RESEARCH AND INNOVATION AT THE UNIVERSITY OF TORONTO • FALL 2014 • VOL.16, NO.2

EDGE

The Connaught Issue

A LANDMARK DISCOVERY, A POWERFUL LEGACY

1921. U of T professor Frederick Banting and his student, Charles Best, discover insulin. Since then, millions of people worldwide have lived full lives as a result of the work of Banting and Best and their colleagues, J.R.R. Macleod and James Collip. And their innovation went even further. U of T's Connaught Fund, created in 1972 from the sale of the laboratories used to manufacture insulin, has provided thousands of U of T researchers with the funding they need to explore and to make an impact, from sociology to stem cells, from human rights to aquaculture.

THIS ISSUE OF *EDGE* TELLS THE CONNAUGHT STORY.

5 things to know about the Connaught Fund

ONE The Connaught Fund is a **unique asset** that supports the work of U of T researchers and graduate students.

TWO The Connaught Fund was founded in 1972, when U of T sold the Connaught Medical Research Laboratories for $29 million. The lab, which had been officially founded in 1917, produced vaccines and antitoxins and, later, insulin, which was discovered in 1921 by U of T researchers Frederick Banting, Charles Best, James Collip and J.R.R. Macleod.

THREE The proceeds from the sale were endowed and the earnings designated to **support U of T research in perpetuity**. Today the fund is worth $97 million.

FOUR Connaught is the **largest university research endowment in Canada**. Since 1972, it has awarded approximately $130 million to U of T scholars.

FIVE Some Connaught programs are specifically designed to help **early career researchers** get their careers started. Others focus on large-scale interdisciplinary work or innovation, with a strong **emphasis on meeting the challenges facing global society**.

To learn more, visit **connaught.research.utoronto.ca**

Connaught is "history fuelling the future"

What's your relationship to the Connaught Fund?
I have been associated with the Connaught Fund for over 30 years — from my first very first junior administrative role until today when, as part of my role as assistant vice-president, I serve as Connaught program director.

What kind of research does the Connaught Fund support?
Connaught has always been about excellence. Although it arose from a medical discovery, for over 40 years it has embraced and supported brilliant research and graduate training across all scholarly fields at U of T. The programs have evolved with the changing research landscape, but the emphasis on excellence has endured. Three years ago, Professor Paul Young, who then served as vice-president, research and innovation, led the most recent program evolution. That included the establishment of the flagship Global Challenge program, which awards $1 million to a single project to help address the world's most pressing questions, as well as the Innovation Fund program to facilitate the commercialization of U of T research discoveries.

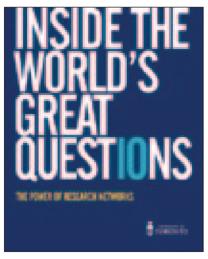
Why did the University start the Connaught Fund to begin with, back in 1972?
The Connaught Fund was mutually agreed upon between the University and two levels of government. Prime Minister Bill Davis discussed the matter personally with the acting president of the day, Jack Sword, and the chair of the University's board of governors. They agreed on the creation of a special trust through which the University could apply its professional expertise to major problems of public interest. Part of the agreement was that the Connaught Fund be held separate from the University's general operating and capital budgets. It was intended to provide niche funding, an opportunity to bet on ourselves and launch research initiatives that might not otherwise be supported but that held great promise for addressing important questions and could eventually become sustainable through regular external funding. The Connaught Fund is the product of a unique confluence of events. Thank goodness that the leaders at the time, and since, had the foresight to protect it.

What makes Connaught unique?
To the best of our knowledge, Connaught is the only fund of its kind in Canada, where the legacy of a single innovation will go on to support U of T research, potentially for as long as the University exists. That's the exciting thing about Connaught — it is both old and new. It is history fuelling the future. It represents excellence in research, creativity, ingenuity, entrepreneurship, and good management — past and present. In that way, it symbolizes much of what people admire most about the University of Toronto. The University's inventions policy ensures that new discoveries, which may have arisen from research funded at some stage by Connaught, will augment the capital value of the Connaught Fund, increasing its capacity to seed future research excellence. It's a virtuous circle.

For more on how U of T research works, please visit:

Edge is available online at:
www.research.utoronto.ca/edge

U of T Ignites Innovation
www.research.utoronto.ca/innovation



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RECRUITING NEW GREAT MINDS

The Connaught Faculty Recruitment Support Program helps to bring new professors – primarily in the humanities – to U of T to bolster our renowned research community.

AMOUNT: VARIES

Music in exile

Ethnomusicologist Farzaneh Hemmasi looks at how pop music answers the questions of what it means to be Iranian

by Sarah McDonald

One of the aims of the Connaught Fund is to bring the best and brightest minds to the university. The Faculty Recruitment Award helps to do exactly that by providing grants to highly sought-after candidates.

Farzaneh Hemmasi is one such candidate. Her area of expertise is ethnomusicology: the study of music in or as culture.

"A phenomenon as seemingly straightforward as a high school kid's attachment to goth music is something we might study. But we also work beyond the individual, on music and social movements, cultural policies of governments regarding music, and thinking about how music among the arts has something special to tell us about how people relate to the world," Hemmasi explains.

Hemmasi's focus is on Iranian popular music produced outside of Iran, often in Los Angeles, where members of the Iranian music industry fled to during the revolution when popular music was banned for close to 20 years. They became the sole preservers, performers and source of new Persian-language pop music during that period.

She also researches the lives of and controversy surrounding pre-revolution pop singers, such as the iconic performer, Googoosh, who created an American Idol-esque televised singing competition.

Scandal recently erupted when a Muslim woman who wore the veil entered and won the competition, angering Iranian secularists and conservatives alike.

"Part of the project is understanding the role of women and women's voices both literally and metaphorically, in the sense of having a voice and the possibilities of expressing oneself. What is that role and how has it changed in Iran in the past 100 years?" she says.

Hemmasi is also intrigued by the ways in which Iranians in LA have taken advantage of media and technology as a way of preserving memories of the pre-revolutionary past.

This use of media helps Hemmasi overcome one of the largest hurdles to her own research: location. "That is precisely the challenge that my exiled interlocutors face. They can't be where they want to be. So we're both turning to the same resource. What we can both access is media: I can access the media they produce and they can use media as a platform for communicating with each other," she says.

"That's one of the key questions of my research: how could media start to constitute this alternative space that is neither Iran nor Los Angeles but both together? Not in some kind of utopian way, with media solving all of our problems but a tool or even this other 'place' where people can go to talk things out, sing things out, feel things together.

"I think one of the best things about ethnomusicology is that we can make those connections and that they're really necessary to our work. It's not just about the notes coming out of a horn or the notes on a page but it's really about understanding how people make it through their lives."

PHOTO: JOHN HRYNIUK

Connaught: A legacy of smart research investment

PROFESSOR PETER LEWIS

Historian and U of T professor emeritus Michael Bliss said in his book, *The Discovery of Insulin*:

The discovery of insulin at the University of Toronto in 1921 – 22 was one of the most dramatic events in the history of the treatment of disease. Insulin's impact was so sensational because of the incredible effect it had on diabetic patients. Those who watched the first starved, sometimes comatose, diabetics receive insulin and return to life saw one of the genuine miracles of modern medicine. They were present at the closest approach to the resurrection of the body that our secular society can achieve, and at the discovery of what has become the elixir of life for millions of human beings around the world.

As Professor Bliss explains so well, there is no denying the historic impact of the work of Frederick Banting, Charles Best, J.R.R. Macleod and James Collip. Millions of people are alive today because of the discovery of insulin.

In addition to improving the health of people with diabetes, the impact of that discovery has gone — and continues to go — even further. Their process served as a model for subsequent medical research. After the discovery, the Connaught Laboratories, which had been founded officially in 1917, were used to produce insulin. In a sense, the Connaught Labs' insulin project became one of the world's first university research spin-off companies.

When the Connaught Labs were sold in 1972, the University of Toronto used the proceeds to establish the Connaught Fund. From there, the impact continued. Over the past 42 years, this internal research funding source has supported thousands of research projects in a dazzling array of subjects that affect us all, from literary studies to stem cells, from urban planning to robotics.

We thought it was time to highlight and celebrate the tremendous work being done by U of T's Connaught researchers, all of whom are making an impact because of the innovation of the team of Banting, Best, Macleod and Collip 93 years ago.

We hope you enjoy this issue.

Peter Lewis

Peter L. Lewis, PhD
Interim Vice President, Research and Innovation

10 new researchers

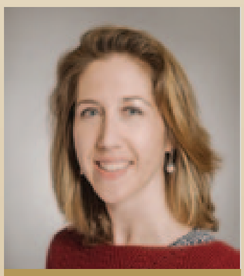
Health as a human right

Insulin — the transformative medical intervention for diabetes — is listed on the World Health Organization's essential medicines list. But insulin is inaccessible in many low and middle-income countries, given inadequate pricing policies and health care systems and unaffordable diagnostic tools. If insulin remains inaccessible almost 100 years after its development, today's health innovations are even less likely to be available globally. Lisa Forman says this is a good example of deepening health inequalities in a globalized, recessionary world. Her Connaught research will follow this hypothesis: that the right to health in international human rights law offers a legal, political and normative framework capable of guiding efforts to advance global health equity, including the development of new global health goals such as universal health coverage.

Lisa Forman
Dalla Lana School of Public Health

Using stem cells to treat muscle wasting

Strong, healthy muscles are essential to quality and longevity of life. When a person's muscles waste away or atrophy due to aging, disease or simply lack of use, the consequences are devastating. The cost of treating muscle atrophy-associated health problems is staggering, with estimates that more than $18.5 billion was allocated to treatment of aging-associated muscle atrophy alone in the U.S. in the year 2000. Gilbert aims to improve stem cell-based therapy to treat muscle wasting by overcoming a major obstacle to this treatment — generation of clinically useful numbers of adult stem cells in culture.



Penney Gilbert
Institute for Biomaterials and Biomedical Engineering

Metromobility versus automobility

Mass transportation is an essential aspect of urban economic and social planning, especially in regions attempting to connect fragmented areas, improve sustainability and remain competitive in the global marketplace. Enright believes that "metromobility" — the widespread use of subways (metros) in urban development — is not necessarily a more public or progressive alternative to automobility, and that it must be understood as a regime of power with its own constitutive contradictions, tensions and potential drawbacks. Enright hopes to gain an understanding of the ambivalent nature of metromobility by studying major cities that have attempted to launch ambitious collective transit systems as levers of regional transformation. This perspective, she says, is crucial for establishing effective public policies and for building just urban societies.

Teresa Enright
Department of Political Science

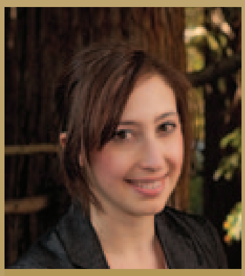
Better manager-employee relationships, better companies

Francesco Bova's research portfolio focuses on the intersection between management's interaction with its employees and management's strategic decisions. In a past study, he found that employee-owned firms tend to take on less risk than non-employee-owned counterparts. As a Connaught New Researcher, Bova will assess whether firms where managers have better manager-employee relationships make less myopic decisions than those with worse employee relationships. Bova believes the project could influence future corporate policy. He notes that there is an increasing push from government and the public for firms to consider stakeholder (for example, employees) objectives on top of shareholder objectives when making decisions.

Francesco Bova
Rotman School of Management

Policing gun smuggling

The tunnel and bridge that connect Windsor, Ontario, and Detroit, Michigan, comprise one of the busiest border crossings in North America. Millions of people travel through this corridor for a multitude of reasons. This corridor is also the main conduit for illegal guns used in Ontario. Carlson will examine how American and Canadian authorities police guns and the flow of guns across borders and how differing social, cultural, legal and political contexts affect the policing of guns and related crimes. While she will look at the problem from a sociological perspective, she also hopes to develop recommendations on best practices for police.



Jennifer Carlson
Department of Sociology, U of T Mississauga

10 great ideas

Sustainability and disease in fisheries and aquaculture

With most fisheries fully or over-exploited, today's global demand for seafood is being increasingly satisfied by aquaculture — fish farming. But the growth of aquaculture in coastal seas has been accompanied by the emergence of infectious diseases that in turn threaten wild stocks. Krkosek studies virulence and antibiotic resistance in marine diseases, using salmon as a model. He is developing a mathematical model of disease evolution and hypothesizes that maintaining healthy marine ecosystems will bolster disease control efforts in farmed populations. His results will be relevant to policy and to the management of coastal seas.

Martin Krkosek,
Department of Ecology & Evolutionary Biology

Literacy through play

Ontario recently introduced a new play-based kindergarten program, which means that skills — reading, for example — are learned though play rather than strictly via traditional instruction. This requires teachers to integrate child-centred play into their programming at the same time that they ensure that academic skills are developed. There isn't a lot of research on the relationship between play and academic learning. Pyle aims to fill this gap by looking at the relationship between children's engagement in play and their literacy development, including best practices for how teachers can bridge academic instruction and play.

Angela Pyle
Ontario Institute for Studies in Education

Is hoarding a disability or a public health hazard?

Hoarding has recently been reclassified within the Diagnostic and Statistical Manual as a stand-alone mental disorder, rather than merely a symptom of other mental disorders. Being medically and legally recognized as an impairment means sufferers may seek legal protections against events like eviction by claiming their disability status. At the same time, most public discourse about hoarding considers it a major public health hazard warranting intervention by landlords, law enforcement and government. Kilroy-Marac will examine how these two opposing ideas about hoarding play out among people facing eviction in Toronto.

Katie Kilroy-Marac
Department of Anthropology, U of T Scarborough

Getting youth with disabilities active

Young people with disabilities in Canada are more than four times less active than their typically-developing peers. Arbour-Nicitopoulos will develop and test a program aimed at improving fitness among young Canadians with physical disabilities as well as those without disabilities. The 17-week program will involve personal fitness and skills development, intensive coaching, health education and physical activity sessions both in and outside of the home.

Kelly Arbour-Nicitopoulos
Faculty of Kinesiology and Physical Education

China and socialist visual culture

The period between 1949 and 1963 witnessed intense exchanges of art works, publications, exhibitions, theories and delegations between Communist China and other socialist nations. Yet these exchanges and their role in socialist visual culture have received little scholarly attention. As a Connaught New Researcher, Gu will fill this significant gap in knowledge and challenge reductionist readings that interpret Chinese socialist culture as a mere product of state propaganda. This rethinking of Chinese visual culture will complicate current understandings of the Cold War and contribute to contemporary debates on art and globality.

Yi Gu
Department of Arts, Culture & Media, U of T Scarborough

HEAD START FOR NEW RESEARCHERS

Investing in the next generation of great researchers is important to U of T — and to society. The Connaught New Researcher Program awards about $1 million a year to new tenure-stream faculty members who are building their research programs.

MOST INDIVIDUAL AWARDS: $10,000

“The next big frontier in genetics”

U of T team will bridge the gap between biomedical research and computer science *by Jenny Hall*

In 1990, after several years of planning, the Human Genome Project (HGP) was launched. An ambitious international scientific project, the HGP sought to map and sequence all the genes in a representative human.

The project took 13 years and cost a billion dollars.

Today, thanks to massive technological advances, the same task can be done in an individual scientist's lab for about a thousand dollars.

And it is being done in labs across the world, generating reams of genetic data. It turns out that even though we all have the same 30,000 genes, there's a huge amount of variability in our DNA.

Brenda Andrews, director of the Donnelly Centre for Cellular and Biomolecular Research and a professor in the Department of Molecular Genetics, is at the helm of an ambitious new project to try to make sense of that variability. She and collaborators are poised to make the next great leap forward in our understanding of genetics — fulfilling the promise of the HGP.

In the post-HGP era, she says, genetic researchers look at single-nucleotide polymorphisms (SNPs), which are part of the genetic variation among people. "Sometimes individual SNPs or other changes in genes, have an obvious effect. For example, SNPs could change the function of an important protein, which may result in a disease. The effects of most SNPs, though, are not understood. But the spectrum of SNPs and other changes in each person's genome is thought to influence susceptibility to disease, as well as our responses to drugs and the environment. For example, my genome might have the same version of a gene that is linked to a disease as yours, but you don't get the disease and I do."

Each person's genome has 10 million SNPs, so trying to understand why one person gets a disease or has an adverse reaction to a drug when another doesn't is a bit like finding the proverbial needle in the haystack.

"It's become very apparent that there's a lot more going on in our genomes than we ever understood," says Andrews. "We haven't really gotten that much better at predicting variable responses among people. We can read the genome, but now the challenge is to interpret. This is the next big frontier in genetics."

With $1 million in funding from the Connaught Global Challenge Program, Andrews will lead a team intent on developing rules for understanding genomes. The funding, she says, will go primarily to bridging the gap between biomedical researchers and computer scientists.

"We are trying to bring together people who do human genetics and generate all these wonderful data with people who are trying to understand the rules using simpler experimental systems like yeast, worms and flies."

Specifically, most of the Connaught funding will be used to recruit postdoctoral fellows with expertise in computer science.

"They will try to think of ways we can take what we are doing in model organisms and apply it to all these reams of disease gene information we've got in human genetics. There's been very little cross fertilization between these fields and we think if we can fix this problem, it will really accelerate our progress."

This juncture between biomedicine and computer science, Andrews says, is critical. It's also largely unexploited because traditional grant-making panels tend to focus more narrowly on a single field.

"We biomedical people can apply and get money to do our projects, and the computational people can apply and get money to do what they do. But the interface is difficult to fund."

Andrews's goal for the two-year project is new protocol for understanding genomes that will be made freely available to the scientific community.

Understanding an individual's genome, of course, has potentially huge implications for the field of personalized medicine. Imagine a future in which your doctor can tell which diseases you're likely to get and help you head them off. Or, just as important, know in advance how medications will interact with your genome before you take them.

Says Andrews: "We think it could be transformative."

PHOTO: JOHN HRYNIUK

Inflammatory bowel disease, diabetes, MS

Why are children of South Asian immigrants so susceptible? *by Paul Fraumeni*

Jennifer Gommerman and Ken Croitoru are onto something.

This is what they know:

- One of the largest immigrant groups that have come to Canada in the past 50 years has been from South Asia – Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.
- Incidence of chronic inflammatory diseases (CID) – inflammatory bowel disease (IBD), types 1 and 2 diabetes and multiple sclerosis (MS) – is low in South Asians, but in the children of South Asian immigrants to Canada, incidence has approached that of the Canadian population.

Why? Right now, that is a mystery.

With $1 million from the Connaught Global Challenge Award Program, Gommerman and Croitoru are leading a multidisciplinary team of 23 researchers to solve the mystery through a project called GEMINI – where they will explore "generational differences in environmental exposures caused by human migration: impact on incidence of inflammatory disease."

Gommerman is an associate professor in U of T's Department of Immunology, renowned for its expertise in the study of how the immune system functions. Croitoru is a professor in the Department of Medicine at U of T and a clinician-scientist at Mount Sinai Hospital. He specializes in IBD. Mount Sinai is, in fact, a global leader in IBD research and treatment.

They – and others – began to notice the high incidence of CID in the offspring of South Asian immigrants initially through anecdotal evidence. "For example, there was a report from Vancouver of second generation South Asian children getting aggressive IBD," says Gommerman. "Clinicians in Toronto were seeing the same."

Gommerman and Croitoru gained more tangible evidence by working with the Institute for Clinical Evaluative Sciences (ICES). Scientists there tapped into public health data and blended it with immigration and other data.

"The ICES analysts found the rate of IBD for someone who had migrated from South Asia was lower than the Canadian population," says Gommerman. "But when they looked at the immigrants' children, that rate of IBD approached that of the general Canadian population. That's a significant jump in just one generation. It couldn't just be genetics, because that's too short a time for a huge genetic change to come about. It has to be something in the environment."

But she notes that studying how the environment influences disease is tough. "It's hard to figure out where to start. There are so many factors – food, pollution, maternal exposures when the children were in utero. And people's memories can be unreliable. They may not recall if they had chicken pox or not know if they were breast fed."

The big plus, however, is an explosion in research around the microbiome, which is known to be sensitive to the environment.

The microbiome is the collection of trillions of microorganisms that live in and on humans. These microbes perform beneficial functions, such as helping us to digest food or fighting disease-causing bacteria. Since chronic inflammatory diseases are driven through a dysregulation of the immune system, the GEMINI hypothesis is that the microbiome of the children of South Asian immigrants is changing.

How will they carry out the research?

"The problem is happening before our eyes," says Croitoru. "As this population migrates and has children in a new environment, we can observe closely, take samples and then analyze that evidence in the context of the new environmental exposures."

He adds that there is already evidence of a north-south gradient in the incidence of IBD, MS and diabetes. "People come here or to other northern latitude countries and their kids get really sick. IBD, diabetes and MS have high rates of incidence in northern countries. Maybe it's Western-style fast food. Or maybe vitamin D has something to do with it. There are many possible factors."

Gommerman feels these factors are important and intriguing but that focusing on the microbiome provides a platform to create a comprehensive picture. "We will recruit first and second generation U of T students, 100 of each, look at the microbiome and immune response to the microbiome, their diets and other metabolic parametres and compare. From there, we can see if we can come up with a signature that differentiates the first from the second generation."

As difficult as the problem will be to solve, both Gommerman and Croitoru emphasize this is a major health challenge that needs to be addressed urgently.

"Migration makes Canada tick," says Gommerman. "We need to understand the health implications of transplanting people from radically different environments into Canada's. And what we discover will be a window into the mechanisms behind these diseases."

Croitoru, from his clinical perspective, notes that this problem is connected to the fact that many North Americans will live longer lives than previous generations. "Inflammatory diseases last through your life. That creates a heavy burden on people with these conditions as they age. Our government and the people who pay for health care are going to have to take notice. This is a huge issue of money and quality of life. Understanding it through research is the only way to get a handle on it."

EXPLORING THE BIG ISSUES

The Connaught Global Challenge Award was created to enable U of T to apply more investigation and innovation to the big issues that face global society.

FOR 2014-2015, TWO PROJECTS HAVE BEEN AWARDED $1 MILLION EACH

PHOTO: ROB WAYMEN

A light bulb moment

Zheng-Hong Lu searches for affordable, efficient, energy-friendly lighting in the form of organic LEDs *by Laurie Stephens*

There's a revolution happening in the world of lighting, and Professor Zheng-Hong Lu's research into organic LEDs is leading the charge.

The award-winning researcher from the Department of Materials Science and Engineering is delving into the centuries-old puzzle of energy efficiency: how to provide high-quality light for a wide array of uses at an affordable cost.

Organic light-emitting diodes, or OLEDs, are one of the latest breakthroughs in energy-efficient lighting that will alter the way we light our homes and cities in the future.

"OLEDs are very light, bendable and environmentally friendly — they are relatively safe to dispose of," says Lu, the Canada Research Chair in Organic Optoelectronics and recent recipient of the University of Toronto's 2013 Connaught Innovation Award.

Energy efficiency has driven innovation in the lighting world since Thomas Edison patented his incandescent light bulb in 1879. In the late 20th century, energy crises led to the creation of the more efficient compact fluorescent bulb that is still widely used for commercial and residential lighting needs.

LEDs emerged as an alternative, albeit with some bugs to be worked out. The early models were only as efficient as incandescent bulbs, they were costly to produce and the quality of the light they emitted was low.

Recent improvements to efficiency, quality and cost mean LEDs are now seeing widespread use for both commercial and residential purposes. However, they are still too expensive for larger scale applications, like lighting a large room or powering giant digital signage.

"Another major shortcoming of LEDs is their inability to reproduce or render all colors the same way as natural sunlight does, and solar grade lighting does have a positive impact on our physiological system," adds Lu.

OLEDs, the next advance in lighting, differ from LEDs in that the semiconductors used to convert electricity into light are not synthetic single crystals but rather films composed of organic molecules. While this organic component makes them lighter and greener, challenges still exist in translating this technology into widespread use.

"The current application of organic LEDS is for small, portable displays like cellphones," says Lu. "This technology is capable of producing solar grade lighting and can replace incandescent light bulbs (for general lighting), but to do that, you really need to increase the brightness and make it more affordable."

A research breakthrough in Lu's lab involving chlorine appears to have tackled both issues. Two PhD candidates on Lu's research team, Michael Helander and Zhibin Wang, observed that a sheet of indium tin oxide (ITO) — the substance used to make flat-panel displays — became brighter after it was cleaned with a solution containing chlorine.

Further research determined that when ITO is treated with a one-atom-thick layer of chlorine, just two OLEDs need to be stacked to produce bright light rather than several. The simpler design also means that an OLED flat panel display is very thin and flexible — you can actually bend it.

The end result is high brightness at a high efficiency, says Lu, plus a simpler manufacturing process that translates into a more affordable, high-quality lighting solution.

"Right now the major barrier is cost. When cost is down, people can use them everywhere — for signage, displays, anywhere you need a lot of light. Our solutions will make it more affordable."

The breakthrough earned Lu and his research team a $100,000 Connaught Innovation Award.

Lu said the funding has been used to support the work of his PhD students to "mature the technology" and to support ongoing research and commercialization of the technology through a start-up company, called OTI Lumionics.

Lu believes the widespread use of OLEDs for general lighting and digital signage is still five to 10 years away. But he notes that LEDs are already available at retailers like Home Depot and Canadian Tire and it is only a matter of time before OLEDs become a mainstream lighting solution.

"It's coming," says Lu. "It's really going to change the whole lighting technology, and we will be part of that revolution."

Disguising drugs to treat brain cancer

"My life philosophy is that we have to do something good for people," says Shirley Wu *by Sharon Oosthoek*

Pharmacy Professor Shirley X.Y. Wu is developing a nanoparticle Trojan horse that can sneak past one of our brain's most formidable defences — the blood-brain barrier.

Wu is trying to solve a particularly vexing problem in cancer treatment. Many cancers metastasize to the brain, including 40 to 50 per cent of lung cancers and 15 to 25 per cent of breast cancers. But brain tumours remain beyond the reach of most drugs because they can't cross our protective blood-brain barrier.

BRINGING INNOVATION TO THE WORLD

The Connaught Innovation Awards are designed to accelerate the development of promising technology and to promote transfer of U of T research to society. The awards provide early-stage seed funding for projects that aren't far enough along yet to be eligible for traditional incubators.

AMOUNT: UP TO $100,000 PER PROJECT

Wu aims to change that. Not only can her nanoparticle make it through, once on the other side, hidden anti-cancer drugs burst forth to attack cancerous cells while sparing healthy ones.

With the help of a $90,000 Innovation Award from U of T's Connaught Fund, she and her team are putting her drug-carrying nanoparticles through a battery of proof-of-principle tests.

Wu has already successfully engineered nanoparticles containing protein-based anti-cancer drugs. She has tested them in cell models and will soon be testing the nanoparticles' performance in live mice with brain tumours.

Wu will measure how reliably the nanoparticles slip past the blood-brain barrier, how well they target cancerous cells and how much of their encased anti-cancer drugs accumulate.

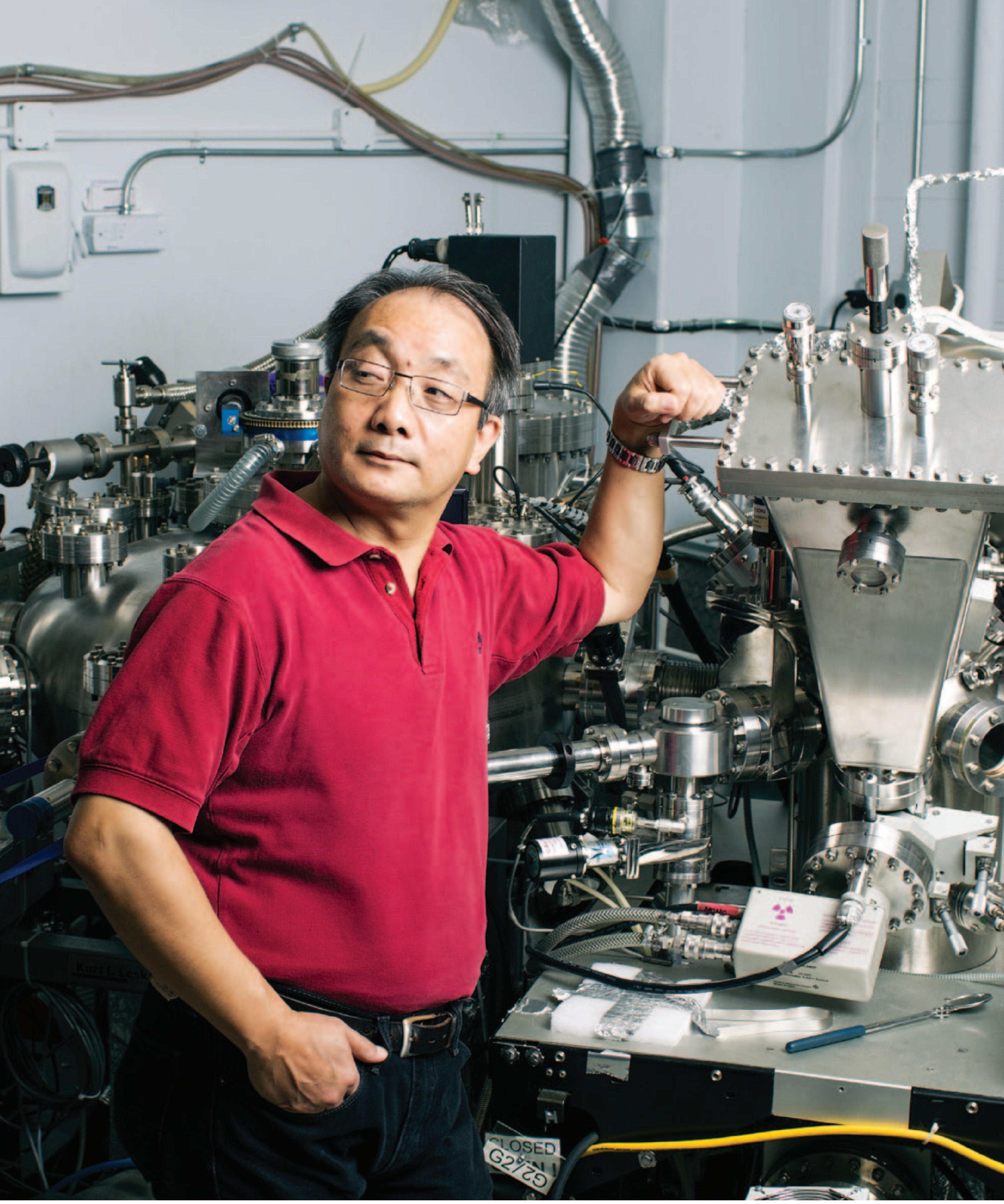
Wu plans to present her results to drug companies with an eye toward getting them to take part in more advanced tests, using their own protein-based drugs. This work would go a step further: measuring whether the combination of her nanoparticles and their drugs actually shrinks brain tumours, and by how much.

"This could be a game-changer," says Wu, who is working with MaRS Innovation to get her nanoparticle to market. "Many of the leading pharmaceutical companies are interested."

There is currently no approved nanoparticle drug delivery system anywhere in the world that is designed to cross the blood-brain barrier. It is, after all, a deliberately tough defence to breach.

The blood-brain barrier is a capillary lining that allows nutrients, such as water, gas, sugar and lipids through to the brain and spinal cord, but not other things such as neurotoxins.

PHOTOS: CHRISTOPHER WAHL



“That makes drug delivery to the brain very challenging,” says Wu. “About 98 per cent of small molecules can’t cross it, and almost no large molecules can cross.”

Protein-based drugs — including some anti-cancer drugs — are large molecules. They are too big to get through.

But their size is no impediment when hidden inside Wu’s carbohydrate-based nanoparticles. That’s partly because the nanoparticles recruit blood components called lipoproteins before approaching receptors on the outer surface of cells forming the blood-brain barrier.

“The receptor then recognizes the nanoparticle as a nutrient, even though it is big,” says Wu. “It’s like the receptor says, ‘I need you, I’ll take you in.’”

While other drug-carrying nanoparticles are being developed in labs around the world, Wu’s system has important advantages. It’s easier to make, less expensive and versatile enough to deliver both multiple drugs and imaging agents, alone or simultaneously.

Before taking on this project, Wu worked on overcoming multi-drug resistant cancers using nanoparticles. But when a colleague with breast cancer later succumbed to a metastasized brain tumour, she switched tracks.

“My life philosophy is that we have to do something good for people,” says Wu. “I have the expertise and resources to help cancer patients so that’s where I chose to do good. We are working hard and at high speed to find solutions for this deadly disease.”

Trapping the light fantastic

The inaugural McLean Award winner has gone on to a distinguished career *by Patchen Barss*

Thirty years ago, many scientists said U of T's Sajeev John was chasing the impossible — that he was asking questions for which the answer was simply "no." But that didn't deter the young physicist from setting out on an expedition to trap one of the most elusive beasts known to humanity: the photon.

Photons, which are elementary particles of light, have no mass and no electrical charge. In a vacuum, they move at nearly 300,000 kilometres per second. Most challenging of all, common, impure materials absorb photons the way a sponge absorbs water.

"You can use mirrors to trap photons for a short period of time, but then they'll escape or get absorbed," says John, who was the inaugural winner of the Connaught McLean Award in 1997. "You have to use materials that just don't absorb light. That was a big part of the challenge."

While John was working out *how* to trap light, he also found himself having to justify *why*. He began with a typical scientist's take that very fundamental questions are worth answering for their own sake.

"Sometimes small questions of science, when investigated thoroughly, lead to extraordinary answers," he says.

But once he succeeded, entrepreneurs quickly took notice. John's light traps — known as photonic crystals — offered an entirely new way to control light. Computer chips operating with laser light. Medical biosensors. Less expensive, more efficient solar panels. Next-generation fibre optics.

"During the telecom bubble, I was getting lots of calls from venture capitalists, but I decided not to take their money at that time," he said. "Today, there are certainly big companies and labs that are pursuing applications."

One application that currently holds John's attention is "Lab on Chip" medical biosensors that can supplant lengthy diagnosis processes.

"You use a thin photonic crystal chip with channels through which a blood sample can flow," he says. "You place certain antibodies along the interior surfaces of the crystal that act as chemically selective 'mousetraps' for biological markers of certain diseases. When the 'mice' attach to the surface, it changes the chip's optical characteristics. You shine a laser beam through that chip and create what we call a 'spectral fingerprint'" of the disease.

Instantaneous diagnosis.

The major challenge: even after more than a decade of research, precise light traps are costly to make.

A photonic crystal is made up of a delicately-sculpted, diamond-like clusters of atoms, which don't absorb light. Light wavelengths are large compared to single atoms, which means scientists must create lattices with billions of atoms in a precise repeating pattern, attuned to the wavelength of the photons they're trying to trap and hold. Every time a photon tries to move in any direction, it instantaneously bounces back on itself. The photon never stops moving, but never gets anywhere.

"It is quite doable for well-funded research labs and companies, but it's still expensive and requires specialized equipment to make high quality crystals," John says.

Since John first started exploring them in the 1980s, photonic crystals have continued a slow but steady march toward commercial applications. Meanwhile, the academic world has been solidly behind John's "small question with extraordinary results."

John won the Connaught McLean Award a decade after he published his first major papers on photonic crystals. Even though the value of his research was established by then, he says the award still gave him a major motivational boost.

"The McLean Award was one of the first awards I ever received," he says. "That certainly had a personal impact in terms of pure encouragement. And of course, it allowed me to expand my research group."

INVESTING IN TOMORROW'S BASIC RESEARCH LEADERS

Big breakthroughs in research can't be achieved until the fundamentals are understood. This is called "basic" research. Created from a gift from alumnus and benefactor William F. McLean, and matched by Connaught funds, the McLean Award supports an emerging leader conducting basic research in physics, chemistry, computer science, mathematics, engineering sciences or the theory and methods of statistics.

AMOUNT: $100,000

PHOTO: ROB WAYMEN

Understanding the Arctic

The Connaught Summer Institute brings experts and students together to look at the big picture behind climate change *by Sarah McDonald*

For many people, the words "summer school" conjure up a feeling of dread. Not so the 42 students who attended the Connaught Summer Institute in Arctic Science: Atmosphere, Cryosphere and Climate in July 2014.

The institute brought together experts and students in the fields of physics, chemistry, earth sciences, geography, environmental science and related areas for an intensive week of lectures, discussions, activities and a career panel in an attempt to give students a greater understanding of what is happening in the Arctic both within and outside their particular areas of study.

"The goal was to bring people together to talk about current issues in Arctic science with a focus on climate, trying to give students the big picture. We wanted to provide them with a broad overview that gave greater context to their own research. So we invited instructors whose expertise covered quite a range of topics," explains physics professor and Summer Institute organizer, Kimberly Strong.

"The climate is inherently a very interdisciplinary topic. It involves the atmosphere, the cryosphere, the biosphere, the oceans and interactions between all of these. In order to understand the whole system, you have to understand how those things fit together." PhD student and Summer Institute participant Joseph Mendonca agrees. "The overall context is much more interesting because we're stuck in our little world of atmospheric physics. So when we go to the summer school, we get to know what all the other parts are doing as well. It's putting together all the pieces of the puzzle of climate change."

The institute wasn't all science all the time. Students were given a drum dancing lesson by lecturer and Inuit elder David Serkoak and had the opportunity to take part in a Q&A session and career panel with a variety of industry professionals to help inform their job searches and potential career paths.

While the Summer Institute drew students from across North America and Europe, piecing together the big picture of atmosphere, cryosphere and climate in the Arctic should be a high priority for Canadians in particular, Strong says.

Not only does a large portion of the Arctic fall within Canada's borders, but the federal government is keenly focused on it and on the associated issues of sovereignty, natural resources and how communities are adapting and coping with changes and challenges.

"As scientists, we're interested in knowing what's happening in the Arctic and why, and if we're not doing measurements and working out what they mean, then it will be other countries that tell us what's happening in our own territory," she says. "There's scientific curiosity, because it's a fascinating place, but there are also practical reasons for making sure that we know what's going on in our own backyard and are able to deal with challenges as they arise. Is the Northwest Passage going to open up? How is the Arctic changing in a changing climate? What kind of changes are going on? If we're not there, we're not going to know. The Summer Institute provided a forum for discussing the many climate-related questions, challenges and opportunities facing the Arctic."

NETWORKING & THE NEXT GENERATION

The Connaught Summer Institute brings together Canadian and international graduate students, postdoctoral fellows and faculty to learn from top scholars in order to foster interdisciplinary collaboration and creative new research methods.

AMOUNT: UP TO $150,000 OVER 3 YEARS

DOCTORAL STUDENT SUPPORT

The Connaught International Scholarship for Doctoral Students helps U of T recruit and support 20 top international graduate students each year.

VALUE: $35,000 PER YEAR PER STUDENT

Connaught's next generation

How will the forest fare in a changing climate? What did ancient scholars think about heaven? Connaught doctoral scholars are tomorrow's research leaders *by Jenny Hall*

Md. Abdul Halim, Faculty of Forestry
Boreal forest is the world's largest biome, and it is essential in cushioning the effects of global climate change. Halim is focused on understanding the microclimate effects of logging and fire on the boreal forest in Canada. In other words, what happens when fire and human intervention open up the forest canopy? He has set up a series of meteorological towers in the forest north of the Lake Nipigon region. Sensors collect data including solar radiation, air temperature and soil moisture, and observations will be combined with field data and information from satellite images to deepen our understanding of the fate of the forest that has been so central to Canada's natural environment. The goal is more sustainable management practices for the boreal forest in light of climate change.

Amy Marie Fisher, Department for the Study of Religion
What is heaven like? A perennial question, and one that has been contemplated for millennia. Just as we do today, ancient thinkers disagreed about the celestial details. In fact, no two narratives of early Judaism and Christianity agree. While the concept of heaven existed in the early Second Temple period (520 BCE – 70 CE), this era saw an explosion of texts dealing with the geography and topography of the heavens. Yet no scholar has ever undertaken a comprehensive study of the development of these heavens in the period. Fisher's scholarship will fill this gap as she charts broad shifts in the ways heaven was depicted and considers how terrestrial events influenced these depictions.

PHOTO: ROB WAYMEN