

VISION

A LOOK INSIDE THE DONALD K. JOHNSON EYE INSTITUTE

Dennis Graff
uses a virtual
reality headset
for an at-home
eye examination

**Seeing the future
of glaucoma treatment**

Visual field testing in the comfort of home

 **UHN** Toronto General
Toronto Western
Princess Margaret
Toronto Rehab
Michener Institute

WELCOME

Relentless pursuit of breakthroughs in vision

According to the World Health Organization, more than two billion people worldwide are living with a vision impairment or blindness. About 1.5 million people here in Canada are living with sight loss and 5.5 million more have been diagnosed with an eye disease that could lead to sight loss.

While a number of eye diseases are genetic, early intervention can lead to significantly better outcomes and improved quality of life for those living with vision-related illnesses, such as age-related macular degeneration, diabetic retinopathy and glaucoma.

At the Donald K. Johnson Eye Institute at University Health Network (UHN) in Toronto, clinicians and researchers work side by side, pursuing new treatments and cures for vision-related illnesses. There is

significant momentum and exciting discovery already happening here because of the incredible team and infrastructure that have been put together to foster discovery.

Our ophthalmology team is passionate about giving back, providing crucial vision care and support to vulnerable communities, within and outside of Canada's borders.

We're so proud of what we have created here: a world-class team of researchers and clinicians working together to do well by our patients. We have never been more optimistic about the future, when it comes to the potential for new breakthroughs in vision.

To Donald K. Johnson and our wonderful supporters, we thank you for your incredible generosity, which allows us to do what we do every day. It can take years, sometimes decades or longer, to pursue answers that may lead to new treatments. We are grateful for your unwavering commitment to helping us find those answers.

Research into eye diseases has already shown much promise, resulting in new treatments. Our goal is to continue to work relentlessly, discovering new insights to improve the lives of patients. Donor support through our 2020 Vision Campaign is helping to make this possible.



Dr. Robert Devenyi
Co-director,
Donald K. Johnson Eye Institute,
Karen and William Barnett Chair in Ophthalmology



Dr. Valerie Wallace
Co-director,
Donald K. Johnson Eye Institute,
Donald K. Johnson Chair in Vision Research

VISION: A LOOK INSIDE THE DONALD K. JOHNSON EYE INSTITUTE

EDITOR: Shelley White

ART DIRECTOR: Kamille Chin

DESIGNER: Frank Perito

PHOTOGRAPHY: Tim Fraser

CONTRIBUTORS: Chris Atchison, Jennifer D. Foster, Jordana Feldman, Mirjam Guesgen, Diane Peters, Anna Sharratt, Kira Vermond

GLOBE CONTENT STUDIO

MANAGING DIRECTOR: Tracy Day

HEAD OF GLOBE CONTENT STUDIO: Sean Stanleigh

DEPUTY HEAD OF GLOBE CONTENT STUDIO: Katherine Scarrow

PROJECT DELIVERY MANAGER: Linda Hoefler

DIRECTOR PRODUCTION, THE GLOBE AND MAIL: Sally Pirri

PRODUCTION CO-ORDINATOR, THE GLOBE AND MAIL: Isabelle Cabral

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Did you know?

People with vision loss are:

3x more likely to experience depression

6x more likely to risk falls

4x more likely to have a hip fracture

More than **5.5 million Canadians** live with eye diseases, such as glaucoma, retinopathy and cataracts
This number will double over the next 20 years

For **69%** of Canadians, vision loss is the most feared disability

More than **75%** of vision loss is preventable or treatable

Every **12 minutes** a Canadian is diagnosed with a visual impairment

Vision loss costs Canada **\$19 billion per year**

the highest direct health-care costs of any disease

That number will reach **\$30 billion** by 2030

A viral video with real-world impact

In the early days of the COVID-19 pandemic, the ophthalmology community had one pressing question: How can we keep everyone safe, when our practice involves such close contact?

"In ophthalmology, we can't really maintain any distance from patients because our exams are right in front of their faces," explains Dr. Efrem Mandelcorn, a retinal surgeon and clinician investigator at the Donald K. Johnson Eye Institute's Retina Clinic and Sprott Department of Surgery at UHN.

To determine how to lessen viral exposure, Dr. Mandelcorn and a team of his colleagues created a series of experiments that quickly had significant, real-world impact.

The team placed a small latex balloon filled with compressed oxygen and fluorescent dye inside a mannequin's oral cavity. The unmasked mannequin was placed in the patient's position in front of a slit-lamp, the instrument routinely used during eye

examinations. A live examiner donned personal protective equipment and took their place opposite the mannequin. When the balloon burst, it simulated a cough from a patient by ejecting dye droplets. The spray, picked up under ultraviolet light, covered the examiner's upper body and equipment.

However, when the mannequin wore various types of masks, including cloth, surgical and N95 varieties, the spread either decreased or disappeared entirely. Findings suggested that wearing a well-fitting cloth mask properly is more effective than wearing a surgical mask incorrectly. And N95 masks are the most effective of all.

Although Dr. Mandelcorn is no stranger to publishing innovative retina research, the reaction to this COVID-19-inspired paper caught him by surprise. The video he posted of the experiments has been watched more than 80,000 times.

"In my little world," he says, "it went viral, pardon the pun."

By Kira Vermond



This mannequin's oral cavity was fitted with a latex balloon filled with compressed oxygen and dye to simulate a patient's cough during an eye examination



For more than 30 years, Dr. Allan Slomovic has shared his expertise with residents and fellows from around the world

A world of good

In January 2020, Dr. Allan Slomovic and a team of six eye specialists from Canada arrived at La Anexión Hospital in Nicoya, Costa Rica, ready to work with local doctors. The week ahead would be intense. More than 80 people – some nearing 100 years old – needed care for corneal disease and cataracts, with some issues requiring corneal transplants and stem cell treatment.

In addition to performing the procedures, Dr. Slomovic would be doing morning teaching rounds each day, a boon for the hospital's residents. An ophthalmologist, Owen & Marta Boris Chair in Stem Cell Vision Research, research director of the Cornea/External Disease Service and director of the Ocular Stem Cell Transplantation Program at UHN's Donald K. Johnson Eye Institute, Dr.

Slomovic is an internationally recognized leader in the field. Over the years, he has trained scores of residents and fellows from across the globe, including the U.S., Israel, Australia, Thailand and Saudi Arabia.

So perhaps it wasn't surprising that when the team arrived, a welcome banner hung above the door that displayed maps of Costa Rica and Canada.

"It's about building good will and good feelings with people from all around the world," says Dr. Slomovic of UHN's ongoing outreach initiatives.

But the global connectivity doesn't end when Dr. Slomovic heads back to Toronto. As an expert in corneal and external disease treatment, he and ophthalmologist Dr. David Rootman lead a group of six fellows from around the world.

Dr. Nizar Din, who arrived at the Donald K. Johnson Eye Institute from London, U.K., in early summer 2020, says he was fortunate to land one of the coveted two-year fellowships, which many consider the most comprehensive in the world. Dr. Slomovic's impact also goes beyond medicine, Dr. Din adds.

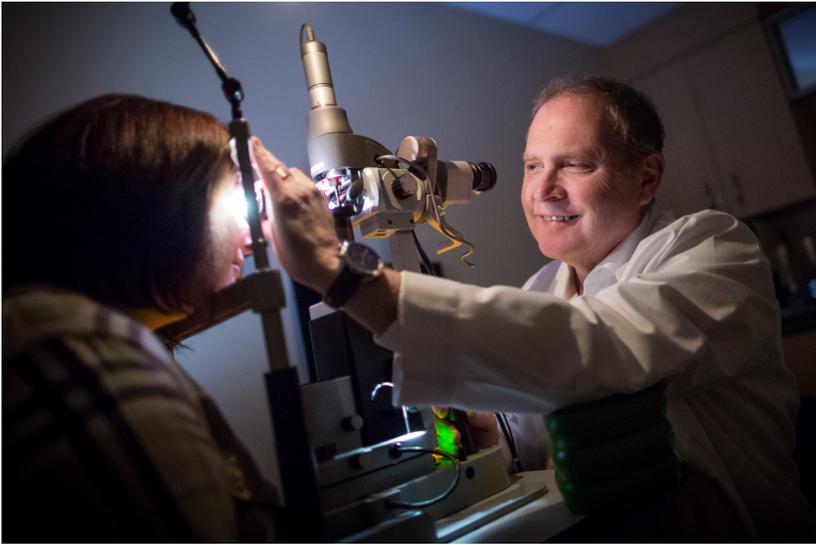
"Dr. Slomovic has a very rare personality," he says. "He has a very genuine and caring heart. He wants you to do well. Not just as a supervisor, but as a human being."

This past year, Dr. Slomovic and fellow University of Toronto faculty members provided free eye exams and treatment at a weekend clinic for more than 100 Syrian refugees. His wife and daughter – who is currently in medical school – also helped out, taking histories and directing patients. People received much-needed care for cataracts, glaucoma and even an undiagnosed tumour.

Dr. Slomovic says he grew up in a family with a strong culture of charitable work, in gratitude for one's own success and good fortune.

"We are so blessed," he says. "It's really important to give back."

By Kira Vermond



Dr. Michael Brent says that a rigorous screening program could help prevent vision loss in vulnerable populations

camera is used to take images of their retinas. These images are uploaded to a secure server and Dr. Brent accesses the information remotely. He then grades the images for the level of eye disease and makes recommendations, which could range from scheduling their next eye screening exam, to an office visit, all the way to the need for surgery.

To date, almost 10 per cent of people screened through mobile units have required specialized retinal care, Dr. Brent says.

“The program is definitely reaching the right demographic and helping to prevent vision loss in vulnerable communities,” he says.

The ultimate goal is to have a program in every province and territory, connected through a common database.

“With a rigorous screening program, diabetic retinopathy could be removed from the top of the list of causes for severe vision loss and blindness.”

By Kira Vermond

Heading off diabetic retinopathy

Diabetic retinopathy is the leading cause of severe vision loss and blindness in working-age Canadians. Yet in Ontario, close to 40 per cent of people living with diabetes have not had their annual screening eye exam in two years, despite the fact that early intervention can prevent it.

Dr. Michael Brent, retinal specialist, Milton Harris Chair in Adult Macular Degeneration and principal investigator for Diabetes Action Canada’s retinopathy screening program with the Donald K. Johnson Eye Institute, is harnessing new technologies to get screening out

into communities where diabetic retinopathy screening rates are low.

Mobile units visit inner city and remote Indigenous communities. People who choose to be screened have their vision and eye pressure checked, and a special digital

Toward vision care for all

Imagine waking with eye pain, blurred vision and redness. Yet despite the discomfort, visiting an ophthalmologist or optometrist is out of the question because you can’t afford to take time off or even pay for parking.

For those who struggle to

make ends meet, routine eye care may seem out of reach. The Donald K. Johnson Eye Institute’s Dr. Ya-Ping Jin, a researcher with expertise in epidemiology, biostatistics and medicine, along with a team of UHN scientists, is uncovering how deep the problem goes – while laying the

foundation for accessible, data-based eye care.

“In Canada, vision care is part of a publicly funded health-care system. However, for those aged 20 to 64, routine eye visits are not funded by any province,” says Dr. Jin. “This barrier likely contributes to our studies, which find socioeconomic status influences access to eye care.”

For example, Dr. Jin and her team identified that the removal of routine eye-care services from provincial insurance in 2004 has meant that socially disadvantaged adults aren’t always getting the vision care they need to avoid treatable sight loss, such as the blindness caused by glaucoma.

In another study, Dr. Jin showed that children receiving care for amblyopia, colloquially known as “lazy eye,” at Toronto’s SickKids were more likely to come from wealthier neighbourhoods. Parents with well-paying jobs and benefits encounter fewer barriers to attending multiple appointments.

There are ways to combat these challenges though, Dr. Jin says. For example, she recommends targeting low-income neighbourhoods for glaucoma education and treatment.

“I’m interested in health policy and the impact this has on people’s lives,” she says.

By Kira Vermond



Dr. Ya-Ping Jin urges policy-makers to examine how their decisions can better serve all members of society

Vision testing in the comfort of home

A UHN-led portable testing tool is providing doctors with a better way to track the progression of glaucoma

By Mirjam Guesgen



MORE CONVENIENT

Dennis Graff says that in-home visual field tests are a vast improvement over doing them at the hospital

Every Saturday morning, Dennis Graff makes himself comfortable in his favourite lounge chair and dons a headset. Although it might look like he's getting ready for a video-gaming session, the 75-year-old Toronto resident is actually testing his vision.

Graff, who previously had surgery to treat both glaucoma and cataracts, is part of a two-year-long study testing the latest tool in eye disease-monitoring technology.

"I'm game to help with something that might help others," he says.

The system, which consists of a smartphone, a virtual reality headset, a remote clicker and advanced control and analysis software, is the brainchild of Donald K. Johnson Eye Institute scientist Professor Moshe Eizenman. Institute ophthalmologists Drs. Graham Trope and Yvonne Buys assist Prof. Eizenman with patient assessments.

Together, the trio is developing new and better ways to track the progression of the eye disease glaucoma. The innovative tool, called the Toronto Portable Perimeter, or TPP, offers a way for patients in remote parts of Canada, or under-resourced countries around the world, to get access to high-quality vision care.

IMPROVING ON AN IMPERFECT PROCESS

Glaucoma is a disease characterized by the degeneration of the optic nerve connecting the eye to the brain. It progresses slowly, with few symptoms. The best way doctors currently have to track its progression is to ask patients to come to the hospital twice a year for visual field tests. The patient sits in front of a large machine, keeps their eye looking straight ahead and watches lights appearing in their peripheral vision. The patient pushes a button when they see the flashes.

"Patients dislike doing visual field tests. It's one of the most stressful parts of coming to the eye doctor," says Dr. Trope. "It's physiologically unnatural, and a number of patients simply don't do the test well."

Graff says doing the visual field test in the comfort of his own home is a vast improvement over doing them at the hospital.

"The at-home test is just more convenient. I find it more relaxing, too" explains Graff, who has the weekly event marked on his calendar and who has become a bit of a pro when it comes to doing the test at home. "It's very simple."

The TPP system offers more than just convenience. Because the standard, in-office test requires specialized training to administer, there's a cap on the number of patients a hospital can see in a week. That means patients will only have their vision tested twice a year, in many cases, and it's difficult to spot if a person's visual field is deteriorating.

"The evidence indicates that we are missing progression," notes Dr. Trope.

The TPP allows patients to do the same

test at home, when they want and more often throughout the year. The results of the test are analyzed and sent wirelessly for assessment. It saves patients time, saves money (the TPP is about 40 times cheaper than the standard device) and could allow clinicians to track the disease more efficiently.

So far, the doctors say the results of the study are promising. When the TPP was tested on 150 eyes, it performed just as well as the standard visual field test in terms of measuring how far, and how well, a person can see into their periphery. The TPP was also the clear preference for patients in terms of comfort and ease of use.

BETTER ACCESS IN MORE PLACES

Lower cost and portability make the TPP perfect for glaucoma screening in remote parts of Canada, where patients might have to travel hours to a hospital. It's also beneficial for under-resourced countries, where patients do not have easy access to hospitals and expensive visual field testing devices.

In 2019, the TPP was sent to northern Ontario, travelling as far as Pickle Lake on-board the CNIB Foundation Eye Van, to screen people in remote communities for glaucoma. The device is also being tested in Singapore and Nepal as a screening tool for the early stages of glaucoma.

The TPP has the potential to make a huge impact in developing countries like Nepal, says Prof. Eizenman, because of how frequently glaucoma progresses to blindness through lack of available testing.

"If you detect the disease early and track it, you can manage it," he says.

The team has high ambitions for the device, which they say is part of a bigger move to bring health care out of hospitals and into people's homes.

"It really could revolutionize the way visual fields are performed," says Dr. Trope. ▽

A NEW WAY TO TRACK GLAUCOMA

With the Toronto Portable Perimeter, Dr. Graham Trope (left) and Prof. Moshe Eizenman hope to increase access to visual field testing



Stopping glaucoma in its tracks

Researchers have discovered a molecule that could prevent or even reverse glaucoma damage. It's a breakthrough that may someday treat devastating brain diseases too

By Mirjam Guesgen

MOLECULES THAT PROTECT

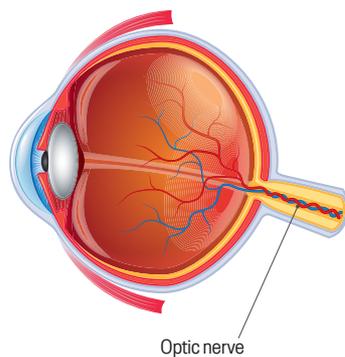
Dr. Jeremy Sivak calls neuroprotection an "ultimate goal for glaucoma treatment"

When scientist Dr. Jeremy Sivak describes how delicate the optic nerve is, he points to a foam model of the eye that he uses for teaching. The place where the thin thread of foam representing the optic nerve should be is now damaged and torn – worn away by bringing the model out during lectures.

"It's easy to see how it's a mechanically weak spot," says Dr. Sivak, who is a senior scientist at the Donald K. Johnson Eye Institute.

That collection of fibres may be tenuous, but it's also crucial to our vision. The optic nerve sends information collected by our eyes to the brain to be translated into sight. Optic nerve damage – a key characteristic of the eye disease glaucoma – can cause blindness when the connection between information gatherer and interpreter is disrupted.

It's estimated that more than



**78 MILLION
PEOPLE
ARE LIVING
WITH
GLAUCOMA
WORLDWIDE**

400,000 Canadians live with glaucoma. That number may be much higher, since the disease comes on slowly, and people may not realize they have it until major damage has already been done.

But because the disease progresses slowly for most patients, there is a chance for doctors to stop it in its tracks. Neuroprotection, or shielding the optic nerve from damage, offers a way to do just that.

Dr. Sivak and his team, along with collaborators, have discovered a molecule that could protect the delicate optic nerve, thus sparing people from gruelling surgeries or, in the worst-case scenario, a life without sight.

"Neuroprotection is kind of an ultimate goal for glaucoma treatment," says Dr. Sivak, who also holds the Chair in Glaucoma Research at UHN.

In addition to preventing the disease from getting worse, it might even be possible to reverse the damage that's been done, says Donald K. Johnson Eye Institute clinical fellow Dr. David Mathew, who's researching neuroprotection with Dr. Sivak.

"Right now, we have no proven way to definitively reverse the damage. All treatments are aimed at stopping or slowing down the disease progression," he says. "That would be a big boon to our patients."

Dr. Sivak's team is studying lipoxins – molecules that in other contexts help reduce inflammation brought on by injury. Other researchers have studied what lipoxins do in various places in the body, but never before in nerve cells of the brain or eye. Dr. Sivak's group found that these molecules play a very different role in brain cells, directly protecting neurons from damage.

The team made the discovery when they noticed that in diseased eyes, the naturally occurring amount of lipoxins (called LXA4 and LXB4) was lower than in healthy eyes. But when the team restored lipoxin levels, they restored the molecules' protective function so they could rescue the neurons from further damage.

Potential therapies could include stimulating the body to make more lipoxins, or delivering the molecules by injection to where they're needed.

"What has become an important quest for us is to map how LXA4 and LXB4 work and what makes them so effective as neuroprotective factors," says Dr. Sivak. "If we can understand that, not only is it interesting new biology, but it also may give us ways to target the pathway that might be clinically feasible."

The work being done by Drs. Sivak and Mathew could resonate far beyond eye disease. Neuroprotection could potentially help treat or slow the progression of other diseases where related neuron damage occurs, such as Alzheimer's or Parkinson's.

Dr. Sivak says they've seen the same kind of protective activity from lipoxins on cells from parts of the

brain such as the hippocampus, which is involved in the formation of new memories, and the substantia nigra, which helps co-ordinate movement.

If the link between low amounts of lipoxins and neuron loss can be proven, a lipoxin-boosting treatment for glaucoma could eventually be tailored to treat neurodegenerative diseases. "We're very interested in trying to pioneer that field," says Dr. Sivak.

While the possibility of breakthroughs in the neurodegenerative realm is undoubtedly exciting, Drs. Sivak and Mathew say that their first goal is to find a solution for those with glaucoma.

"Vision is so important to our quality of life and increasingly so in our virtually connected world," says Dr. Sivak.

Dr. Mathew hopes the pair can work together to bring their findings from the lab to their patients, and the millions of people struggling with glaucoma around the world.

"I have seen a lot of patients eventually go blind from glaucoma, so I know first-hand how valuable a neuroprotective strategy would be," he says. ▽

Easing the pressure

One of the biggest risk factors for developing glaucoma is high eye pressure. This pressure puts strain on the optic nerve, which eventually becomes irreversibly damaged. In a healthy eye, the fluid that keeps your eye nourished drains out, but when this drainage system isn't functioning properly, pressure can build up.

One way doctors can relieve some of that pressure is by creating an entirely new drainage channel. In the past, that meant intense, invasive eye surgery. Now, ophthalmologists can implant tiny tubes or micro stents into the eye using instruments the size of tweezers. This process, called fluid shunting, involves less tissue manipulation and can lead to shorter recovery times and less chance of complications.

Dr. Matthew Schlenker, an eye surgeon at the Donald K. Johnson Eye Institute and the Sprout Department of Surgery at UHN, explains that fluid shunting is a great option for patients where lasers or topical medications are not enough. It can also be a better fit for patients who find taking topical medications too taxing.

"Patients may have three or even four different drops they have to put in their eyes up to three times a day," he says. "I had one patient tell me it's like a full-time job."

With one fluid-shunting device, 77 per cent of patients saw their eye pressure go back to safe levels without the need for medications, Dr. Schlenker says. This device is not yet approved in Canada, though it has been used under the Health Canada Special Access Program with promising results.

Dr. Schlenker sees great promise for glaucoma patients with devices like this.

"It's an area of need, and an area where we're on the cusp of something so much better," he says.



Eye surgeon Dr. Matthew Schlenker



NEW HOPE FOR PATIENTS

Dr. David Mathew says it may even be possible to reverse the damage caused by glaucoma

From discovery to drug development on home turf

She did the basic science, now he's helping to turn her findings into a drug. Drs. Valerie Wallace and Mark Reed embody the spirit of true scientific collaboration, right here in Toronto

By Diane Peters

What if there were a protein that could influence eye development, slow the growth of brain tumours and allow doctors to get medications more directly to the brain?

After years of trial and error in her lab, Dr. Valerie Wallace has made a series of important discoveries about Norrin, a protein involved in neurological signalling for the eye, brain and ear. Now, she's leading the world in research on this protein that could hold the key to a range of vision-preserving and life-saving applications.

Discoveries of this sort require a willingness to keep asking questions, notes Dr. Wallace, co-director of the Donald K. Johnson Eye Institute at UHN and the Donald K.

Johnson Chair in Vision Research. "Sometimes you need to be wrong in order to be right," says Dr. Wallace. "I'm often surprised, I tell my lab. I'm very curious by nature."

Until recently, it would have been up to other researchers or pharmaceutical companies to build on Dr. Wallace's ideas and make products for market, such as medications.

Not any longer. Dr. Wallace is working with UHN's Krembil Research Institute's Centre for Medicinal Chemistry and Drug Discovery (CMCDD) to find small molecules that target Norrin – the early steps to making a drug. The CMCDD was established in 2018 to help more homegrown discoveries make it to market.



Dr. Wallace and Dr. Mark Reed are working together to make sure the basic science about this protein doesn't get forgotten, or end up a profitable innovation for another organization.

"There's so much excellent research going on at UHN, and some of it never gets translated," says Dr. Reed, a medicinal chemist and scientist who heads up the CMCDD. "We can take some of these new, therapeutic targets and commercialize them right here."

This new process has been a revelation for Dr. Wallace. Always keen to explore other aspects of science, she's excited that Dr. Reed and his team are making it possible.

"I'm not a medicinal chemist. I don't make drugs," she says.

**IT TAKES
12 YEARS
ON AVERAGE
FOR A DRUG
TO GET FROM
INITIAL
RESEARCH
TO MARKET**

“

The more biology and basic research we can do, the better the drug targets we find.

Dr. Valerie Wallace

“

There's so much excellent research going on at UHN, and some of it never gets translated.

Dr. Mark Reed



“I could not do this without Mark and his group.”

TWO DECADES OF INQUIRY

The work on the Norrin protein has grown out of 20 years of basic biology research in Dr. Wallace's lab. She's been looking at how the eye develops, specifically the retina, and her investigations into a certain neural pathway revealed some of Norrin's unique functions.

Dr. Wallace and her team discovered that Norrin has an impact on the growth of the eye, but it also affects tumour growth in the brain. Norrin can make some deadly glioblastoma brain tumours grow more, and in other instances, slow them down. As well, for certain childhood brain tumours, Norrin affects how

hospitable the environment is to tumour growth.

She compares it to how soil in a garden influences how plants flourish. “This was the first time that anyone showed that the soil was really important to how those tumours grow,” she says.

The team also observed that if Norrin was removed, key blood vessels in the brain would open. Dr. Wallace says they've identified a way to use the protein to open and close the blood-brain barrier, which protects the brain but also keeps medicine from getting through.

“This could be useful in the treatment of tumours, but also blood vessel problems in the eye, such as macular degeneration,” says Dr. Wallace.

Having identified the profound effects that the presence – or absence – of Norrin has on blood vessels, brain tumours and the blood-brain barrier, the challenge becomes: How can this powerful protein be harnessed?

ON THE ROAD TO DRUG DEVELOPMENT

When Dr. Reed was hired in 2018 to get the CMCD up and running, his goal was to collaborate with basic scientists at Krembil to find molecular targets from which they could develop new drugs, and offer support for getting those new treatments to market.

Dr. Reed began by knocking on doors, including Dr. Wallace's. He was impressed by what she

had already discovered about Norrin.

“This pathway she's shown has several applications,” says Dr. Reed, who has extensive experience in drug discovery and development, including working at startups, biotech and pharma companies.

As his team works to make Dr. Wallace's discoveries “druggable,” they will collaborate and share what they learn with her group.

“We're going to work together very closely,” says Dr. Reed. “They are involved at every single step.”

That appeals to Dr. Wallace, who knows she can play a vital role in the process. “Drugs fail because their mechanism of action is not well understood,” she notes. “The more biology and basic research we can do, [the better] the drug targets we find.”

In order to develop a drug to impact Norrin, the team needs to find a molecule that will either inhibit it, or boost it. With that molecule and a patent in hand, they can start raising money to fund more testing and even early-stage clinical trials. From there, they could create a spinoff company that can take new drugs right to market.

Dr. Reed admits this journey could take years and cost millions, but it is what's needed to create a vibrant, local biomedical economy. Donor support has been a critical part of the journey so far.

“It's exciting to think about what we can grow right here in Toronto,” he says. ▽



It's like a light switch that's gone on.

Ken Moscoe on how biofeedback therapy changed his daughter Nicole's life

Bringing life into focus

The team at UHN's Low Vision Rehabilitation Program is using novel approaches to help the brain see the world more clearly. It's a game-changer for patients like Nicole Moscoe

By Anna Sharratt



Nicole Moscoe first noticed in kindergarten that something was wrong with her eyes. Even when squinting, she could not make out the white letters the teacher wrote on the blackboard.

It soon became clear to Nicole's father Ken that there was a lot more his daughter couldn't see: the lettering on street signs or in grocery stores, or the details in video games. When she began using a computer, Nicole had to memorize the keyboard because the white letters and numbers were a blur.

Like most parents, Ken assumed Nicole's vision problem could be fixed with a corrective device. But after visiting optometrists, then specialists, and getting glasses for Nicole, the Moscoes realized there was no quick fix. She had idiopathic foveal hypoplasia, a condition where there is a malformation of a depression in the retina called the fovea that is responsible for clear, sharp vision. Ken says doctors were not optimistic about the possibility of treatment.

"Everyone was stumped. And it really affected the quality of her life," he says of Nicole, now 12. "We were actually exploring options outside of Canada to treat this."

Feeling discouraged, Ken heard about the innovative approaches being pioneered by Dr. Monica Daibert-Nido and the team at the Donald K. Johnson Eye Institute's Low Vision Rehabilitation Program. Nicole's doctors at Toronto's SickKids referred the family to the program.

After assessing Nicole, Dr. Daibert-Nido recommended biofeedback, a revolutionary treatment that employs visual imagery to retrain the brain into using parts of the eye that are undamaged or less damaged.

"Biofeedback is a technique where patients learn to use their remaining vision," says Dr. Daibert-Nido, clinician scientist at the Donald K. Johnson Eye Institute.

The process is relatively simple: patients look into a device called a microperimeter that projects a target that they need to follow with their eyes. A member of the team then tweaks the target to ensure that areas of the eye that were formerly unused become active. "The brain will train ocular muscles to focus on that spot," says Dr. Daibert-Nido.

The whole concept is built upon the concept of neuroplasticity – the idea that the brain can "reset," regardless of the age of the patient, says Dr. Samuel Markowitz, a clinician investigator at UHN's Donald K. Johnson Eye Institute.

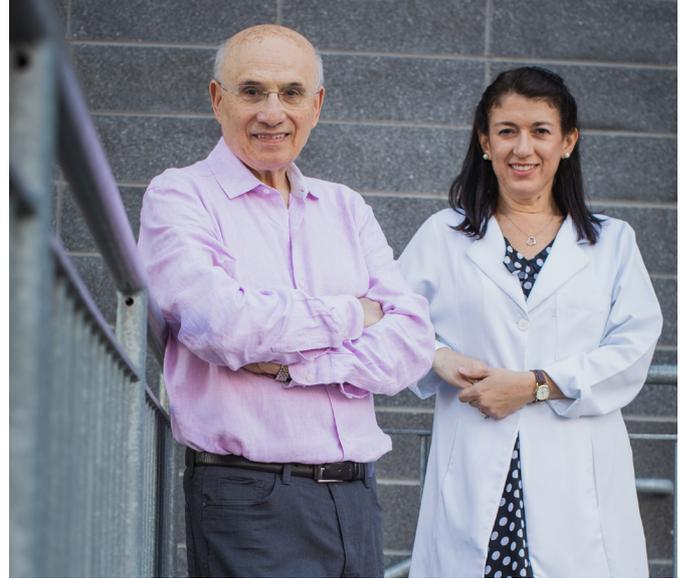
"This is teaching the brain to work better with whatever residual vision patients have," he says. After biofeedback, the brain remembers how to use the undamaged parts of the eye and patients end up with better vision. They are usually able to read one to three lines better on an eye chart than they did before, says Dr. Markowitz.

In addition to conditions such as Nicole's, this transformative technique can help improve sight in patients with macular degeneration who are rapidly losing vision. Dr. Markowitz says for many patients, the biofeedback provides them with enough vision that they can resume activities they formerly enjoyed – and it gives them their freedom back.

"Many of them say, 'I can take the bus now,'" he says.

"It really affects their quality of life: their reading speed, orientation, mobility and learning," adds Dr. Daibert-Nido.

Nicole underwent five sessions of biofeedback, for 20



minutes once a week. She saw improvement right away.

Ken recalls his daughter exclaiming: "Daddy – you won't believe it! I can see the numbers on the wall!" She can now see the signs that she formerly couldn't read.

"Nicole's vision has improved significantly in terms of distance, small print and contrast, and glasses have gone from trifocals to single lens," says Ken.

"It's like a light switch that's gone on. It's pretty amazing."

In addition to treating patients with biofeedback, Drs. Daibert-Nido and Markowitz are also investigating other emerging treatments for low vision. For example, there's photobiomodulation – an innovative treatment that rejuvenates the retina.

With this technique, low-intensity "cold lasers" are applied to the retina, causing photochemical changes at a molecular and cellular level. The light affects the mitochondria – organelles that convert nutrients and oxygen into energy – inside retinal cells. The light allows them to "reignite," improving their sight, says Dr. Markowitz.

The technique was developed at UHN and is currently approved to treat macular degeneration in the EU – with great success. "But it's not yet approved in Canada," he says.

"We proved it really enhances

EYE-OPENING TREATMENTS

From "cold lasers" to artificial vision, Dr. Samuel Markowitz (left) and Dr. Monica Daibert-Nido are investigating several emerging treatments

vision," he says, adding he hopes Health Canada will soon approve the procedure.

The researchers are also exploring artificial vision, which is created with the implantation of a retinal prosthesis. Dr. Markowitz says artificial vision can benefit patients with conditions such as retinitis pigmentosa, a rare genetic disorder that leads to cell loss in the retina and declining vision. There are a number of studies worldwide looking at the effectiveness of different procedures, says Dr. Markowitz.

With so many emerging treatments on the horizon, Drs. Daibert-Nido and Markowitz say their end goal is to find solutions for vision-impaired patients like Nicole, who have been told there is nothing left to help them.

"Mostly, we want to make people aware that there is help today in many cases with vision," says Dr. Markowitz.

"Our aim is always to use remaining vision to find new ways of helping people with low vision live more functional lives." ▽

Follow the bouncing ball

Dr. Michael Reber is harnessing the power of virtual reality to retrain the brains of people with low vision

By Anna Sharratt

Ever since the words “virtual reality” entered our lexicon, humankind has been fascinated with the concept. We imagined visiting far-flung worlds in our very own *Star Trek*-style holodeck, without ever leaving home.

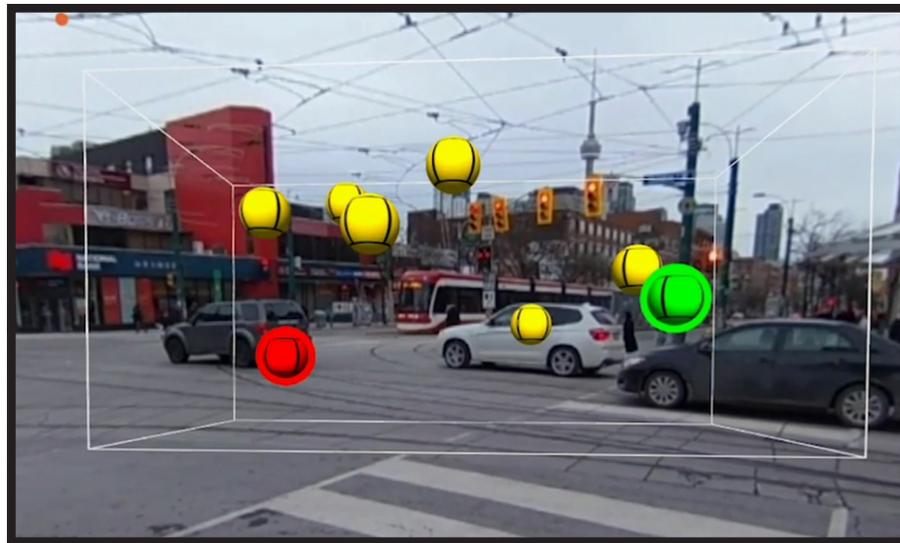
Holodecks haven't come to fruition just yet, but virtual reality, or VR, is being put to very practical use: transforming the lives of people with low vision.

One of the leaders in this cutting-edge area of research is Dr. Michael Reber, senior scientist at the Donald K. Johnson Eye Institute. He's using VR to solve complex vision challenges, enhancing sight for patients of all ages who had virtually given up hope.

At the heart of Dr. Reber's treatment program is the Oculus Go, a device normally marketed to gamers looking for an immersive experience. Here, the headset and a specialized program are used to treat people with peripheral vision loss.

Low vision patients wear the headset and perform visual exercises at home. A series of animated yellow balls move around a realistic environment (such as a city street); the patient follows and identifies the balls when they change colour. The game gets more challenging as the patient progresses.

“With the Oculus Go, you're repeating over and over a variety



A GAME WITH PURPOSE

Using a VR headset, low-vision patients see yellow balls moving around a streetscape

Similar to the concept of a “shell game,” patients need to track the balls that briefly turn colour, then use a pointer to identify them

of visual tasks – following targets with different colours and speeds,” Dr. Reber explains. “You stimulate those brain areas that can compensate for the loss in another area. You train the brain to use what is left of the visual information it gets.”

The patient's performance is recorded and sent to members of the team, who can remotely tweak the exercises to enhance progress. “We can fine-tune the stimulation in real time,” says Dr. Reber. “It's personalized medicine.”

He notes that the Oculus Go's portability allows more patients to benefit from the treatment in their own homes. Patients only need to visit the clinic every two to three weeks for a visual assessment, rather than coming in daily.

“I think it's extremely powerful and convenient for patients,” says Dr. Reber.

Tom Roberts* knows the benefits of the system firsthand. Due to aggressive brain and spinal-cord tumours that were first diagnosed at age eight, Roberts went through years of surgeries and chemotherapy. Residual tumours around his optic nerves affected his peripheral vision, and he had resigned himself to a lifetime of poor vision.

When one of his doctors told him about groundbreaking low-vision research at the Donald K. Johnson Eye Institute, Roberts was skeptical. “For 20 years, I was told that this was something I had to live with,” he says.

After a thorough assessment by Dr. Reber, Roberts took the device home and spent three months doing visual exercises, performing them every other day for 15 to 20 minutes.

It made a difference right away. “There was a noticeable

difference in my visual field,” says Roberts. “Before, I would sometimes walk into things on my left side – and now I'm doing that much less.”

Dr. Reber notes that Roberts's reading ability has improved, and he has become more comfortable going out than he was before.

“It was absolutely astounding to me that using this device could improve vision,” says Roberts.

Dr. Reber is keen to scale up the use of the Oculus Go for people with low vision. He says the successful experience of patients like Roberts shows how life-changing it could be for others dealing with similar vision challenges.

“He improved on many objective measurements,” says Dr. Reber. “This is proof the stimulation [exercises] work.” ▽

**Name has been changed to ensure patient privacy.*

How to feed a hungry neuron

Eye diseases such as glaucoma can starve optic neurons of nutrients, causing them to die. Once that happens, the neurons, also known as retinal ganglion cells, stop building pathways with other neurons and the eye stops relaying messages to the brain. Once a critical number of these neurons is lost, vision loss sets in.

But what if there was a way to keep those neurons from degenerating?

Dr. Michael Reber has built a

nutrient-filled scaffolding of sorts for the eyes, using silk. The silk is reprocessed and then made into tiny fibres printed on a 3D printer.

“We take the silk filaments, we dissolve them and then from that we reprocess them as fibres,” says Dr. Reber. “When we engineer these fibres, we add the molecules the neurons need to survive and grow.”

The idea is that when the fibres are surgically implanted in the eye, “the neurons will climb on the

fibres and chew on the nutrients,” he says. Providing the neurons with both support and food will allow them to build new neural pathways and may allow patients to restore their vision.

The approach will require transplants into preclinical models before it can be tested on people, Dr. Reber says. But he is excited at the prospect of successfully treating diseases that lead to blindness. “Every day, we know a little bit more. It’s giving us hope.”



Dr. Michael Reber operates a specialized 3D printer that can make tiny silk fibres for use in the eye



Solving the puzzle of brain development

With sophisticated gene editing tools, Dr. Karun Singh is investigating how genes influence neurological development and vision

By Chris Atchison

One of the key roadblocks to treating neurodevelopmental disorders (NDDs) such as autism, schizophrenia or Down syndrome is understanding the root causes of the conditions.

Dr. Karun Singh is on a mission to overcome these hurdles by leveraging the power of stem cells and gene editing technology, with the goal of developing effective treatments – or even cures – for NDDs. It's a daunting task, but one the neuroscientist relishes, especially because he has the opportunity to bring hope to families of children with NDDs.

"I interact with families all the time, and the thing I tell them is that they're taking part in the latest and most emerging research," says Dr. Singh, a newly recruited senior scientist at the Donald K. Johnson Eye Institute. "When we can use a stem cell-based approach, it really is a more accurate way to study their disorder."

Simply put, NDDs impair development in the brain, resulting in everything from learning disabilities to visual impairment. Scientists have struggled to study these disorders because they can't access live patient brain tissue, limiting their research capabilities.

Dr. Singh's groundbreaking work focuses on understanding how genes and genetic mutations influence neurological development. By lab-engineering brain cells from patient stem cells using sophisticated gene editing tools, he's able to study neurological conditions in a more comprehensive way.

He and his team can take a blood sample from an individual with a specific brain disorder, then mimic what's happening in the person's brain in a controlled laboratory setting, without invasive testing.

"Many of the brain development disorders that we study are caused by genetic mutations," explains Dr. Singh, who joined UHN in June 2020, after earning accolades for his work at the Stem Cell and Cancer Research Institute at McMaster University in Hamilton. "We try to model that [genetic defect] in the lab by creating stem cells from the person's blood and then recreating their brain tissue in a dish."

Dr. Singh is using the same approach to model eye tissue in the lab, gaining insight into the visual impairment caused by NDDs and the development of vision disorders like macular degeneration.

He explains that once they understand the molecular dysfunction happening in the brain, they can find an already-approved drug which targets that particular molecular dysfunction and might correct the deficiency.

"If it's a different drug that's normally used to treat cancer, for example, we can repurpose it for this neurological brain development disorder caused by a genetic defect," says Dr. Singh.

"In order to know which drug to choose, you have to know, at the molecular level, what's wrong." ▽

Dr. Karun Singh received the Canadian Association for Neuroscience's Young Investigator Award in 2018

New solutions for the window of the eye

Researchers at the Donald K. Johnson Eye Institute are on the leading edge of corneal transplant technology

By Kira Vermond



Dr. David Rootman (above) and Dr. Clara Chan (below) are pushing the boundaries of innovation when it comes to corneal transplant technology

Corneal transplant techniques have come a long way. No one knows that better than Dr. David Rootman, a scientist, clinician investigator and ophthalmologist specializing in corneal surgery at the Donald K. Johnson Eye Institute and Sprott Department of Surgery at UHN. Dr. Rootman has performed corneal surgery for more than 30 years.

Yet, the cornea – the clear, domed window of the eye – is complicated.

The availability of human donor corneas is limited. And replacing an injured corneal component with an artificial one is not always successful.

“There are some [eye] conditions where it’s like planting a tree in the middle of the desert and not giving it any water,” says Dr. Rootman. “It’s not going to survive.”

Fortunately, advances in artificial cornea surgery, also called keratoprosthesis, are on the horizon. An Israeli medical device company is developing a new synthetic cornea that bio-integrates with the eye wall using nanofabric – a textile that is engineered with microscopic fibres that give it special characteristics.

Dr. Rootman was an integral part of the development of the artificial implant, providing guidance, resources and modification ideas for nearly four years. The device takes less than an hour to implant, doesn’t have an expiry date or require special storage and could help reduce the need for donor corneas.

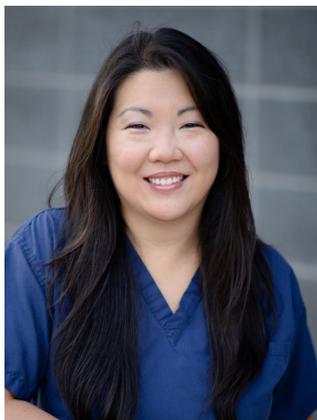
“I think that’s [a big] part of the excitement about it,” Dr. Rootman says. The implant is now going through an expedited FDA approval and has also been submitted to Health Canada for approval.

There is plenty of excitement around other aspects of cornea transplant too. Dr. Clara Chan, a cornea surgery specialist at the Donald K.

Johnson Eye Institute and Sprott Department of Surgery, made history when she became the first to perform a deceased donor ocular limbal stem cell transplant in Ontario. (Limbal stem cells are essential to maintain the protective outer layer of the cornea and deficiencies can result in vision loss.) She also transplants stem cells from live donors to help patients with severe corneal scarring.

Although her work is innovative, Dr. Chan notes that not all patients may be good surgical candidates and recovery after such transplants is a lengthy process. Eyes that suffer from limbal stem cell deficiency often are at risk for other ocular complications. Still, she has seen limbal stem cell transplant patients experience life-altering outcomes. One man stopped needing his white cane after years of struggle. Another, a young mother born with limbal stem cell deficiency, can now look after herself and her children independently.

“We try our best to see what ways we can help them,” says Dr. Chan. ▽



Protein with potential

The work of Dr. Philippe Monnier is helping patients with degenerative eye disease retain vision. It may lead to breakthroughs in neurological conditions too

By Chris Atchison

A close-up portrait of Dr. Philippe Monnier, a man with light brown hair and a beard, wearing a blue shirt and a dark jacket. He is looking directly at the camera with a neutral expression.

When Dr. Philippe Monnier set out to find effective treatments for debilitating vision disorders, he had no idea that his research might also lead to breakthroughs in the treatment of a wide range of neurological conditions, from multiple sclerosis to stroke.

It was a welcome – if unexpected – discovery.

Dr. Monnier, a senior scientist at the Donald K. Johnson Eye Institute, has been conducting research into how a protein called neogenin influences the progression of inherited retinal degenerations, or IRDs. This family of vision diseases affects about one in 2,000 Canadians and includes age-related macular degeneration, retinitis pigmentosa and glaucoma.

IRDs are caused by gene mutations that result in the death of photoreceptor cells in the eye, typically leading to vision loss. There are currently no cures for IRDs, and all treatments to date have been focused on slowing their progression.

Dr. Monnier and his team discovered that the protein neogenin can have a big influence on whether photoreceptors live or die. Neogenin levels were found to be higher in the eye tissue of patients with retinal degeneration. Limiting neogenin production using genetic tools in lab models was found to promote photoreceptor survival and, in turn, limit vision loss.

“What we found is that neogenin is a major trigger of cell death in photoreceptors,” Dr. Monnier explains. “If we can turn off that switch, we can promote survival in photoreceptors.”

Dr. Monnier and his colleagues have since developed a therapy that does exactly that. So far, it’s been used in multiple models for retinitis pigmentosa, delivering impressive results.

But the application of the team’s cutting-edge neogenin research doesn’t end there. Dr. Monnier believes that neogenin also has an impact on other cells types, including neuronal cells. Neuronal cells die in conditions such as multiple sclerosis, spinal cord injuries and stroke.

“When you have a stroke, for example, many neuronal cells die within the brain. That has a negative effect on long-term survival and recovery,” Dr. Monnier says. If researchers can find a way to use neogenin to prevent neuronal cell death, “we may be able to restore brain function and quality of life,” he adds.

The next step is to develop a drug that can treat eye diseases and potentially a wider range of brain disorders.

“Our long-term goal is to apply these new insights into different areas of human health,” Dr. Monnier says. “You start work on the eye, but then you realize that because the eye is made of neurons, you can apply this discovery to other parts of the brain.” ▽

Dr. Philippe Monnier’s work with the protein neogenin has already delivered results in treating retinitis pigmentosa

A champion of eye ingenuity

With leadership, generosity and a passion to make charitable giving easier, philanthropist Donald K. Johnson is driving advancements in vision care and research

By Jordana Feldman



In his decades of fundraising for countless not-for-profit organizations, Donald K. Johnson has often sealed the deal with a favourite pair of quotes.

"I like to tell people, 'It's better to give it away with a warm hand than a cold hand,' and, 'He who gives while he lives always knows where it goes,'" Johnson says with a chuckle from his Toronto home.

A veteran investment banking executive, Johnson is one of Canada's most renowned philanthropists. And as a board member of Toronto General & Western Hospital Foundation for more than 20 years, he is a driving force behind the 2020 Vision Campaign underway at the world-class facility that bears his name. The Donald K. Johnson Eye Institute, one of the largest and most comprehensive eye clinics in North America, set the ambitious target of raising \$20 million this year.

Health charities and organizations across the country have faced intense challenges in the wake of the COVID-19 pandemic, with cancellations of in-person events disrupting fundraising plans. Despite these challenges, the 2020 Vision Campaign is well on the way to achieving its goal. Johnson is both proud and unsurprised by the campaign's success.

"Ours is the leading eye institute in Canada and one of the top five in North America, and I think donors like to give to an organization that is both a leader and recognized internationally," he says. "There are also many very grateful patients, families and friends who want to give back to the Institute and express their gratitude."

Johnson is one of those grateful patients himself.

Having experienced myopia, glaucoma, cataracts and macular degeneration throughout his life,

he enjoys healthy vision now, thanks to the sharp diagnostic eyes at the Institute. Johnson's glaucoma went undetected for years, but when he saw Dr. Graham Trope, now co-director of the Glaucoma Clinic at the Donald K. Johnson Eye Institute, the doctor "diagnosed it right away and began the treatment, which prevented its progression," he says.

Johnson and his late wife Anna McCowan-Johnson have donated more than \$15 million over 10 years to help the Donald K. Johnson Eye Institute become the eye care and research powerhouse it is today.

Another of Johnson's passions is his mission to make it easier to give. He was made an Officer of the Order of Canada in 2009, in part for his role in changing tax laws to eliminate the capital gains tax on gifts of listed securities to registered charities.

Johnson says that measure

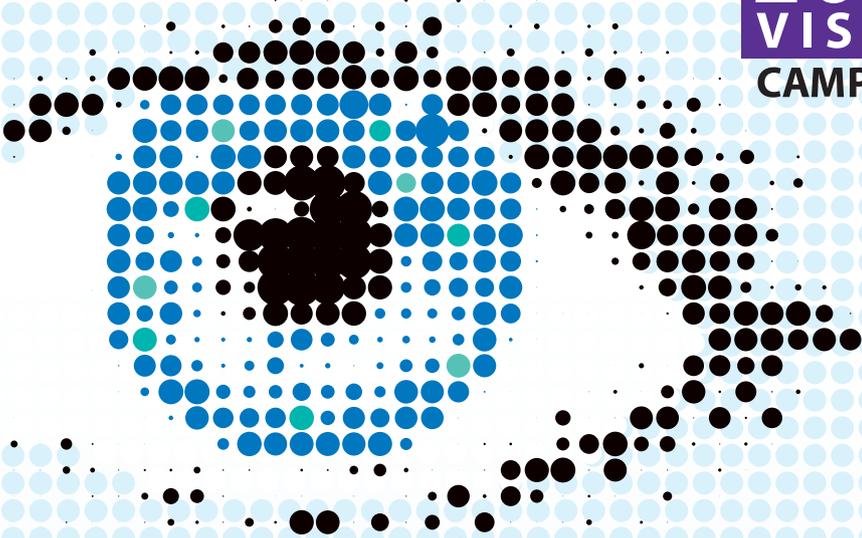
Donald K. Johnson's new book, *Lessons Learned on Bay Street*, will be published in 2021

brings in more than \$1 billion in gifts of stock to charities every year. Now, he's lobbying to bring in a new law that will remove all capital gains tax on charitable donations of private company shares and real estate. Johnson estimates that Canada is losing up to \$200 million a year in additional charitable donations, because this measure is not yet in place.

"With the COVID-19 pandemic, many charities are really struggling from a financial perspective," he says. "So the timing is really right now." ▽

To support the 2020 Vision Campaign, please visit: tgwhf.ca/vision2020

**2020
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