The Maker: George Klein
Canada’s most productive inventor of the 20th century?

New frontiers in health-care innovation
Cutting-edge interdisciplinary research from U of T Engineering

Engineering on the front lines of crisis
Q & A with alumna Sara Badiei

The Future of Health-Care Engineering
Improving lives on a global scale
E ngineers across all of our disciplines play a critical role in human health — from developing affordable prosthetics and growing heart cells, to combining machine learning with genomic science to study genetic diseases. Through these advances, U of T Engineers are improving lives around the globe.

In this issue we celebrate the many U of T Engineering alumni, researchers and students who are at the forefront of addressing the world’s most pressing health challenges — and we reflect on the ways we have been doing so for more than a century.

Alumnus George Klein (MechE’78) is considered by many to be the most prolific Canadian inventor of the 20th century. Klein designed the first mass-produced electric wheelchair in the mid-1950s — technology that greatly improved quality of life for people with physical disabilities. The joystick control system he implemented is still a common feature of electric wheelchairs today.

While Klein’s story underscores U of T Engineering’s long history as a leader in health-care engineering, today we remain at the forefront of innovative solutions that will advance human health well into the future. We are making a positive impact on a global scale by fostering multidisciplinary biomedical engineering research. Medicine by Design, led by Peter Zandstra (IBBME), focuses on regenerative research in the design and manufacturing of cells, tissues and organs for regenerative medicine. The Translational Biology and Engineering Program, led by Craig Simmons (MIE, IBBME) and part of the Ted Rogers Centre for Heart Research, carries out research in advanced cardiac care, genomic medicine and tissue engineering. And the Centre for Healthcare Engineering, led by Timothy Chan (MIE), is developing assistive robots for home health care and emergency response. A team from CGEN, led by Yu-Ling Cheng (ChemE), has designed low-cost, off-grid toilets to prevent the spread of disease in developing nations. Other CGEN researchers are exploring novel ways to improve the nutrition of those in India and Vietnam.

The CEIE will also be home to our renowned Entrepreneurship Hatchery and new prototyping and fabrication facilities that will accelerate student and faculty innovations from concept to commercialization. Recently launched spinoff companies such as ChipCare, Deep Genomics and TARA Biosystems are already leading the way, bringing U of T Engineering discoveries from the lab to a clinical setting around the world.

Our unique educational programs provide our students with remarkable opportunities to develop key competencies that enable them to address health-related challenges across disciplines. These include the undergraduate minor in biomedical engineering and the Engineering Science biomedical systems major. Graduate students benefit from research-based clinical and professional programs, including the new master’s degree in biomedical engineering, which focuses on the design and commercialization of biomedical devices.

There has never been a more exciting time for health-care engineering innovation in Canada. This issue of Skulematters highlights stories of our leadership in this field, past, present and future.
This issue/
Features

THE MAKER: GEORGE KLEIN
One of Canada’s most prolific inventors of the 20th century, responsible for designing the first electric wheelchair.

NEW FRONTIERS IN HEALTH-CARE INNOVATION
Interdisciplinary research from U of T Engineering is helping us live longer, healthier lives.

ENGINEERING ON THE FRONT LINES OF CRISIS
Alumna Sarra Badiei transitioned a career in the American energy sector to humanitarian aid, rebuilding infrastructure in war zones and providing relief following natural disasters.

BACK TO SKULE™
A busy career as a pharmaceutical industry executive doesn’t keep Elaine Campbell from her role as an active member of our vibrant, global alumni community.

Sections
1 A Message from Dean Cristina Amon
2 Skule™ in Photos
3 CEIE Update
4 Entrepreneurship News
5 Awards
6 News from Your Field
7 Honour Roll

This issue/
Features

Young Alumni Reunion
June 15, 2016
Jessica Xie (ElecE ’14 + PEY) gets creative with her pizza dough at Cibo Wine Bar in Toronto, the venue for this year’s Young Alumni Reunion.

PHOTO / TOBIAS WANG

Spring Reunion
May 28, 2016
From exhibits and lectures to departmental lunches and dinners, Skule™ grads of all ages reminisced and reconnect ed at Spring Reunion. (L–R): Robert Wong (ElecE ’86); Sohayla Praysner (ElecE ’86); and Dino Prioro (ElecE ’86) pose for a photo at the Engineering Reception and Dinner at the Hyatt Regency Toronto.

PHOTO / MICHAEL TENAGLIA

The Entrepreneurship Hatchery Accelerator Weekend
January 22–23, 2016
Fuelled by coffee, snacks and sage advice, students worked furiously to transform their entrepreneurial ideas into viable business models in just 28 hours. Their business ideas were judged by a panel of industry experts, entrepreneurs and alumni.

(L–R): Yuri Sagalov (EngSci ’08 + PEY), CEO and co-founder of AeroFS, partner at Y Combinator; Kat Manalac, partner and director of outreach at Y Combinator and Joseph Orozco, founder and executive director of The Entrepreneurship Hatchery.

PHOTO / CHERRY FAN

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Alumni Magazine / 2016
Faculty of Applied Science & Engineering / University of Toronto
Leadership Luncheon  
April 15, 2016
Corporate partners, alumni, faculty and students gathered at Massey College for a luncheon to celebrate the success of the Institute for Leadership Education in Engineering (ILead).

BizSkule  
April 28, June 16 & June 23, 2016
Engineering leadership in business was showcased at BizSkule events in Toronto, Calgary and Sunnyvale, Calif. this year:

PICTURED A/ Alumnus Somen Mondal (CompE 0T2), co-founder and CEO of Ideal Candidate, moderated the Toronto BizSkule panel, “The Business, Benefits and Risks of the New Sharing Economy,” which included alumni Ashley Lawrence (IndE 0T0), CEO of Kijiji Canada; and Keith Cochrane (CivE MASc 1T2), operations and logistics manager at Uber.

PHOTO/ BRIAN SUMMERS

PICTURED B/ (L–R) Professor Timothy Chan (MIE), guest lecturer at the Calgary BizSkule event, “Engineering Moneyball in Hockey, Baseball and Beyond,” stands with Claire Kennedy (ChemE 1T3), BizSkule founder; Dean Cristina Amon and Professor Grant Allen (ChemE). PHOTO/ CAITLIN MCCOY

PICTURED C/ (L–R) BizSkule California guest lecturer Professor Brendan Frey (ECE) stands beside Rami Rahim (ElecE 9T4), CEO of Juniper Networks; Dean Cristina Amon and Professor Farid Najm (ECE). Frey’s talk, “Deep Genomics,” presented the “genotype-phenotype gap” and how the value of closing this gap exceeds Google’s $200B ad market. PHOTO/ CARLOS FOGEL

Engineering Society Heritage & Awards Celebration  
March 24, 2016
Generations of Engineering Society presidents reconnected at the Engineering Society Heritage and Awards Celebration, demonstrating a history of leadership.

L–R: Bill Hollings (EngSci 8T5), Márta Ecsedi (CivE 7T6), Kevin Sui (EngSci 8T5), Teresa Nguyen (CivE 8T5), Ernesto Diaz Lozano Patiño (CivE 1T6 + PEY), David Cheung (ChemE 1T6 + PEY), Milan Maljković (Year 4 CompE + PEY), Scott Jolliffe (ChemE 7T5) and Howard Malone (CivE 6T1).

University of Toronto (Hong Kong) Foundation  
20th Anniversary Gala  
November 28, 2015
Members of the U of T Engineering Alumni Association’s Hong Kong Chapter, Hong Kong Campaign Cabinet, Dean Cristina Amon, alumni and friends celebrate an important milestone.

Dean’s Visit to Singapore  
November 30, 2015
Dean Cristina Amon joined members of the alumni community in Singapore for an intimate dinner at Shang Palace. The visit to Singapore was part of a trip to celebrate the 20th anniversary of the University of Toronto’s Hong Kong Foundation and Asia Pacific Convocation.

Back Row (L–R): Robert Fu (MechE 7T4), Lim Ming Seong (MechE 7T0), Er Kwong Wah (ElecE 7T0) and CK Chang (MechE 6T8). Front Row (L–R): Dean Cristina Amon, Jennifer Lancaster and Sui-Sim Chang. PHOTO/ COURTESY OF CK CHANG

Our vibrant and global alumni community is the heartbeat of U of T Engineering. If you want to get involved in a particular program or event, email us at engineering.advancement@utoronto.ca to let us know.
In the year since breaking ground, we continue to make remarkable progress, despite some delays, on what will be one of the finest teaching and learning environments in the world when it opens in 2017. The Centre for Engineering Innovation & Entrepreneurship (CEIE) made headlines in 2016, from a landmark funding announcement from the Ontario government to participating in a city-wide contemporary art event.

**CEIE: A Year in Review**

**Toronto’s longest single graffiti installation celebrates the CEIE**

A bold, colourful and unconventional collaboration with street artist Jason Wing, also known as SKAM, (pictured with Dean Cristina Amon), came together in September 2015. SKAM painted a massive 84-metre-long installation that spans the outer wall around the construction site of the CEIE. It is currently the longest single graffiti installation in Toronto. With a surface area that rivals that of a standard tennis court, the work contains more than 50 unique design elements. They depict innovations such as Horizon, the solar vehicle created by the Blue Sky Solar Racing team, and Nanoleaf, the world’s most energy-efficient light bulb, invented by alumni Gimmy Chu (ElecE 0T6), Tom Rodinger (IBBME PhD 0T7) and Christian Yan (ElecE 0T6). Other images such as wind turbines, a streetcar, a satellite and a human heart illustrate the multidisciplinary and collaborative research and industry partnerships for which U of T Engineering is known around the world. The artwork also includes the Lady Godiva Memorial Bnad [sic], Skule™ Cannon and other examples of the Faculty’s energetic student community and traditions. Visit uoft.me/CEIExSKAM for more information about this iconic St. George campus landmark.

**#CEIExSKAM at Scotiabank Nuit Blanche**

From sunset on Oct. 3 to sunrise on Oct. 4, 2015, more than 5,000 Scotiabank Nuit Blanche revellers interacted with graffiti surrounding the CEIE construction site. The 10th anniversary of Toronto’s free all-night contemporary art event provided the perfect opportunity to highlight the connections between the University of Toronto and the vibrant city of which it is part. Titled #CEIExSKAM, the installation was one of five exhibits on the St. George campus. Lit by floodlights, the mural was interpreted for visitors by engineering student ambassadors, who distributed buttons and used the imagery as a starting point to share their own stories of what engineering means to them.

**Province backs CEIE with $15-million investment**

The Government of Ontario announced $15 million in support for the CEIE, introduced in the 2016 Ontario Budget delivered on Feb. 25. The investment is designed to strengthen the Innovation SuperCorridor in Ontario. The CEIE will bring together smart building design and state-of-the-art learning technologies, enabling students, faculty, alumni and industry partners to work together in addressing some of Canada’s most pressing economic challenges. “U of T Engineering is at the heart of Ontario’s innovation economy,” Dean Cristina Amon said. “This investment in the CEIE will catalyse multidisciplinary research and set new standards for engineering education and student experiential learning.”

**$31.6M investment supports lab infrastructure at U of T Engineering**

The Faculty will benefit from a major investment through the Lab Innovation SuperCorridor (LIFT) project, which will accelerate infrastructure improvements across U of T Engineering, enabling world-class research and enhancing the student experience. A total investment of $31.6 million will support renovations to 89 laboratory facilities. The work will benefit more than 330 U of T Engineering researchers, including professors, graduate students and undergraduate students. The funding includes contributions from the federal government through its Post-Secondary Institutions Strategic Investment Fund.

**CEIE Tables & Benches Campaign**

Be a part of U of T’s history through our tables and benches sponsorship campaign. A limited number of tables are available to be named in perpetuity in the CEIE’s state-of-the-art auditorium. U of T Engineering will place a nameplate above the table in your honour. Interior and exterior benches on the ground floor of the CEIE are also available to be named. Visit uoft.me/CEIEtablesandbenches to find out how you can become a benefactor.
Entrepreneurship News
The innovators, makers and creators of U of T Engineering

Cutting-edge innovation to help you breathe easy

U of T researchers want to clear the air: Professor and alumnus Greg Evans (ChemE) and his colleague, Jeffrey Brook, a senior research scientist at Environment Canada and adjunct professor in the Department of Chemical Engineering & Applied Chemistry and Dalla Lana School of Public Health, are developing AirSENCE (Air SENsor for Chemicals in the Environment), a portable, easy-to-use air quality monitor, pictured below. A panel of sensors gauge the levels of five common types of air pollutants: nitrogen oxides, ozone, carbon monoxide, carbon dioxide and particulate matter. AirSENCE can be mounted virtually anywhere, and users have instant access to air quality data via a complimentary smartphone app. Evans and Brook are currently collaborating with the Canadian company AUG Signals on an advanced prototype. Prototypes are being tested in Beijing and the collaborators aim to see AirSENCE devices on the market within a few years.

A few clicks to better mental health

Struggling with anxiety and stress? Cognitive behavioral therapy (CBT) can help. But finding a practitioner and scheduling regular visits can be both expensive and inconvenient. Alumna Chakameh Shafii (MechE 1T2, MasC 1T4), pictured right, experienced this first-hand, which inspired her to co-found TranQuo — an online CBT service that pairs users with licensed therapists for 45-minute secure video therapy sessions. Within a few clicks, clients find themselves matched up with a therapist based on their needs, preferred language and location in the comfort and calm of their own homes. tranquool.com

Health data for firefighters

Smartphones could soon join axes, ladders and helmets as indispensable tools of the firefighting trade. As part of their fourth-year Multidisciplinary Capstone Program course, U of T Engineering students Shatha Abuelaish (CompE ITS), Priyadeep Jaswal (CompE ITS), Fei Ba (IndE ITS) and Alex Liu (IndE ITS) developed an app called Xposure, pictured above, that can help firefighters take control of their health by tracking the hazards they are exposed to as part of their jobs. The app’s multi-level menu adapts to a given user’s responses, zeroing in on the most relevant questions for particular exposure, making it more intuitive — and faster — than a paper questionnaire.

Point-of-care disease testing

A startup driven by unique U of T Engineering-developed technology is poised to revolutionize in-the-field work, allowing doctors to perform HIV-related testing — and deliver results — within minutes. U of T Engineering researchers James Dou (ECE MasC 0T6) and Professor Stewart Alitchson (ECE), along with biological testing expert Rakesh Nayar, founded ChipCare Corporation, a socially driven global health venture, in 2009. The company is researching solutions for a wide range of tests, including for other sexually transmitted infections, tropical diseases and fetal development. To date, ChipCare has raised more than $10 million in financing, and is currently testing its hand-held prototype, pictured right, in regions around the globe. chipcare.ca

Seize the Diem Pouch

Almost half of all unplanned pregnancies in the U.S. occur in women who are using birth control, according to a 2004 report from the Guttmacher Institute. This information inspired Simon Bromberg (EngSci ITS, IBBME PhD ITS), Sandra Fiset (IBBME MHSc ITS), Eric Ma (EngSci ITS, IBBME, MasC candidate), Valentin Peretroukhin (EngSci ITS, UTIAS PhD candidate), Courtney Smith (MPh Epidemiology candidate) and Tony Zhang (EngSci ITS, UTIAS MasC candidate) to develop the Diem Pouch (formerly Pillyo), a startup that aims to address this issue. Pills are stored in a leather pouch, which is twinned with a smartphone app via Bluetooth. The pouch, pictured above, registers when a pill is taken and provides accurate and useful information about consumption habits. The app sends notifications when a pill is missed and can also alert users when the Bluetooth connection is severed, indicating that the pouch may have been forgotten. diempouch.com

Reject-me-not biomaterial

If you need to have your hip replaced, the last thing you want is for your body to reject the implant. Alumnus Kyle Battiston (EngSci 0T9, IBBME PhD ITS), pictured above, has developed a novel biomaterial to be used as an implant for regenerative tissue and a coating on medical devices such as screws, plates and dental implants. The product is made from a family of polymers found to reduce inflammation, specifically when they interact with white blood cells. The coating calms the body’s immune response, eliminating the risk of both implant failure as well as the need for anti-inflammatory drugs. Battiston’s innovative product will be developed through Polumiros Inc., a startup co-founded by alumnus Soror Sharifpoor (EngSci 0T3, IBBME PhD ITS), and is expected to be on the market within five years. polumiros.com

Feel the buzz, not the bump

For those with vision loss, walking through busy urban neighbourhoods can be treacherous. Traditional navigational aids such as canes and guide dogs often don’t detect obstacles above waist height. In response to this challenge, iMerciv co-founders Bin Liu (CivE 1T4) and Arjun Mali developed the BuzzClip, pictured above, a small wearable mobility tool that can scan out virtually any item of clothing. The BuzzClip vibrates to indicate obstacles one- and two-metres away so users can gauge the distance to an object in front of them. imerciv.com

Do you have a startup, spinoff or remarkable innovation to share with your Skule™ community? Email skulealumninews@ecf.tutoronto.ca with details. Visit uoft.me/engineering-entrepreneurship for more entrepreneurship news.
U of T Engineers and engineering researchers continue to earn more awards and honours than faculty at any other Canadian school. Their ground-breaking work is a source of pride for our Faculty and alumni around the world. Visit uoft.me/engineeringawards for a complete list of Faculty awards and honours.

### Selected Faculty Awards

**Highlights**

- **Elizabeth Edwards (ChemE)**
  - Edwards, who holds the Canada Research Chair in Anaerobic Biotechnology, was one of the five recipients of this year’s Killam Prizes, presented by the Canada Council for the Arts. The awards honour eminent Canadian scholars and scientists actively engaged in research.

- **Milica Radisic (IBBME, ChemE)**
  - Radisic, the Canada Research Chair in Functional Cardiovascular Tissue Engineering, received the Canadian Society for Chemical Engineering Hatch Innovation Award.

- **Edward (Ted) H. Sargent (ECE)**
  - Sargent and Professor Shana Kelley of U of T’s Faculties of Pharmacy and Medicine are co-recipients of this year’s Brockhouse Canada Prize for Interdisciplinary Research in Science and Engineering.

- **Engineering Institute of Canada Fellow**
  - Kamran Behdinan (MIE)
  - Hugh Lin (UTIAS)
  - Heather MacLean (CivE)

- **Engineering Institute of Canada**
  - Julian C. Smith Medal
  - Doug Hooton (CivE)

- **Molly Shoichet (ChemE, IBBME)**
  - Shoichet was one of four Canadians elected as Foreign Members of the U.S. National Academy of Engineering (NAE) this year. Members of the NAE rank among the world’s most accomplished engineers.

- **Craig Simmons (MIE, IBBME)**
  - Simmons, the scientific director for the new Translational Biology and Engineering Program, was named U of T Distinguished Professor of Mechatronics.

- **David Zingg (UTIAS)**
  - Zingg, former director of UTIAS and founding director of the Centre for Research in Sustainable Aviation, was named the U of T Distinguished Professor of Computational Aerodynamics and Sustainable Aviation.

### Selected Alumni Awards

- **American Society of Mechanical Engineers**
  - Fellow
  - Kamran Behdinan (MIE)

- **American Society of Mechanical Engineers**
  - Honorary Member
  - Cristina Amon (MIE)

- **Canadian Academy of Engineering**
  - Fellow
  - Nazir Kherani (ECE, MIE)
  - Deepa Kundur (ECE)
  - Milica Radisic (IBBME, ChemE)
  - Murray Thomson (MIE)
  - Sankar das Gupta (MSE)

- **Engineering Institute of Canada**
  - Fellowship
  - John Yeow (ElecE)

- **Inventors Council of Canada**
  - Inventor of the Year
  - Larry Seeley (ChemE 6T6, MASc 6T8, PhD 7T2)

- **International Institute for Nanotechnology**
  - Electrochemist of the Year
  - Tom Chau (IBBME)

- **March of Dimes Canada**
  - Jonas Salk Pioneer Award
  - Tom Chau (IBBME)

- **NSERC: E.W.R. Steacie Fellowship**
  - David Sinton (MIE)

- **Ontario Professional Engineers Award**
  - Engineering Excellence Medal
  - Vaughn Betz (ECE)

- **Ontario Professional Engineers Award**
  - Research and Development Medal
  - Stewart Aitchison (ECE)

- **Ontario Confederation of University Faculty Associations**
  - Teaching Award
  - Greg Evans (ChemE)

- **Royal Canadian Institute**
  - Fleming Medal and Citation
  - Molly Shoichet (ChemE, IBBME)

- **Royal Society of Canada**
  - Fellow
  - Levente Diosady (ChemE)
  - Brendan Frey (ECE)

- **Royal Society of Canada**
  - Member, College of New Scholars, Artists and Scientists
  - David Sinton (MIE)

- **Terumo Foundation for Life Sciences and Arts**
  - Terumo Global Science Prize
  - Michael Sefton (ChemE, IBBME)

- **U of T Celebrates Innovation**
  - Inventor of the Year
  - Brendan Frey (ECE)

- **University Professor**
  - Peter Zandstra (IBBME)

- **Women’s Executive Network**
  - Canada’s Most Powerful Women Top 100
  - Siobhan Robinson (ChemE 0T9, MSE MASc 1T0)
  - Jeannette Southwood (ChemE 8T6, MASc 8T7)

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2016 EAA Awards

Diverse, accomplished and fascinating — meet this year’s Engineering Alumni Association (EAA) Award recipients.

Engineering Alumni Medal

The EAA’s highest honour, this award recognizes outstanding achievement, superior accomplishments and flair, and excellence in response to challenges.

David Colleugh

Chemi E’79, MASC E’80, PhD E’79

David Colleugh’s leadership in commercial organizations forms an impressive record of personal growth and development. Elected CEO of DuPont Asia-Pacific and then chairman, president and CEO of DuPont Canada. Since his retirement in 2003, Colleugh has been using his leadership expertise to build companies and teach the next generation of entrepreneurs, executives and engineers. His leadership philosophy and pedagogy has had a profound influence at U of T Engineering.

Ali Khademhosseini

Chemi E’99, IBIME MASC E’06

Ali Khademhosseini is a professor at the Harvard-MIT Division of Health Sciences and Technology and Harvard Medical School. His research is based on developing micro- and nano-scale technologies to control cellular behaviour, with particular emphasis in developing micro-scale biomaterials and engineering systems for tissue engineering and drug delivery. He is an author of more than 450 peer-reviewed journal articles, editorials and review papers and has been cited over 25,000 times.

Ronald Bertram Sidon

IndE E’67

Ron Sidon was born in Woodstock, Ont., where his parents met and farmed after emigrating from Germany and Czechoslovakia. Up to age 19, he worked alongside his parents to develop and modernize their dairy farm. This business exposure taught him how to manage other workers, to be ingenious at fixing equipment, and to find unique solutions to problems. In 1966, Sidon graduated from the University of Toronto with a BSc in industrial engineering, and in 1968 he received his MBA from York University. He joined IBM in 1968 as a software engineer and later as a sales engineer before leaving in 1971 to start the first of five unique entrepreneurial business ventures.

Paul Henderson

EngPhy E’79

As a young boy spending his summers on Toronto Island, Paul Henderson dreamed of becoming a competitive sailor. His dream would become reality. Henderson holds the record of having competed in all of the Canadian Olympic Sailing Trials from 1948 to 1984. He competed in three Olympic Games: 1964, 1968 and 1972, and would have represented Canada in 1980 if not for the Olympic boycott against the Soviet Union. He served for over 30 years in the International Sailing Federation (ISAF), the governing body for sailing officially recognized by the International Olympic Committee. For 10 years, from 1994 to 2004, he served as the ISAF’s first non-European president. In his professional life, Henderson transitioned a plumbing contracting business into a leading commercial food equipment company.

Engineering Alumni Hall of Distinction Award

The EAA is proud to present this assembly of extraordinary alumni selected by their peers for their lifelong accomplishments. Commemorated in a display in the Sandford Fleming Building, Hall of Distinction members are a familiar daily presence in the lives of students and serve as examples to future generations of U of T engineers.

Dan Lipton

EngPhy E’79

Dan Lipton’s creative approach to engineering has had a profound influence on the world. A pioneer of remote surgery and tele-presence, Lipton’s discoveries and innovations have made it possible for surgeons to perform operations that were once considered impossible. His work has not only revolutionized medical practice, but it has also had a profound impact on the field of engineering, opening up new possibilities for the design and implementation of tele-presence technology.

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Many consider George Klein (MechE 2T8) to be one of Canada’s most prolific inventors of the 20th century.* More than 1,000 novel and useful devices were shaped by his imagination, including the world’s first electric wheelchair.

In many ways, George Klein rivaled Thomas Edison, Alexander Graham Bell and other icons in the scope of his inventiveness and impact — certainly in his effect on society. His project areas ranged from aviation, defense systems and nuclear energy to construction safety, communications and space technologies.

At the same time, Klein’s work could be overstated if not placed in the context of his fruitful collaborations and the contributions of others. Many remarkable people not only helped and inspired him, but also applied his inventions to daily practice. Klein’s career and experience is a model for innovation in any field, particularly, health-care engineering.

Born in Hamilton, Ont. in 1904, Klein spent his spare time as a child hanging out at his father’s jewellery store and watch factory where the artistic work of gold and silversmiths ran in parallel to the micro-mechanics of the watch makers. He often referred to it as a gymnasium for creativity and the touchstone for many of the ingenious mechanical devices he later designed and built. Not a great student academically, he nevertheless showed talent in the workshop and earned technical school marks strong enough to gain entry to the University of Toronto’s Faculty of Applied Science & Engineering. Here, he learned the benefits of collaboration and the skills that would shape his career.

For 40 years of that career, Klein worked as a mechanical engineer and designer at the National Research Council of Canada (NRC) labs in Ottawa where he came in 1929 to join his former U of T Engineering professor John Hamilton Parkin (MIE). At NRC, Klein collaborated not only with doctorate-level colleagues, but also the tradespeople, machinists and technicians who could rapidly build and tweak his many prototypes.

Multidisciplinary collaboration fuelled his innovations in many of the same ways it inspires engineering research today.

Klein considered the project to be the most rewarding of his career. In the end, he developed a unique package of technologies including the joystick, tighter turning systems and separate wheel drives that are still features of electric wheelchairs today. After Canadian veterans were provided with their electric chairs, an international effort was made to engage manufacturers. This culminated in the formal transfer of the prototype chair to the United States Ambassador to Canada and the head of the U.S. Department of Veterans Affairs with patent-free rights to encourage production in the U.S. Within a few years, major wheelchair manufacturing companies had embraced the technology and made it available to disabled civilians en masse.

The prototype wheelchair was kept at the Smithsonian in Washington for years, but returned to Canada in 2004 and is now part of the Canada Science and Technology Museum collection in Ottawa. When visitors look at it in the display case, they are informed not only of Klein, but also that the wheelchair was a project that engaged health-care workers, doctors, therapists, mechanical designers, electrical engineers, administrators and, uniquely, the patients.

Today, patients in research projects are routinely regarded as participants and collaborators in the process who participate, with consent, and provide valued feedback. But in the early 1950s, it was an enlightened approach to include them in the early stages of a project. Klein was particularly empowered by his respect for the views of patients — those who would ultimately benefit from his innovation.

Lifesaving microsurgical suturing device

Though listed among Klein’s inventions, the microsurgical suturing device is also rightly catalogued in patents as “the NRC-Vogelfanger” instrument. The Vogelfanger cited here was Klein’s key co-inventor — a respected university professor and physician — known as one of the most skilled surgeons in Canada.

Motivated by gruesome experiences in Joseph Stalin’s prison system, Isaac Vogelfanger was looking for more effective ways of connecting severed arteries and veins when he approached Klein’s NRC lab for assistance in the late 1950s.

Klein’s skill as a mechanical designer and his access to workshop colleagues who could make ideas real with relative ease led to the development of a stapler that easily enveloped severed blood vessels, folded back the tissue and connected the pieces with a snap. Cumbersome and crude by the standards of today’s advanced technologies, the tool did the trick and was used in hundreds of experimental surgeries in the 1960s and 1970s. It was eventually licensed to a Montreal manufacturer that did well with its commercialization.

Using this device, Vogelfanger performed the first kidney transplant at Ottawa’s Civic Hospital and the first double transplant with organ transfers between two hospitals — anywhere.

*Source: Canadian Encyclopedia

THE MAKER
by DICK BOURGEOS-DOYLE

The first electric wheelchair

Atypical collaboration is at the core of thousands of innovations in the health-care engineering field and more than a few involve Klein. But one of the most vivid examples is the development of the first mass-produced electric wheelchair — a design known in its day as “The Klein Chair.”

The story begins with the discovery and refinement of penicillin, which dramatically reduced the number of fatalities from wartime spinal cord injuries. During the First World War, a spinal injury resulted in almost certain death from ensuing infection. But by the Second World War, soldiers had an 80–90 per cent rate of survival from spinal injuries thanks to the revolutionary new antibiotic.

One of those Second World War survivors was John Counsell, a Canadian officer shot through the back at Dieppe. He would live the rest of his life with paraplegia. At first satisfied with manual wheelchairs, it became clear to Counsell that quadruplegics would need something more. His advocacy, and Canada’s particular commitment to health care and veterans support, came together in the post-war period to manifest as a request to NRC and Klein to build an entirely new wheelchair.

The research today.

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Innovations Aplenty

Beyond the electric wheelchair and suturing device, Klein spent his time at the NRC working on projects that ran from “the stick and string” era of aviation to the Space Shuttle. Here are five of his most renowned inventions:

**A Mighty Wind**
He contributed significantly to the construction and design of the first NRC wind tunnels, helping to not only guide development of the Canadian aircraft industry, but also the first streamliner locomotives, bridges and buildings across Canada.

**Wartime and the Weasel**
Klein’s work played a critical role in many of our country’s scientific and technical contributions to the Second World War. The mechanical instruments that his team built for the military often transferred to private industry to contribute to the post-war industrial development. His expertise in mechanics and materials brought him to work on the first military snow vehicle, the Weasel, one of his wartime projects and once tied to the First Special Service Force, The Devil’s Brigade.

**First Canadian nuclear reactor**
Klein was also the chief engineer and mechanical designer for the Zero Energy Experimental Pile (ZEEP). Located near Chalk River, Ont., ZEEP was the first nuclear reactor to operate outside the U.S.

**Putting skis on planes**
He was a leading expert in the design of aircraft skis and made it practical to put them on bushplanes, indirectly opening up vast areas of Canada to exploration and air transport services. This work led him to establish a practical system for ground-cover snow classification that became the international standard and framed research in construction, transportation and avalanche prevention.

**The Space Race**
In the early 1960s, Klein’s retractable Storable Tubular Extendible Member (STEM) antenna gave Canada a special place in the Space Age. It was used in all Mercury, Gemini and Apollo spacecrafts, famous satellite projects and over 100 other innovations. After retirement and well past the age of 70, Klein worked as chief consultant on gear design for the first Canadarm and then after his 80th birthday, he contributed to the system’s further development within the Shuttle program. Turn to page 35 to see how one EngSci alumnus is building on Klein’s technology and applying it to pediatric surgery.
NEW FRONTIERS IN HEALTH-CARE INNOVATION

by TYLER IRVING & MARIT MITCHELL

Interdisciplinary research from U of T Engineering is helping us live longer, healthier lives.

Optimizing surgical schedules

Long wait lists for elective surgeries are a major challenge in the Canadian health care system. According to Professor Dionne Aleman (MIE), pictured below, right, the problem may not necessarily be a lack of resources, but rather a result of not using the resources we have as efficiently as we could.

"Hospitals have rules that indicate who gets operated on when, but the schedules that result are sub-optimal," she said. Aleman and her team are addressing this problem by building mathematical models that can optimize the matches between patients, surgeons and operating rooms to generate the most efficient schedule.

One technique the team uses involves pooling resources. Rather than each hospital maintaining its own waiting list, patients would be treated as a single large waiting list. Patients would be assigned to a given surgeon or operating room to minimize the time when resources are unused. Using mathematical optimization tools, the team has generated schedules that could increase the number of patients treated in a given time period by up to 30 per cent.

Aleman collaborates closely with Dr. David Urbach, a surgeon and senior scientist at the Toronto General Research Institute. Her models are based on data from Toronto General Hospital, Toronto Western Hospital and the Princess Margaret Cancer Centre.

"Right now we’re adding workload balancing into our models," Aleman said. "We want to ensure that all surgeons and hospitals are being used to an equitable level."

Some hospitals are already using patient pooling on a small scale, and Aleman hopes that her models will help the technique be applied more broadly.

"Most affordable prosthetic knees rely on mechanisms that are not designed to concurrently provide safe and efficient mobility, so they often feel awkward and unstable during walking," said Andrysek, pictured above, right. "The AT-Knee is designed to lock and unlock smoothly as you walk, and move just like the human knee joint."

While typical prosthetic knees can carry price tags of $1,000 to $50,000, the AT-Knee is available at a much lower cost through NGOs, making it a huge step forward for patients with lower-limb impairments, especially in war-torn or developing nations. His team has tested their design in over 15 countries around the world. In April 2014, Andrysek along with three co-founders launched the company LegWorks to commercialize the AT-Knee technology. As of January 2016, the AT-Knee is commercially available in many countries globally.

Andrysek and his research group are now working to improve communication between people’s bodies and their artificial limbs. His lab is designing a non-invasive biofeedback system to improve the wearer’s awareness of limb position. "Basically, using small vibratory signals, the system provides amputees with information about the position and loading of the artificial limb to improve mobility,” he said.

“Walk this way

Jan Andrysek’s research helps amputees walk tall. A professor at IBME and scientist at the Bloorview Research Institute in the Holland Bloorview Kids Rehabilitation hospital, he is the engineer behind the AT-Knee (short for “all-terrain”) — a mechanical prosthetic knee joint that is natural feeling, durable, energy-efficient and inexpensive.

“Most affordable prosthetic knees rely on mechanisms that are not designed to concurrently provide safe and efficient mobility, so they often feel awkward and unstable during walking,” said Andrysek, pictured above, right. “The AT-Knee is designed to lock and unlock smoothly as you walk, and move just like the human knee joint.”

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Reducing the risks of cycling

Cycling and walking are good for your health, right? It’s actually a more complicated question: while increased physical activity can improve cardiovascular function, cyclists and pedestrians are also exposed to air pollution, which can do the opposite. Professor and alumna Marianne Hatzopoulou (CivE), pictured below, right, and her team aim to help city dwellers get more of the benefits of physical activity while reducing the risks.

This summer, Hatzopoulou and her team collaborated with Health Canada on a study that aimed to map out how pollution affects human health in different areas of the city. Volunteers walked the streets of Toronto equipped with GPS devices and instruments to monitor their heart rates and blood pressure, as well as the level of noise and air pollution they are exposed to. By correlating location with pollution and physiological data, the team can find the cleanest, safest routes.

Hatzopoulou has already created an online tool that does just that, based on the results of previous studies. The Clean Ride Mapper leverages Google Maps to help cyclists find routes that have lower levels of pollutants like ultra-fine particles or nitrogen oxides.

Optimizing ambulance distribution and routing

In Toronto, the average response time for ambulances is six minutes. In Dhaka, Bangladesh, the 11th largest city in the world, it’s 60 to 80 minutes. Professor Timothy Chan (MIE) and his team are working to help close this health-services gap.

“Our research has two components: first, optimizing the locations of ambulances throughout the city, and second, routing them to the patients,” said Justin Boutilier, pictured above, a PhD candidate in Chan’s lab.

In September 2015, Boutilier spent three weeks in Dhaka assessing the current situation. Collaborating with Moinul Hossain, a traffic engineer and professor from the Islamic University of Technology (IUT), Boutilier surveyed patients regarding emergency transportation to hospitals to better understand the current state of the system. He also distributed a GPS-based app to rental car drivers that will track driving speeds and help map traffic patterns in the city.

All this information will be fed into a computer optimization model, which will test out hundreds of possible scenarios before arriving at an ideal distribution of ambulances across the city. The data will also be used to develop an app that provides real-time recommendations to drivers on the fastest route. In a city where it is not the cultural norm to yield to ambulances — and where there is little room to move aside anyway — avoiding busy streets can mean the difference between life and death.

Boutilier and Chan will also evaluate other forms of transportation, such as three-wheeled cabs or rickshaws, in order to address issues with reaching patients in areas without adequate access to ambulance transport, such as slums. They hope their approach can bring significant health benefits for the citizens of developing countries.

“There is a long history of using operations research to improve emergency medical services in North America, but in developing countries many of these ideas are still very new,” Chan said. “I think we can make a big impact there.”
Target practice on tumors

The side effects of cancer treatment can be painful: hair loss, ulcers and nausea. Cancer drugs cause damage because they destroy fast-growing cells indiscriminately, whether they’re cancerous or healthy. Professor Warren Chan (IBBME), pictured above, right, has spent the last decade figuring out how to deliver chemotherapy drugs directly into tumors — and nowhere else.

Chan, a pioneer in the field of nanomedicine, brings a holistic view to his research. His group works on engineering more effective nanoparticles for drug delivery, modelling and imaging the behaviour of nanoparticles inside the body, and studying the effectiveness — or ineffectiveness — of nanoparticle treatments. The group published a paper in spring 2016 revealing that less than one per cent of nanomedicines reach their intended tumor targets. Now they’re trying to find out why.

Lab-grown tissues could help repair damaged hearts

Professor Milica Radisic (IBBME, ChemE) and her team create sophisticated, realistic systems for growing human cells outside the body. Their lab-grown tissues are already being used to discover and test new drugs, and could one day replace or repair damaged organs.

The team’s latest invention, the Angio-Chip, is a three-dimensional scaffold complete with tiny channels that act as internal blood vessels. Made of POMac, a polymer that is both biodegradable and biocompatible, the Angio-Chip is seeded with heart or liver cells, which attach to the surface and begin growing just like they would in the body.

“Our heart muscle tissue actually beats, and our liver produces urea and metabolizes drugs,” said Radisic, pictured below, left.

The team has licensed the technology to a spinoff company, TARA Biosystems, which uses the lab-grown tissues to screen new drug candidate molecules for negative side effects on the heart or liver. This reduces the use of animal testing and can prevent potentially dangerous drugs from reaching the market.

In the future, the tissues could also be used to screen large libraries of molecules for beneficial effects, helping to discover new drugs. But the ultimate goal would be to implant the lab-grown tissues back into patients whose own organs have become damaged through disease or injury.

Radisic and her team have many collaborators, from fellow U of T professors Michael Sefton (ChemE, IBBME) and Aaron Wheeler (Chemistry, IBBME), to researchers at the University Health Network and her business partners at TARA Biosystems.

“It’s all about meeting the right people and making connections,” she said. “When you are able to look back and see something you invented in lab turn into something that could really help people, I think that’s very motivating.”
Mind reader

Professor Tom Chau (IBBME) wants to break down communication barriers. He has devoted his career to applying engineering solutions to clinical settings, with the goal of helping children with disabilities share their opinions and reach their goals with their families and in daily activities of life.

Chau, who is also the vice-president of research at Holland Bloorview Kids Rehabilitation Hospital, is working to find non-invasive ways for children with limited mobility, motor control or loss of speech to communicate and interact with the world around them using technology. One of his latest projects is an intuitive brain-computer interface that uses near-infrared spectroscopy to image blood flow on the surface of the brain, and map that data to thoughts and intentions.

“We’re trying to ‘teach’ the computer to recognize patterns in blood flow, and guess what that person might be thinking,” said Chau, pictured below, left.

Before the computer can read your mind, it needs to be trained to understand how your brain works. Chau and his team have developed a set of training paradigms that ask the subject to perform a mental task, such as singing a song in your head, performing mental arithmetic or thinking of all the words you know that start with a given letter of the alphabet. These tasks induce patterns of blood flow that are generally identifiable and relatively similar across individuals.

The next step is for you to “send” blood to different part of your brain without performing the mental task. “When people come into our lab, they are always sceptical — they don’t believe they can do it,” Chau said. “In our studies, we’ve shown that by the 10th session people can modulate blood flow in their brain without the task. They learn how it feels.”

They’ve also taught the computer to recognize a relaxed, wandering mind — not so simple, it turns out. “The brain at rest is incredibly noisy,” he said.

Chau’s team works at the leading edge of both medicine and engineering, and welcomes fresh ideas and approaches from all fields.

“Collaboration is critical in our group,” he said. “I’ve had exceptional grad students from U of T — from IBBME, but also chemical, electrical, aerospace and mechanical. All of them bring such innovative approaches to biomedical challenges.”

Machine learning

In the decade since the genome was sequenced in 2003, scientists, engineers and doctors have struggled to answer an all-consuming question: Which DNA mutations cause disease?

Professor Brendan Frey (ECE), pictured above, right, and his team aim to revolutionize genomic medicine by applying advanced deep-learning computational techniques to unravel mysteries contained in the three-billion paired DNA molecules that make up the human genome.

In 2015, Frey and his collaborators founded Deep Genomics, the first company to combine the group’s decades of world-leading expertise with machine learning and genomic science. “Our vision is to change the course of genomic medicine,” said Frey, the company’s president and CEO. “We’re inventing a new generation of deep learning technologies that can tell us what will happen within a cell when DNA is altered by natural mutations, therapies or even by deliberate gene editing.”

In its first year, Deep Genomics secured $5 million in seed funding and has grown to 17 full-time employees. Its multidisciplinary scientific advisory board includes Yann Lecun, director of artificial intelligence research at Facebook, Stephen Scherer, director of the Centre for Applied Genomics and world-leading expert on autism spectrum disorder, and Anshul Kundaje, a professor of genetics and computer science at Stanford University.

Frey feels that collaboration is key to informing the company’s direction. The network he and his colleagues are building will see their technology reach across disciplines and industries to benefit real patients, on a global scale.

“At its core, Deep Genomics is a research-driven company,” Frey said. “We want to have good relationships with the academic community and we want to provide a computational framework that will help speed up academic discoveries, as well as advances in medicine, including screening, genetic testing, drug targeting, personalized medicine and more effective treatment.”

“We’re inventing a new generation of deep learning technologies that can tell us what will happen within a cell when DNA is altered by natural mutations, therapies or even by deliberate gene editing.”
Occupying the entire 14th floor of the MaRS Discovery District’s West Tower, the new Translational Biology & Engineering Program (TBEP), part of the Ted Rogers Centre for Heart Research (TRCHR), is a unique interdisciplinary research initiative that brings together leading experts in engineering and clinical research in heart repair and regeneration. TBEP is one of three components of TRCHR, which also includes The Hospital for Sick Children and University Health Network.

Translational Biology & Engineering Program

Cardiac regeneration

Professor Hai-Ling Margaret Cheng (SCE, IBBME) and her team have discovered a more effective way to monitor cardiac stem cell therapy for treating heart disease. Cheng is developing and testing new contrast agents — chemical compounds that are injected into cells and tracked using MRI technology.

Biomaterials to repair the heart

Professor Paul Santoro’s (BBME, Dentistry) research focuses on developing polymers and other biomaterials that can repair heart damage. His work includes developing new materials that can be injected into damaged heart tissue and can help repair itself.

Cell technologies with cellular and tissue engineering techniques, cell signaling, experimental platform development and clinical research in heart repair and regeneration. TBEP is one of three components of TRCHR, which also includes The Hospital for Sick Children and University Health Network.

Heart flies for fundamental research

Approximately 70 to 80 per cent of genes implicated in human diseases are found in fruit flies. Professor Rodrigo Fernandez-Gonzalez (IBBME) is researching fruit fly embryos to gain a better understanding of how heart cells develop and how they could be stimulated to repair themselves.

A HEALTHY ALLIANCE

U of T Engineering faculty members are leading multidisciplinary collaborative research and educational initiatives that are changing the face of health care.

Centre for Healthcare Engineering

The Centre for Healthcare Engineering (CHE) was established in 2008 to bridge academic research in engineering with health-care practice. CHE is a leader in interdisciplinary research and education in health-care engineering, comprising engineering faculty and students whose research is directly impacting health-care organizations and partners in practice across Canada.

Ambulatory clinic scheduling

Outpatient care is a major component of the Canadian health-care system. Professors Timothy Chan (MIE) and Michael Carter (MIE), in partnership with Toronto’s Women’s College Hospital, developed software that generates optimized clinic schedules. The result: an improved use of space and clinic experience in their new hospital.

Systematic interruption management in intensive care

Intensive Care Unit (ICU) nurses receive frequent non-critical interruptions during a shift. In an effort to reduce these interruptions, professors Birsen Donmez (MIE), Anthony Easty (IBBME) and Patricia Trbovich (IBBME) developed a task-severity awareness tool (TAT). Using buttons or a foot pedal inside the room, nurses can activate a “Do Not Disturb” LED display hung above the door to an ICU room. In an observational study at the Toronto General Hospital, TAT was found to significantly reduce non-critical interruptions.

Perioperative decision support

Professor Michael Carter (MIE) leads a group of researchers who are developing simulation-based decision tools to help hospitals inform decisions that can lead to improved access, efficiency and quality of surgical processes. The pilot model was developed with Juravinski Hospital (Hamilton Health Sciences), St. Michael’s and Mount Sinai Hospitals and has been used by over a dozen hospitals across the country.

"Health-care systems are a lot like giant factories — they involve a large number of people and processes all working together in different stages to meet one goal. At the CHE, we pioneer research that optimizes many of those stages, making health-care delivery more efficient, less costly and quicker."

— Timothy Chan (MIE), CHE Director

PHOTO / NEIL TA

Craig Simmons (MIE, IBBME), middle, is one of eight U of T faculty members who are collaborating on research for the Translational Biology and Engineering Program. Simmons is TBEP’s scientific director.

The future of health-care engineering starts in the classroom

U of T Engineering offers unique educational programs that develop competencies at the intersection of engineering and medicine:

Biomedical Engineering Minor

Specifically designed for undergraduate students interested in applying their engineering knowledge to health-care initiatives.

Biomedical Systems Engineering Major (EngSci)

The first undergraduate program of its kind in Canada. Its interdisciplinary curriculum builds strong foundations in both engineering and the life sciences.

MASC in Biomedical Engineering (IBBME)

Provides a strong academic foundation for students who want to become immersed in the discipline of biomedical engineering.

MEng in Biomedical Engineering (IBBME)

An accelerated, one-year full-time program with a focus on the design and commercialization of biomedical devices.

MEng Certificate in Healthcare Engineering (MIE)

Students learn how to apply industrial engineering methods to clinical problems, focusing their studies on either operations research or human factors.

MHSc in Clinical Engineering (IBBME)

Students learn how to apply and implement medical technologies to optimize modern health-care delivery.

PhD in Biomedical Engineering

With courses and a strong research thesis component, students emerge from this program ready to pursue careers in academia, medicine, industry and government.

PhD in Biomedical Engineering — Clinical Engineering Concentration

Provides the competencies, philosophy and values to enable students to reach the forefront of leadership in biomedical engineering and have a direct impact on health care.
U of T Engineering’s Professional Experience Year (PEY) internship program is the most highly regarded paid internship program in Canada. Third- and fourth-year students are available for 12- to 16-month placements — an excellent way for your company to assess and recruit some of the world’s brightest future engineering leaders. More than 300 companies worldwide employ close to 800 PEY interns each year.

HIRE TOMORROW’S GLOBAL ENGINEERING LEADERS

"The calibre of PEY students that join us is incredible. The students that we hire are not only top of their class from a technical perspective, but they are also very creative, great communicators and ready to take on any challenge."

COBY SEGALL (ElecE 0T1 + PEY)
Manager of Research and Innovation
Zebra Technologies

PROFESSIONAL EXPERIENCE YEAR INTERNSHIP

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Q & A WITH SARA BADIEI

She began her career in the North American energy sector. In 2011, U of T Engineering alumna Sara Badiei (ElecE 0T4) left to turn her talents towards humanitarian work. Since then, she has travelled the world rebuilding infrastructure in war zones, providing relief following natural disasters and helping to treat thousands in areas affected by disease.

Five years ago, you left your role as a power systems engineer at a large Southern California energy company to work for Médecins Sans Frontières, the International Committee of the Red Cross (ICRC) and now the World Bank. What made you decide to change your career from the private sector to humanitarian aid?

It was just perfect timing. I really love travelling and the unknown, and I was at a point where I’d paid off my debts, had a pretty good amount of savings and a nice foundation of experience. I didn't have any obligations and was still young enough that I didn’t mind sleeping in tents in the jungle. I was ready to do something a little more exceptional that I didn’t think I’d be able to do later if I had kids.

How did the idea come to you?

I had a colleague who had done something similar. He was an accountant, but he mentioned that he had worked with Médecins Sans Frontières. I was confused because I thought that you had to be a doctor to do that kind of thing, but he said that people from many different backgrounds can do this kind of work and, in fact, they’re very much needed. I started looking into it more and thought ‘Wow I can apply my skills to help people, travel, get paid and build an actual career.’ It was like a whole new world opened up to me.
I think U of T graduates are somewhat overachievers and humble opinion. And, if you can, as an engineer, apply your location, set of people and skills, and an entirely different kind of thirsty for knowledge. They need challenge. I definitely moved over to the humanitarian sector. But those things are it comes to together and you build something to put on top. I worked for five years in the energy sector in North America, and then I thought I had completely changed gears and moved over to the humanitarian sector. But those things are merging into one job, now that I’m an energy specialist at the World Bank. I don’t look at it necessarily as a career change. I look at it as a progression toward that niche area that defines me, that’s made up of different things that I really like and get excited about. I don’t think about it like it’s a job, it just feels like it’s what I love doing.

How would you describe the work that you do? Is there such thing as a typical day for you?

Not really — and that’s really nice about it. We just get thrown so much stuff that we learn to thrive in constantly changing environments and challenges. During my first mission with Médecins Sans Frontières Holland (MSFH), I was the manager of supply chain operations in Chad and it was so different from anything I’d done before. For the next mission with Médecins Sans Frontières France (MSFF), I was in the middle of Congo’s jungles doing water and sanitation. Then, I was in the Philippines with MSFH after a typhoon doing emergency response work. For my first mission with the ICRC, I was sent to Gaza during the longest and most intense war ever experienced in a small enclave. As the head of the engineering department, which was the largest department in the sub-delegation, I was overseeing endless repairs to critical infrastructure damaged by the war. Next, the ICRC sent me to Afghanistan where I worked in Kandahar, Kabul and Herat to design wastewater treatment plants for provincial prisons.

Now, I’m living in Jerusalem and working for the World Bank on energy policy, institutional reform, regional integration, renewable technologies and more. So the days are different, people are different. Everything is different all the time. Which is really, really nice, but at some point it can get tiring. At some point, you want to have a home, so that’s the flip side.

What is the impact or role that engineering plays in disaster relief and, more broadly, humanitarian work?

Next to doctors, engineers are — I would argue — the best people you can send to the field. If you need somebody to manage your program, to get the funding, to handle the water and sanitation, build your building, build your infrastructure — send engineers. They can do all of it. They can do anything.

What advice do you have for engineering students and alumni who might be interested in a career in humanitarian work?

The number one piece of advice I have is to not be afraid. It’s totally possible and it’s really worth it. It’s a pretty cool career. I had a bug inside of me that wouldn’t be quiet and just kept saying ‘go, go, go.’ It was just calling me, and I know some other people have it. If you have it, listen to it. You have to go. Even if it’s for just one year, you have to do it.

How did your background in engineering help to prepare you for this new challenge?

I worked for five years in the energy sector in North America, and then I thought I had completely changed gears and moved over to the humanitarian sector. But those things are merging into one job, now that I’m an energy specialist at the World Bank. I don’t look at it necessarily as a career change. I look at it as a progression toward that niche area that defines me, that’s made up of different things that I really like and get excited about. I don’t think about it like it’s a job, it just feels like it’s what I love doing.

Managing micronutrients
The diets of people in the developing world often lack essential micronutrients such as folic acid, thiamine, iron and zinc. Professor Levente Diosady (ChemE) and his team have worked out a way to create tiny edible particles — basically indistinguishable from salt grains — that are rich in iron. The particles are mixed with traditional iodized salt to create double fortified salt (DFS). Diosady has teamed up with Venkatesh Mannar of the Micronutrient Initiative to distribute DFS to more than five million children a day in India’s Tamil Nadu province, and will expand into the province of Uttar Pradesh, where it will be distributed to between 10 million and 20 million people.

Improving aquaculture
Fish is a key source of protein worldwide, but fish farming is not always easy to sustain in developing nations. Oxygenating the water isn’t easy — electricity is not always reliable, and the high cost of buying equipment is a barrier. Professor Amy Bilton (MIE) and her team have taken up this challenge by installing a passive aeration device in test ponds in Vietnam and Bangladesh. The device increases the level of dissolved oxygen in the water without the need for electricity, increasing fish production. Aquaculture is big business in South East Asia and accounts for over five per cent of gross domestic product in Bangladesh and Vietnam. Bilton’s next phase of the project involves field trials with 100 fish farmers in Bangladesh with support from the Powering Agriculture Program.

Smarter soils
Food production depends largely on the quality of the soil that sustains it. Professor Arun Ramchandran (ChemE) and his team aim to design a kind of chemical probe that could be impregnated into a small-scale substrate such as a piece of fabric or paper. When placed into a mixture of soil and water, the chemical probe would react with the target nutrient to create a colour change, similar to a litmus test, indicating whether supplements such as fertilizers need to be added. Because only tiny amounts of the probe are needed, the kits could be created for mere pennies apiece.

Visit uoft.me/centreforglobalengineering to read more about CGEN’s full scope of research.
OCCAM to advance world-leading research

The Ontario Centre for the Characterisation of Advanced Materials (OCCAM) — a $20-million analytical laboratory co-led by Professors Charles Mims (ChemE) and Doug Perovic (MSE) — officially opened in May 2016. The facility contains leading-edge equipment for imaging, analyzing and manipulating materials with nanometre-scale precision that helps researchers understand the natural world and design better devices for a number of different sectors, including health care.

Professor Chris Yip (ChemE, IBBME) and his team are some of the many researchers who use the Centre. “How biomolecules interact with each other is pivotal to all biological and cellular processes — from controlling our mood and brain function to our cellular processes — from controlling metabolism and senses,” says Yip. “When these interactions are disrupted — whether through genetic mutations, disease or other factors — we get sick.”

Yip and his team study how proteins self-assemble and interact, which in turn could lead to new strategies to treat disease and improve human health. The team makes extensive use of an OCCAM tool called nanoIR to image protein molecules. In a two-step process, a tiny needle tracks over the surface of individual molecules, mapping their shape and organization in 3D. The needle also measures how these molecules interact with infrared light, which may yield new insights into the local chemical structure, organization and bonding. These insights are critical to learning how proteins might assemble or mis-assemble. The nanoIR will help identify structural and chemical details of how antibodies bind to proteins and protein aggregates, which may herald new approaches to treating diseases such as Alzheimer’s.

“The nanoIR serves an important role not only in my area of research, but in our overall understanding of nano-scale material structure, composition and conformation,” Yip said.

LAB-GROWN HUMAN CELLS AND TISSUE

An allied research program led by Professor Milica Radisic (ChemE, IBBME) received a Collaborative Research and Training Experience grant from the Natural Sciences and Engineering Research Council worth $1.65 million over six years. Through this grant, Radisic and her team, which includes professors Alison McEwen (ChemE, IBBME) and Arun Ramchandran (ChemE), will help train a new generation of experts in developing leading-edge treatments for disease based on lab-grown human tissues.

Late last year, McEwen and Professor Radhakrishnan Mahadevan (ChemE, IBBME) developed a way to grow cancer cells in the form of a rolled-up sheet that mimics the 3D environment of a tumour. The innovation will enhance the study of cancer by moving away from the traditional petri dish, which only provides a 2D perspective. Their findings were published in the prestigious science journal Nature Materials in November 2015.

Professor Doug Perovic (MSE) work on the new secondary ion mass spectrometer at the Ontario Centre for the Characterisation of Advanced Materials (OCCAM).
Leader in action: Six career tips from alumnus Rami Rahim

Rami Rahim (ECE'94), CEO of Juniper Networks, stepped to the podium as the guest speaker for Convocation 2016 and confessed something surprising about his career.

“Never have I had a five-year plan; I’ve never had a one-year plan; I’ve never even had a one-year plan,” Rahim said. “At each stage of my career, the next was never obvious to me.”

His lack of planning worked to his advantage. As one of Juniper’s original employees — the 32nd, to be exact — Rahim focussed on his first breakthrough product, the revolutionary M40 internet router. He then spent the next 20 years progressing through a series of technical and leadership roles to become the company’s CEO and a member of its Board of Directors. Rahim was recently ranked 24th in the U.S. on Glassdoor’s 2016 Highest Rated CEOs list with a 94 per cent employee approval rating.

1. Do not dwell too much on the next career step: “Do a great job in your current role, stand out and thrive.”
2. Finish what you start: “You can either let the pressure destroy you or motivate you to work even harder … Pressure can truly create diamonds with the right attitude.”
3. Push yourself outside of your comfort zone: “Never let fear, uncertainty or self-doubt slow you down or prevent you from taking that next step.”
4. Work with wicked-smart people: “If the initial idea is flawed a great team will almost always figure out a course correct.”
5. Be kind: “Everybody has a role to play in the success of a company.”
6. Work hard: “You need to find a mission that motivates you in your career and your life.”

Rahim punctuated his speech with six of the most important lessons he’s learned throughout his career.

Rami Rahim spoke to the graduating ECE and MSE classes on June 9, 2016.

“Professionals are engineers — nothing is impossible.”
Rahim to the graduating ECE and MSE classes on June 9, 2016.

WITH MOBILITY COMES GREAT CREATIVITY
An expert in field-programmable gate arrays, Professor Jonathan Rose (ECE) never thought he would count pediatricians, speech pathologists and physiotherapists among his students — but mobile devices and their many applications have a way of bringing people together.

ECE 1778 Creative Applications for Mobile Devices is a project-based course open to all graduate students from across the University of Toronto. ECE and Computer Science students with graduate-level programming skills are matched with specialists from other fields to create new interdisciplinary applications for mobile devices that aim to solve an open problem in the specialists’ fields.

Past projects include CardiACT, an app that helps bystanders respond quickly and effectively if someone goes into cardiac arrest; Snap‘N‘Dose, an app that helps parents deliver the correct dosage of medication based on their children’s age and size; and, an addiction-support app that inspired a research project in collaboration with the Centre for Addiction and Mental Health to create a smoking cessation app.

Robotics interest has skyrocketed in the world. “The goal now is to make smaller, smarter tools, while mimicking the dexterity of a human hand,” Looi said.

“With the technology into the surgical arena, he jumped at the chance. "Robotics interest has skyrocketed in all areas from medicine to cars," said Looi. "It's a lost opportunity for injury prevention."”

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GETTING A HANDLE ON SAFETY FOR SENIORS
Falls are the leading cause of injury, disability and death in seniors, sending nearly 80,000 Canadian seniors to hospital each year. “Surprisingly, building codes for stairs and railings are not always based on data of how we walk and fall,” said Vicki Komisar (EngSci OT0, IBBME PhD candidate). “It’s a lost opportunity for injury prevention.”

Komisar uses the Challenging Environments Assessment Laboratory — a tilting, shaking “lab on a platform” at the Toronto Rehab Hospital — to study the biomechanics of balance loss and recovery. She has helped improve Canadian regulations for stairs, and shown that current handrail standards are insufficient.

“Using engineering to address serious public health issues is very rewarding,” she said.

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EngSci CONNECT is a network of engaged alumni who give back by inspiring current students, who are the next generation of leaders. Join today at engsci.utoronto.ca!
Prime minister backs regenerative medicine research at U of T and partners

Regenerative medicine is the way of the future for Canadian health care, Prime Minister Justin Trudeau said, and the federal government will help strengthen collaborations between U of T and its partners in stem cell research and manufacturing.

In January 2016, Trudeau announced a $20-million grant for the Centre for Commercialization of Regenerative Medicine (CCRM) to establish and operate the Centre for Advanced Therapeutic Cell Technologies in the MaRS Discovery District.

The CCRM is the commercialization arm of U of T’s Medicine by Design (MbD) initiative, a program led by Professor Peter Zandstra (IBBME) with a mandate to undertake transformative research and clinical translation in regenerative medicine. Supported by the largest federal government grant in U of T’s history, MbD will use its $124-million funding to bring together more than 90 researchers across the University and its health-care partners to develop next-generation treatments for serious injuries and diseases.

“Stem cells offer avenues to treat — and perhaps cure — devastating and costly illnesses such as cardiovascular disease, diabetes, blindness, lung disease, neurodegenerative disorders, and diseases of the blood and musculoskeletal system,” Zandstra said. “This program will allow us to take regenerative medicine to the next level — we’ll be able to design cells, tissues, and organs from the ground up, hopefully with benefit to patients and benefit to the Canadian economy.”

The federal government’s support for the new centre at MaRS is matched by a $20-million investment from GE Healthcare.

Read the full Q-and-A at soft.mie.utoronto.ca/2016/Prime-minister-backs-regenerative-medicine-research-at-U-of-T-and-partners/

Q-AND-A WITH ALUMNUS AMIR MANBACHI

A faculty position at a prestigious institute is a coveted career path for many PhD graduates. Alumnus Amir Manbachi (EngSci 0T8, IBBME PhD 1T5), a recent appointee in the Department of Biomedical Engineering at Johns Hopkins University, shares some insights on his journey.

Can you tell us about your role? As the director of innovations at the Carnegie Center for Surgical Innovation I will be working closely with researchers in the Johns Hopkins Neurosurgery Spine Program on medical imaging modalities for image-guided neuro-interventions and spine applications, as well as 3D printing for surgical use.

How did you gain exposure to 3D printing technology? My primary exposure to this technology happened during my postdoctoral appointment at Harvard-MIT’s Division of Health Sciences & Technology. My supervisor, Professor Ali Khademhosseini (ChemE 99, MASc 00), is a world-renowned expert in micro- and nano-scale biomedical engineering, and one of the projects I worked with him on involved the use of 3D printing for tissue engineering.

How did your PhD from U of T prepare you for this position? In three ways: 1) my exposure to hospital surgical observeships in my PhD clinical engineering concentration program, 2) my stellar research supervisor, Professor Ementurk Richard Cobaal (CCS, IBBME) and his guidance for my thesis on image-guidance technology for spine surgeries, and 3) the knowledge and experience I gained when I founded Spineos Medical Inc., a startup based on my research.

I would become an entrepreneur, because I really enjoyed research. I thought I could have an impact that way.

His impact will now be felt in the sport of boxing (and in the ring). Boxing coaches traditionally use clickers to measure the number of punches thrown. But Zahar said that method is subject to human error — plus, it doesn’t allow you to log additional data.

“Adding this device means you can differentiate each punch, you can dig deeper into the data so that you can improve as a boxer, and you can measure endurance in real-time in order to change your regimen as you go,” he said. “It can even help in pinpointing an injury.”

Since launching Hykso in 2013, the company is now based in Orange County, Calif., and has generated $360,000 in sales. Zahar also hopes to improve the design. He was recently awarded a $900,000, three-year NSERC Collaborative Research and Development grant to make it happen.

Behdinan and his research group will work alongside SPP Canada Aircraft Inc. and its parent company Sumitomo Precision Products Co. in Japan to develop an integrated computational methodology for the design, testing and development of the next generation of landing gear.

“With the help of engineering alumnus Amir Manbachi, I will be working closely with researchers in the Johns Hopkins Neurosurgery Spine Program on medical imaging modalities for image-guided neuro-interventions and spine applications, as well as 3D printing for surgical use.

The Hykso device, shown above, connects instantly to a companion smartphone app via Bluetooth.

Olympic boxer Hykso

The Canadian and American boxing teams had the upper hand going into the 2016 Summer Olympics. Leading up to the Games, both teams trained using a wearable sensor — created by MIE alumnus Khalil Zahar (MechE 1T4) and his company Hykso — that tracked each punch, measuring its speed and intensity.

The small sensor is strapped onto a boxer’s wrists to track their hand movements 1,000 times per second. Combining motion tracking and machine-learning technology, the device then calculates, in real-time, the speed of the punch, and even recognizes the type of punch thrown.

Zahar says the University of Toronto’s Impact Centre, as well as his engineering background, helped pave the way for his successful startup.

“My engineering background helped me in a lot of ways,” he said. “To create this device, I had to explore and validate my hypothesis, and iterate my assumptions, just as I would in research — it’s very scientific, actually. I didn’t think

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Zebra mussels could inspire better medical adhesives

An invasive species, zebra mussels arrived in the Great Lakes from Russia in the late 1980s. They are known best for clogging water pipes and causing headaches for many industries in the region, but for Professor Eli Sone (MSE, IBBME) and his team, zebra mussels could hold the key to a new generation of better medical adhesives.

“Zebra mussel glues have properties very similar to what we need for biomedical or dental glues,” says Sone. “They stick to just about any kind of surface in wet conditions and are non-toxic, which is something we can’t get with most synthetic glues.”

Sone and his team have studied the substances that make up zebra mussel glue using both structural and biochemical techniques. Over the past several years, they have discovered nearly a dozen new proteins that give the glue its unique properties. They recently presented their findings at the Annual Meeting of the American Chemical Society in Montreal last May.

Understanding how zebra mussels stick to surfaces could enable Sone and his collaborators to design synthetic materials that mimic the proteins, creating safe, strong adhesives for dentistry or surgery.

At the same time, Sone is working with Professor Ben Hatton (MSE) to make surfaces that mussels have a hard time sticking to. These surfaces would be more environmentally friendly than current synths, and could potentially save industries millions in costly removal operations.

“It’s a fascinating problem,” says Sone. “The best part is discovering proteins that no-one has ever seen before and trying to figure out how they work. For me, that’s really exciting.”

Three UTIAS researchers are collaborating with the University and the University of Sherbrooke. Kelly and his team are developing a self-driving wheelchair prototype.

The world is mourning University Professor Emerita Ursula Franklin, one of Canada’s most accomplished scientists and educators and one of its most renowned feminists and peace activists.

Franklin, who died at the age of 96, was born in Germany and educated in Berlin. After surviving the Holocaust, she came to the University of Toronto in 1949. Following 15 years as a senior scientist with the Ontario Research Foundation — where her research on strontium-90 in baby teeth was instrumental in achieving a moratorium on atmospheric nuclear weapons testing — she joined U of T Engineering in 1967 as the first female professor of what is now called the Department of Materials Science and Engineering.

Franklin pioneered the field of archaeometry, applying modern materials science to the dating of archaeological artefacts. In 1984, Franklin became the first woman to receive the title of University Professor, the highest academic rank at U of T. She joined UTIAS as a senior scientist with the Ontario Institute. Their aim is to improve both accessibility in ways that we have not thought of before.
The collective generosity of U of T Engineering’s vibrant community of alumni, faculty, students and friends is nothing short of outstanding. We offer our deep thanks for your tremendous support and dedication.

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6T7) continued their support for leadership education at U of T Engineering in 2015–2016 with a
$1-million gift for the Institute for Leadership Education in Engineering (ILEAD) to enhance co-curricular leadership training and $125,000
for the Department of Chemical Engineering & Applied Chemistry’s Leaders of Tomorrow Program. With these new gifts, the Troost family has contributed more than $7 million to the Faculty, including a $2 million gift to create new space for ILead in the
Centre for Engineering Innovation & Entrepreneurship.
Elaine Campbell (ChemE 8T0) spent some of her best years at U of T Engineering — and has been a familiar face at the Faculty ever since. She met her husband during her undergraduate studies. Their three children all graduated from U of T.

“Staying connected to the University just felt very natural,” Campbell said.

Campbell, the interim president at Innovative Medicines Canada, currently sits on the Board of Advisors for the Department of Chemical Engineering & Applied Chemistry (ChemE), a position she’s held since 2012.

A number of factors influenced her to volunteer for ChemE’s Board of Advisors, but it was the department’s connections to the biomedical world — including its close collaboration with the Institute of Biomaterials & Biomedical Engineering, its world-leading bioengineering research centre, BioZone, and its close proximity to the network of hospitals along Toronto’s University Avenue — that really inspired her.

“The idea of medicine, engineering and pharmacy having a nexus is really appealing,” she said. “I’m proud of what the Faculty has done there. There are unique investment opportunities both for global corporations and entrepreneurs and the world needs to be aware of this.”

She brings a wealth of pharmaceutical industry expertise to the ChemE board. Over the past 25 years, Campbell has held leadership positions at both DuPont Pharmaceuticals and AstraZeneca — including president and CEO of the latter’s Canadian operation.

While studying at Skule™, Campbell was driven to improve the quality of life and health of others, and was intent on a career in the biochemical engineering sector. After a brief stint working as an engineer in DuPont’s polymers division, she quickly found her way into the pharmaceutical side of the company’s business.

“I like to say that life is just chemistry in motion,” she said. “All living things are based on chemistry, so the pharmaceutical industry was a natural fit for me … I found my way back to my first love — the biomedical and bio-chemical part of the discipline.”

Campbell also represents U of T on the MaRS Discovery District’s Board of Directors and has participated in U of T Engineering’s Alumni Mentorship Program.

Her suggestion for getting and staying involved?

“It all looks very consolidated,” she said of her volunteer work. “Define what’s important to both your personal and professional life and make the time.”

Volunteer Leadership

The Faculty of Applied Science & Engineering is grateful for the support and counsel of dedicated volunteers. These leaders give generously of their time and remarkable expertise to enhance advancement activities across the Faculty, including alumni relations and development. Visit uoft.me/volunteer-leadership for a complete list of individuals who have donated their time and service to Skule™.
We wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this land.