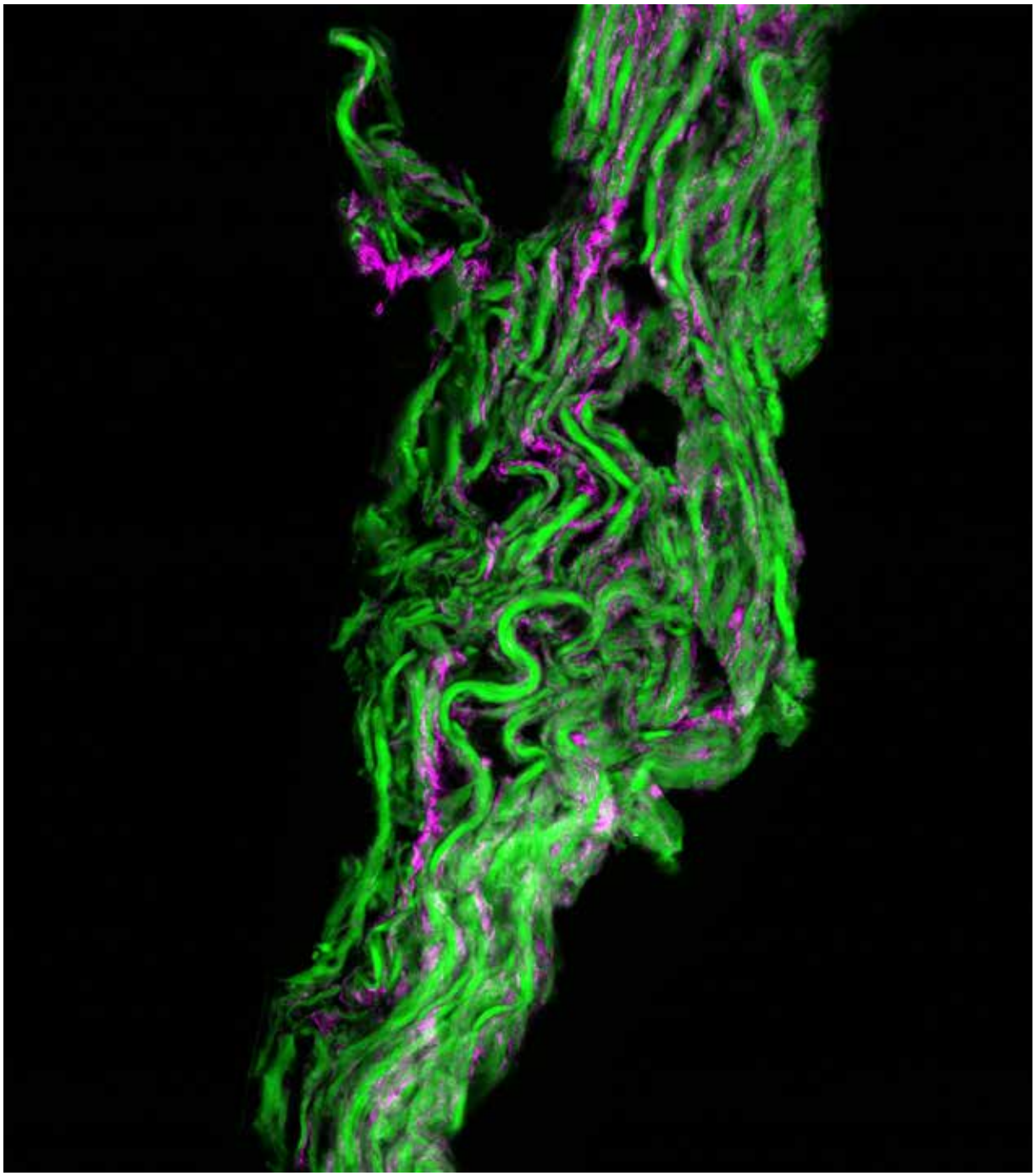
Studying here grants me the opportunity to develop my knowledge in an environment where I can collaborate with clinicians, patients, and the relevant industry.

I am looking forward to gaining major skills to make a valuable contribution towards the development of new concepts for the prediction and prevention of health issues.



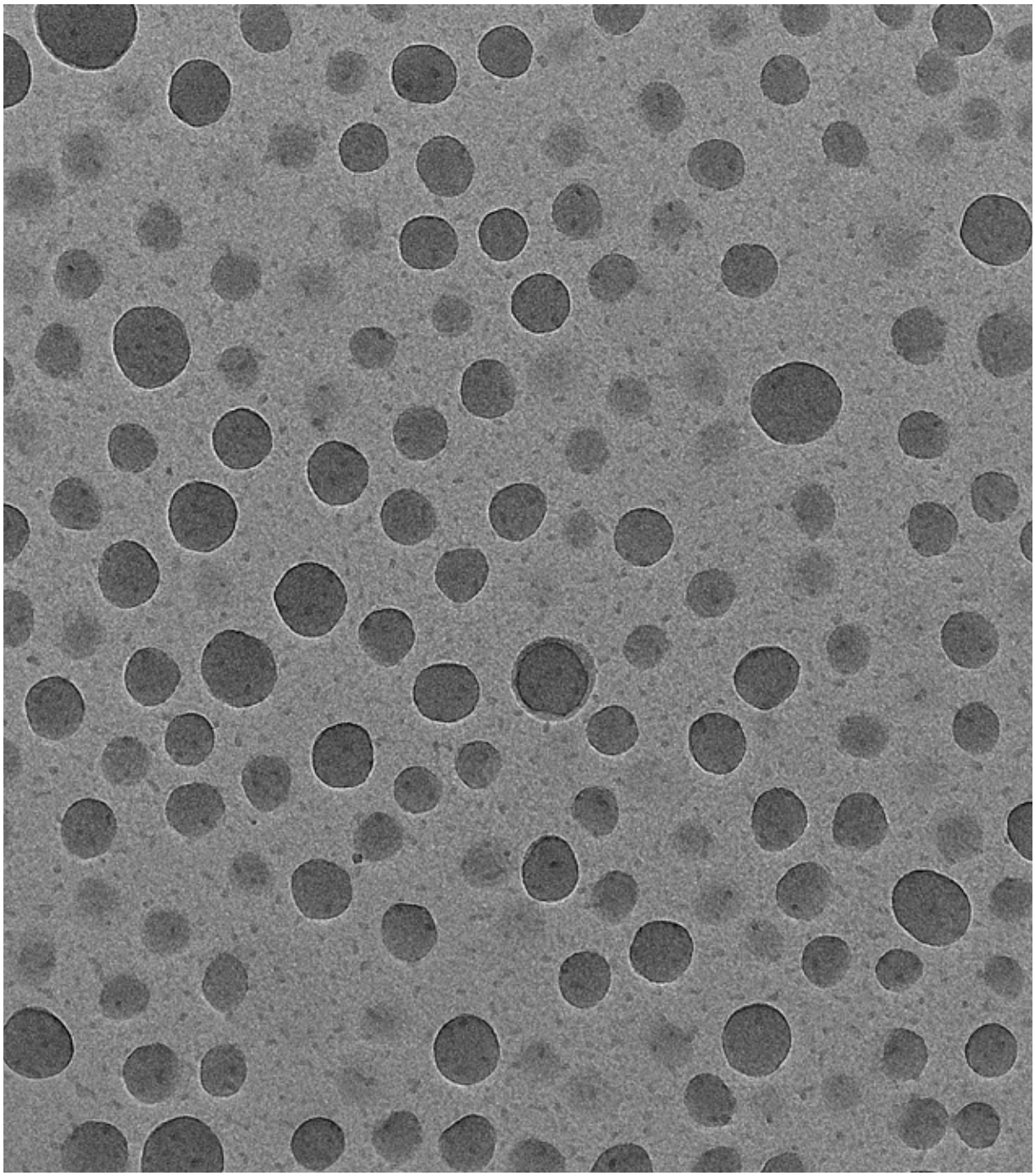
DESMOND VAN DEN BERG, PHD CANDIDATE
BENJAMIN HATTON LAB

'In the Matrix - bacteria following microcracks in silicone'. Image shows the preferential attachment and alignment of Pseudomonas aeruginosa PAO1 to linear microcracks (spacing of 30 micron) in a silicone elastomer. Damage similar to this can be generated through typical handling and disinfection protocols, highlighting the danger this phenomena can have on overall device infection likelihood.



DANIELLA ELIATHAMBY
CRAIG SIMMONS LAB

Ex-vivo elastin fragmentation and resulting alterations in the collagen network captured by multiphoton imaging.

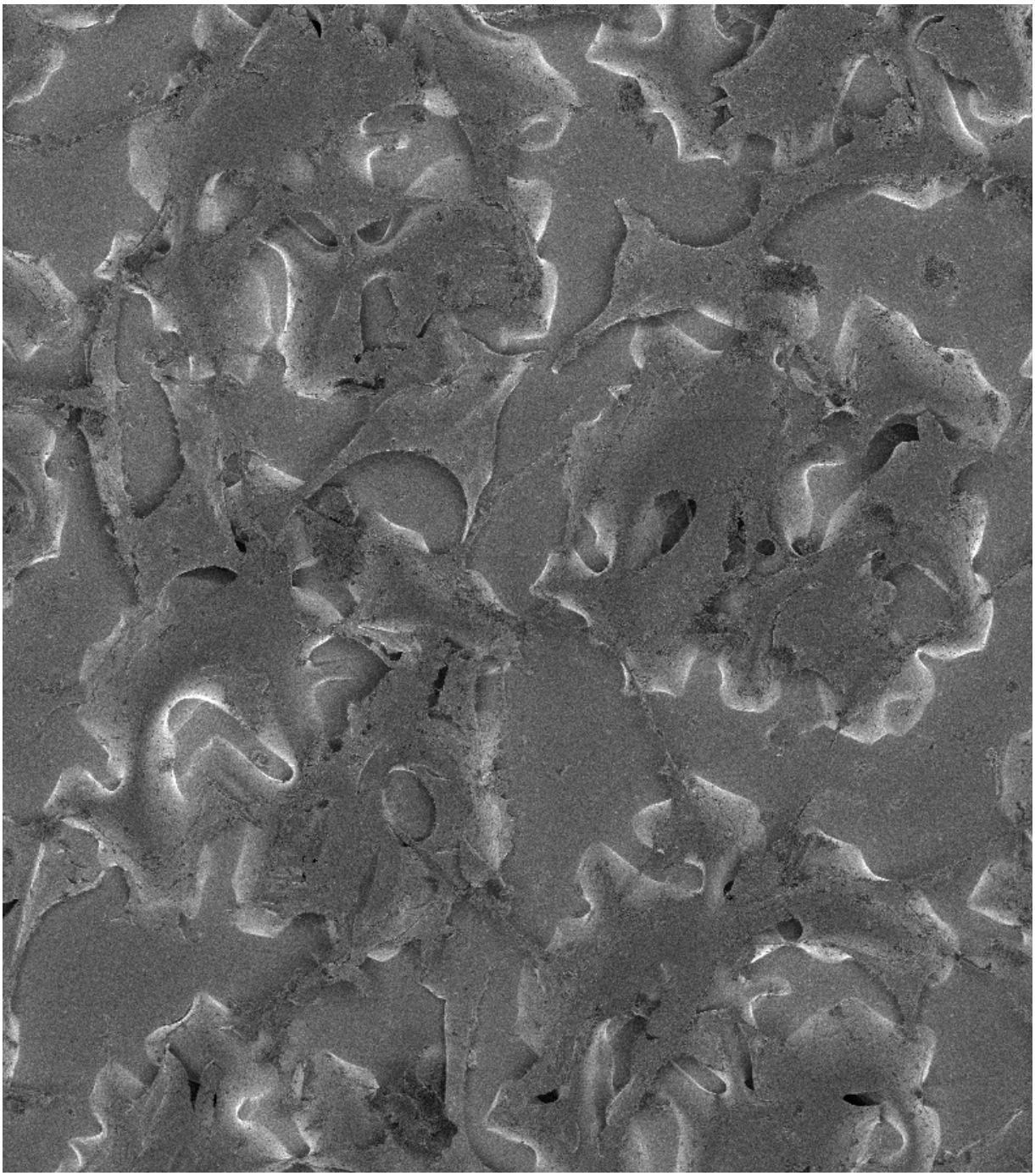


JULIEN COUTURE-SENECAL, PHD CANDIDATE
OMAR KHAN LAB

Lipid nanoparticles encapsulating mRNA were captured by cryogenic electron microscopy. These nanoparticles have an electron dense core and a diameter of approximately 100 nm. Similar particles are used in current mRNA vaccines against COVID-19 to ensure efficient cytosolic delivery and to provide adjuvant activity.

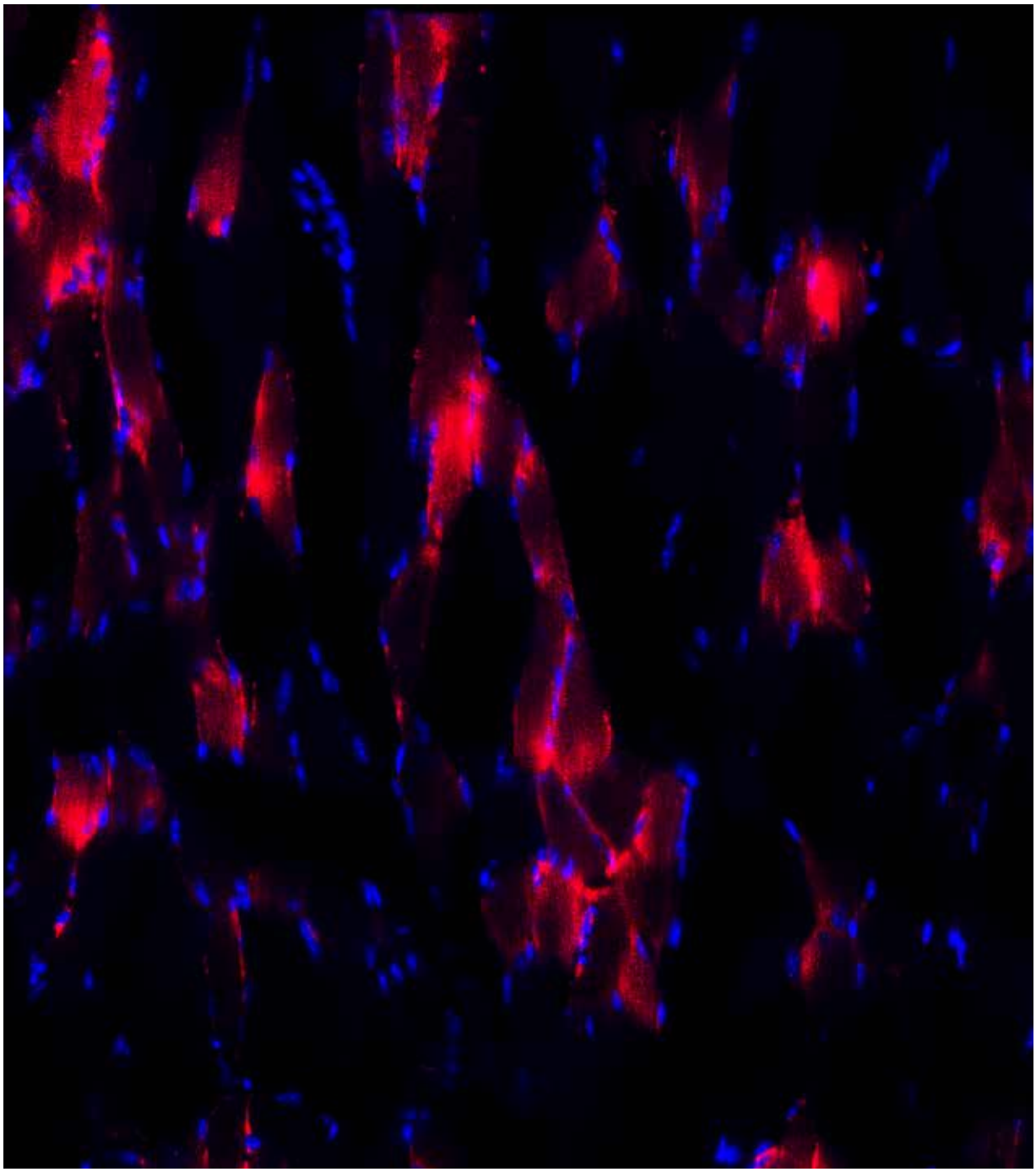
GRAYSON TILSTRA, PHD CANDIDATE
OMAR KHAN LAB

Fragile crystals begin to form at the bottom of a flask.



CHUAN LIU, PHD CANDIDATE
MILICA RADISIC LAB

Specialized kidney epithelial cells (podocytes) preferentially grew on the "hill" region of a topographical substrate with fractal patterns designed to mimick the structural complexity of the native glomerulus, as demonstrated by scanning electron microscopy.



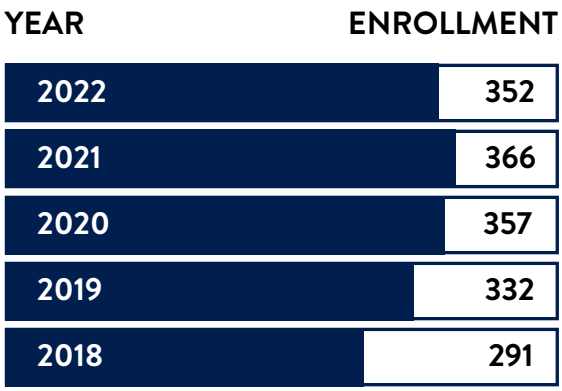
ANSON LAU, PHD CANDIDATE
OMAR KHAN LAB

The expression of tdTomato, a red fluorescent protein, in myocytes after successful gene-editing via intramuscular delivery of lipid nanoparticles carrying CRISPR/Cas9 RNA.

YEAR IN NUMBERS

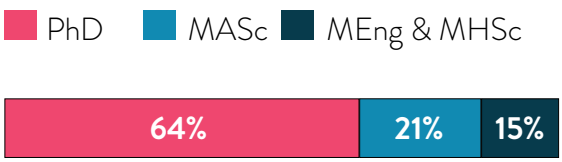
Enrollment Trend

BME graduate student body has been experiencing steady growth in the past 5 years. At the beginning of 2022 academic year, the graduate population stabilized and had a 3.8% decrease compared to last year. The enrollment represent the number of students registered in our programs as of September of every year. Data was collected in December, 2022.



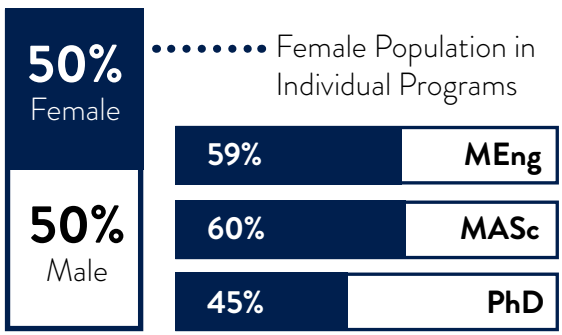
Enrollment Breakdown

BME is one of the leading research intensive units within FASE. Approximately 64% of BME's graduate population consists of PhD students in 2022. Data was collected on December, 2022.



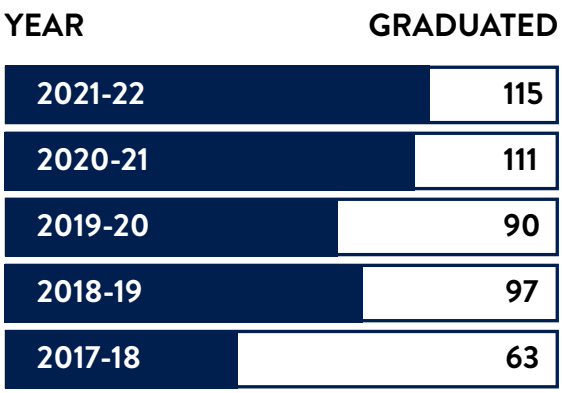
Self-reported Gender Distribution

BME has a balanced female to male graduate student body ratio. All data is self-reported by candidates during registration. Unreported data was not included in the analysis. Data was collected in December, 2022.



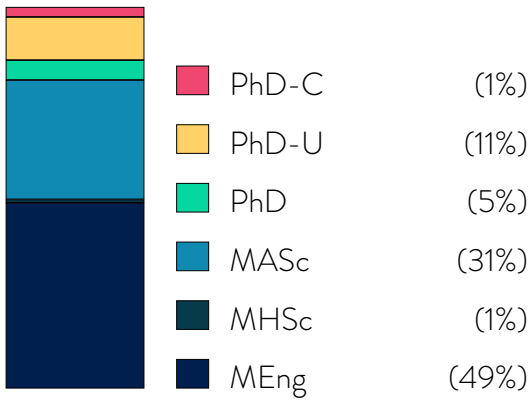
Graduation Summary

The graduation number is similar to the last academic year. The numbers indicate the students who have met all program requirements and are eligible to graduate. The numbers from the 2021-2022 academic year was calculated from adding 2021 September, 2022 January, and 2022 May sessions. Data was collected in December, 2022.



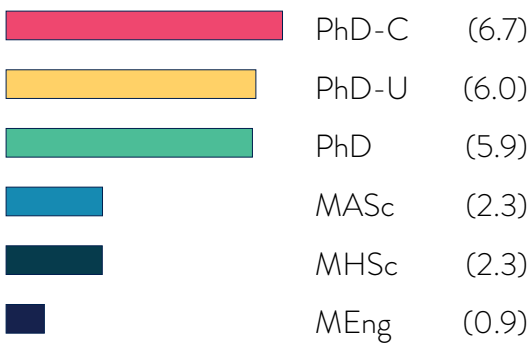
Graduation Breakdown

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 115 total graduates in 2021-2022. PhD-C: Clinical stream. PhD-U: Direct-entry. PhD: students who had previously obtained a masters. Data was collected in December, 2022.



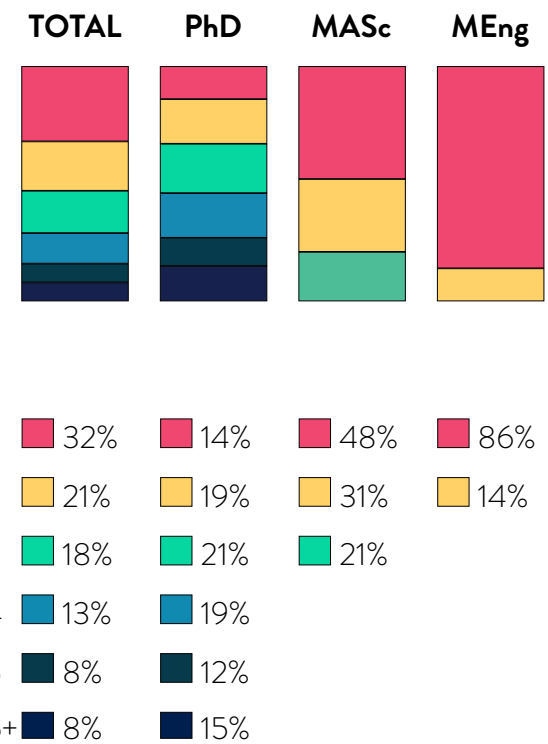
Graduation Time

Graduation time is dictated by degree type in 2021-2022. PhD-C: Clinical stream. PhD-U: Direct-entry. PhD: students who had previously obtained a masters. The number of years was calculated as an average. Data was collected in December, 2022.



Year Distribution

First year students are the most prevalent in the student body. Within the 352 students registered, 111 are first year students. While the student distribution is balanced in PhD and MASc programs, MEng has 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. Data was collected on December, 2022.



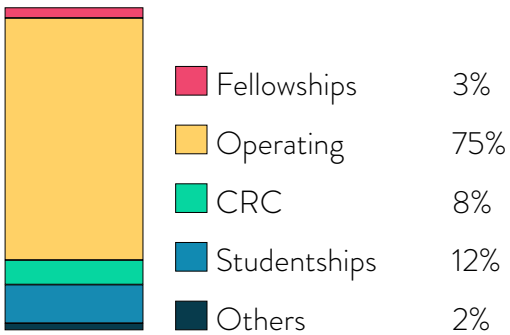
Research Funding Trend

BME has received $7.94 million in research funding amongst 42 core faculty members. On average, funding per faculty member is approximately $0.19 million between September 2021 – August 2022. Data was collected in December, 2022.

YEAR	FUNDING
2021-22	$7.94M
2020-21	$9.31M
2019-20	$11.13M
2018-19	$10.51M
2017-18	$12.02M

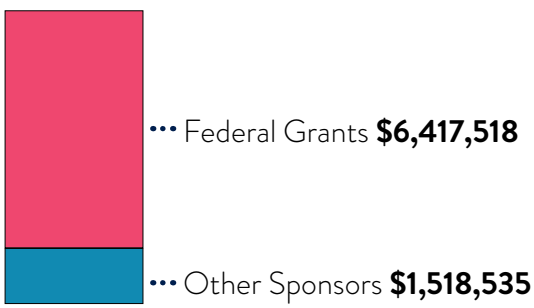
Grant Distribution

There are 92 funding packages for the September 2021 - August 2022 period. Majority of the funding packages were operating grants for research activities. CRC: Canadian Research Chair funding. Others include: technology transfer and clinical trials. Data was collected in December, 2022.



Funding Breakdown

Majority of the research, equipment, and personnel funding originate from the federal government of Canada. 'Other Sponsors' are categorized as funding from education bodies, foundations, hospitals, international organizations, and societies. The numbers represent percentages of $7.94 million from the September 2021 – August 2022 period. Data was collected in December, 2022.



Publication Record

BME has published 171 peer-reviewed papers during January 2022 - December 2022 from our core faculty members. The data on the right was aggregated via SciVal, an Elsevier subsidiary. Data was collected in December, 2022.

YEAR	PUBLISHED
2022	171
2021	206
2020	203
2019	215
2018	207

YEAR IN PEOPLE

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