RCIScience

2021 ANNUAL

MAGAZINE

NAVIGATING THE PANDEMIC

CHALLENGES, RESILIENCE AND A DOSE OF HOPE

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Royal Canadian Institute for Science

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INSULIN TO INNOVATION 100 YEARS

Insulin to Innovation

2021 marks the 100th anniversary of the discovery of insulin. This pivotal moment in medical history happened right here in Canada, at the University of Toronto. Since its discovery, insulin has saved millions of lives, moving diabetes from a death sentence to a manageable condition.

Today, the legacy of this discovery continues through the many people living with diabetes, health care providers, researchers, caregivers and others who have felt the impact of this miraculous drug. Still, it is not a cure for diabetes, and that fact drives many to continue to innovate and engage in the search for a solution.

Our consortium of organizations has come together to celebrate the discovery of insulin and explore the many ongoing efforts across Canada to improve the lives of those living with or affected by diabetes.

Learn more about one of Canada's greatest gifts to the world—visit insulintoinnovation.ca.

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ANNUAL 2021 | ISSUE 4

RCIScience

RCIScience Magazine is a publication of the Royal Canadian Institute for Science

EDITORS
Carrie Boyce
Angela Zhou

DESIGN/ART DIRECTION
Yianni Tong

COVER ART
Darren Cheng

CONTRIBUTORS
Eliza Ali
Darren Cheng
Rebecca Dang
Ana de Faria
Nargol Ghazian
Nathaniel Goldstein
April Hrynyk
Kali Iyer
Sameer Jafar
Michael Limmena
Gloria Manga-Ebengue
Aaliyah Mulla
Joanne Pearce
Shivana Seth
Kirsten Vanstone
Michael Zara
Angela Zhou

(416) 977-2983
information@RCIScience.ca
6 Queen's Park Cres. West, Room 9
Toronto, ON M5S 3H2

The Royal Canadian Institute (RCIScience) is a registered charity: 131635286RR0001

EDITORS' WELCOME

Thank you for sticking with us in 2020-21!

More than 3,000 of you tuned into 26 online events this season, with over 24,000 visitors watching more than 5,600 hours of our science content on YouTube! While we miss seeing you all in person, our new virtual home allows us to host scientists from across Canada to share their research, not just nationally, but globally.

Our volunteer writers worked hard to bring you this issue of *RCIScience Magazine*, which inevitably explores the theme of navigating the COVID-19 pandemic. We are very proud of the programs we developed over the course of the pandemic, enabling you to stay connected with trusted science at a time when we were forced to physically keep apart and the 'infodemic' spread rampantly across the internet.

Our #SidewalkScience campaign connected scientists with their neighbours. Our book club fostered conversations about science and society. We explored novel ways to tackle misinformation and spoke with trusted experts about pandemic management and the COVID-19 vaccines. And when we needed a break from the virus, we took to the kitchen to explore the science of baking and fermentation, or played video games to map bacterial DNA! All of these initiatives and more are featured in this year's edition of *RCIScience Magazine*.

We hope you will continue to attend RCIScience's events and support our efforts to strengthen Canada's science culture. And if you're new to RCIScience, we hope you'll stay a while.

RCIScience Editorial Team

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COVER ART: *A cacophony of unprecedented events, breaking news and trends have filled the past two years since living with the COVID-19 pandemic. This cover depicts the unending pile of information we're constantly exposed to and how it permeates almost every corner of our daily lives. (By Darren Cheng)*

Formed in 1849 and receiving a Royal Charter in 1851, RCIScience has been connecting Canadians with Canada for over 170 years. Follow us @RCIScience.

MESSAGE FROM THE CHAIR

TO SAY THAT THE 2020-21 program year was unusual is an understatement. The global COVID-19 pandemic continues to impact all our lives and we find ourselves inundated with facts, fiction, science and pseudoscience every single day.

Learning to spot misinformation has always been a key theme at RCIScience and it has never been more crucial than during this global health emergency. Professor Timothy Caulfield received our 2020 Fleming Medal recognizing excellence in science communication for his work on the front lines of the war against misinformation, and we explored innovative vehicles with which to tackle the 'infodemic' through online games and our *Some Questionable News* segment.

While vaccines became the big story of 2021, climate change and wildfires remained firmly in the headlines. And for many of us spending more time at home, kitchen science has become especially relevant. I've loved all our events but the ones on sauerkraut, chocolate and baking have been my personal favourites, reminding us that science is everywhere, and in everything we do.

And just as science is in everything, science is for everyone! Our transition to online programming was done out of necessity but turned out to be transformational for RCIScience. Over the past year, we have been able to connect global audiences with excellence in Canadian science. Our new Instagram Takeovers proved especially popular, giving a behind-the-scenes look at science—and scientists—across the country.

In 2021, RCIScience celebrated the centenary of the discovery of insulin in Toronto, in partnership with the Banting Research Foundation, the Sir Frederick Banting Legacy Foundation and the Charles H. Best Foundation, and with support from Sanofi Canada and the University of Toronto. Our *Insulin to Innovation* program showcases top diabetes researchers across Canada while *100 Lives of Insulin* tells the stories of the impact of insulin's discovery, not just on people living with diabetes, but in launching the biomedical research ecosystem in Canada.

The Board and staff are working hard to safely navigate the ongoing pandemic and create a sustainable future for RCIScience. A future where we continue to strengthen Canada's science culture, fostering an informed public that embraces science to build a stronger Canada. Trust in science is critical to our society's future and RCIScience's platform continues to connect Canadians with the science that is lighting the path out of this pandemic. We hope you will continue to support us through 2021-22. As a charitable organization, our work is only possible because of the support of our members and donors: you are the backbone of our organization. Thank you.

This magazine is made possible through the efforts of an incredible group of volunteer writers (many of whom are students), along with managing editor Angela Zhou (who started as a volunteer writer) and designer Yianni Tong (who began her association with RCIScience in the Youth Science Academy in the 1990s). I would also like to thank Executive Director Carrie Boyce, who stepped up from the position of Programs Manager to fill Kirsten Vanstone's shoes in the Fall of 2020, and Virtual Engagement Coordinator Celia Du for keeping RCIScience running and our programs sharp and relevant.

I hope that you enjoy these articles as much as we have enjoyed bringing them to you. And I hope that next year won't be quite as unusual...

Suzanne MacDonald

REMEMBERING
DR. DEBORAH ZAMBLE

In the summer of 2020, RCIScience lost one of its most devoted supporters, Dr. Deborah Zamble.

Deborah served initially on the Royal Canadian Institute's Council, and then Board for many years, starting in 2006. She was a valued member of the Program Committee, working to advance our mission to connect Canadians with science. Deborah was passionate about making science available to everyone, particularly people outside of the scientific and academic community, and especially kids. She was always available to help ensure everything went smoothly at our events, often bringing her own young family. At our family programs in particular, Deborah made sure that all of the children attending found something fun and interesting to do. In her quiet but incisive way, Deborah was a great sounding board for ideas, always ready with an honest opinion and generously extending invitations to her network on behalf of RCIScience.

Deborah was also a very accomplished scientist working at the intersection of biology and chemistry at the University of Toronto.

We send our deepest sympathies to her family, friends, students and colleagues.

RCIScience will formally recognize Deborah's service and contributions to RCIScience through an annual volunteer award.

Click here to read more about Deborah's work.

SPOTLIGHT: Board Chair
DR. SUZANNE MACDONALD, Biologist

Dr. Suzanne MacDonald has served as the Chair of RCIScience's Board since Fall 2020. She joined the charity in 2018, chairing the Program Committee and helping drive our diverse calendar of events. You might recognise her from the news where she is often called upon to speak about Canada's favourite urban neighbour—raccoons!

Dr. MacDonald is a University Professor in the Department of Psychology at York University, appointed to the graduate programs in both Psychology and Biology. She has 3 main areas of research expertise:

1. Memory and cognition ("how animals think");
2. The psychological well-being of captive animals;
3. The impact of human activity on wildlife.

Her research is conducted in the field, at sites in Kenya and throughout Canada, as well as at the Toronto Zoo, where she has volunteered as their Behaviourist for over 25 years!

Asked what RCIScience means to her, "I am proud to be part of an organization that spans the whole country, that crosses all disciplines, and that sparks conversation and debate about issues that are important to us all. I also really love the history and traditions of the organization. Not many organizations have been around for 170 years—we must be doing something right!"

SUPPORT RCIScience

From the science in everyday life to its role in solving our greatest challenges, our free and engaging programs connect thousands of Canadians to trusted sources of scientific information every year.

As a charitable organization, the support of our donors makes all our work possible. Please join us in building a stronger, more informed country by making a gift.

Click here to donate to RCIScience.

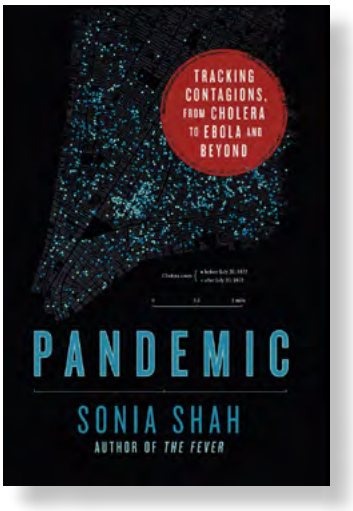
SO THIS ISN'T A DIRECT COLLABORATION, BUT IT'S SORT OF TRADING OFF. IT'S THE WAY SCIENCE TYPICALLY WORKS, THAT WE PUT OUT SOMETHING, SOMEONE ELSE LOOKS AT IT AND THEN UPGRADES IT. THEN SOMEONE ELSE UPGRADES THAT AND YOU SORT OF BUILD OFF EACH OTHER'S WORK.

DR. KEITH VANDERLINDE
Strange Signals: Fast Radio Bursts

PANDEMIC *In Conversation with* Sonia Shah

by SAMEER JAFAR

CREDIT: Pexels



2020 SAW THE WORLD FALL VICTIM TO A VIRUS that affected so much more than just physical health. Families separated, economies crashed, and anxiety took hold as many were stuck at home with uncertain futures. Despite ample warnings from dedicated experts and researchers, decision-makers were caught off guard. As Sonia Shah's 2016 book *Pandemic: Tracking Contagions, from Cholera to Ebola and Beyond* highlights, industrial human activity has changed our relationship with the natural environment, leaving us vulnerable to increased exposure to novel diseases. Shah, a renowned American science journalist, sat down with the RCIScience Book Club to discuss the cycle of pandemics that humans have experienced and how the importance of communicating clear public health measures can limit future outbreaks.

IMPULSIVE RESPONSES

While pandemic planning existed before COVID-19, new pathogens with unique characteristics always present a challenge. The relentlessness of SARS-CoV-2 and how it transmits was a puzzle pieced together by scientists in real time. Meanwhile, jurisdictions scrambled to control the virus and keep people healthy. Initially, the world collectively fought the pandemic by shutting borders and staying home. As time passed, some countries were more successful at 'stopping the spread' or 'flattening the curve' than others. But as infections mounted worldwide, so too did the unanswered questions.

A lot of people felt isolated, frightened by the news and frustrated with lock downs. "[There are] all sorts of contrasts that make these situations difficult," Shah explains, emphasizing that the pandemic has impacted different people in different ways. "Young people sacrifice more during this pandemic compared to someone who's older and stays at home anyway." Those who can work from home experience the pandemic differently from essential workers. Consider single family households versus multi-generational homes. Suddenly socio-economic class, cultural diversity and a host of other nuances come into play.

The public's risk perception was not adequately addressed. Motivating people to stay home became increasingly difficult once policy decisions across the globe began to differ, with some jurisdictions in neverending lockdowns and others basically operating as business as usual. Those who listened to the science were better able to anticipate and manage the virus, but other countries who took their time to enact these strategies were left playing catchup after the first wave. "The [World Health Organization] told us what to do—you test everybody and you trace their contacts and you isolate them with support," says Shah. "That would have worked in places that did it but we just didn't have a coordinated response."

"The missing piece is trust."

Other interests outside of public health seemed to dictate public guidelines and people's trust in governments dwindled as policies changed rapidly. Many jurisdictions in North America lacked clear-cut responses, resulting in weak control of the virus. Soon the rhetoric of "stay at home" and "wear a mask" was no longer enough to satisfy the masses. Anxiety built no matter how hopeful the latest government speech was. It brought into question the scientific literacy of decision makers and their willingness to follow expert advice.

COMMUNICATING TRUTHS

People have a tendency to decline new truths if they go against social norms, even when presented with hard evidence. London's cholera outbreaks in the early 1800s are a classic example of this. The scientific paradigm held at the time—that diseases spread through climatic events—supported the misconception that cholera was a respiratory infection transmitted through the air. Dr. John Snow's studies indicated that cholera travelled through brackish water and entered the human digestive system. His assertions were initially rejected, and it wasn't until after he died that his profound impact on public health took hold.

Science is a process. It's an evolving body of evidence that we've seen and continue to see unfold rapidly in real time during the COVID-19 pandemic. It is not a body of absolute facts and is often nuanced. This has been a sticking point amidst changing public health policy and messaging, with the resulting confusion eroding public trust.

Shah emphasizes the importance for world leaders to recognize public health research, with many countries failing to enact robust public health measures such as test, trace and isolate. Some areas were already experiencing tumultuous conditions, including ongoing outbreaks like malaria and Ebola (to name a few), so didn't have the capacity to aggressively combat a global pandemic. Public health also took a back seat in some countries governed by populist leaders who butt heads with 'elitist' groups like academics and medical officials over recommended health measures. "We have this crisis of governance going on at the same time we have this biological catastrophe of the pandemic," Shah muses. "All of these crises amplify each other and make it more difficult to address the problem of the pandemic."

"Science is a process."

While academics and medical professionals have the expertise and knowledge to advise on pandemic handling, Shah argues that they make themselves easy to be tagged as elitists. These groups commonly find themselves socially isolated and privy to a knowledge base not accessible to the average person. Shah states "we need to democratize science so populists can't make the argument that [scientists] are out of touch with the common man." As experts piece together our understanding of the virus and develop appropriate treatments, gaps in communication to the overall population still present challenges towards effective action. Shah claims, "science should be something for everyone, not just experts." Without a sense of connection to the biomedical community, we lose trust. Trust can be built through proper streams of scientific education which, as Shah puts it, "needs to be embedded in early years [of children's learning] so that we can all be a part of it." Until that happens, it is understandable for someone who was not educated on how vaccines work, or another person who is unfamiliar with microbes, to be skeptical about what "experts" are telling them.

ADAPTING TO A DYNAMIC WORLD

Public policy should evolve alongside scientific research so people have the tools to make better decisions about their health. This becomes increasingly important as industrial activity has put us in closer proximity with other organisms and vectors of disease. Encroaching on different wildlife habitats for agricultural development, or even simply for leisure, blurs the interface between wild animals, microbes and human habitations.

Conserving natural habitats keeps certain species that may carry disease separated from us to limit the amount of crossover events. Crossovers may seem harmless at first but this sort of interaction can lead to things like infected wet markets, fungal invasions or even contaminated playgrounds that children play in. Small scale preventative action like creating hunting boundaries, having food market limitations and more accessible sanitation stations would keep us from cleaning up huge outbreaks. Shah explains that once one dangerous pathogen is contained, "we go back to business as usual...we tolerate and make due with what happened. [T]he rational thing to do would be to rethink how we do housing, group activities, travel, public health support and public structure." It may not be a linear change, but a consistent shift in this direction will prevent repeat disasters.

"The missing piece is trust," Shah emphasizes. "It's [the lack of] trust between our governing bodies of science, policy and the general public that prevents us from anticipating and avoiding global catastrophes." Our response to this pandemic lacked effective communication. Shah expresses the need for people to work together in order to survive the world's new challenges, stating, "we have to change our behaviour, rely on our friends, neighbours and strangers to help us through this." ●

Science journalist and author Sonia Shah

Click here to watch the full interview.

RCIScience BOOK CLUB

Summer 2020 brought a new wave of pandemic tension, misinformation and social unrest in the United States, Canada and around the world. RCIScience was thrown into distance learning mode. How could we engage our audiences online and create a safe space for constructive conversation while we collectively experienced anxiety at the current state of the world? Enter our first ever book club.

The goal was simple: **foster a community of Canadians with a shared love of reading to explore how science can help us understand current events.** Reading allows you to dive into a subject at your leisure, and the club provides a home for our community. A place to discuss ideas, learn more, hear different perspectives and scratch our science itch. Pre-pandemic, there was hardly an event that went by without a Member recommending a good book to us!

Our **Summer Reads** series consisted of a short list of compelling books highlighting **how science and society are never isolated from each other.** Conversations with the authors complemented our programing, allowing our community to dive deeper into the leading issues impacting society. Some of these conversations are summarized throughout this year's magazine and we hope you find a new favourite book amongst them!

Click here to join us!

DANIELLE NADIN, Neuroscience

Quandaries of Consciousness

by NATHANIEL GOLDSTEIN

Neuroscience is a simultaneously exciting and perplexing field. For McGill University MSc student Danielle Nadin, the brain is at the centre of scientific curiosity and research. In Summer 2020, Danielle shared her experiences and knowledge about consciousness, consumer technology and being a scientist in a takeover of RCIScience's Instagram account.

Danielle studies consciousness, a controversial and complicated field that focuses on the nature of personal awareness and perception. Her research specifically investigates disorders of consciousness, which occur in some cases of brain injury where people can only indicate low-level voluntary conscious acts such as blinking. Danielle explained that such scenarios can raise complex ethical considerations in clinical settings when the matter of whether someone should continue to receive treatment is raised. Although there are various tests to determine whether a patient can recover from this type of injury, many of them rely on a patient's ability to exhibit a wide range of conscious behaviours such as moving and speaking. She noted that depending on how consciousness is measured, between 15 to 40% of unresponsive patients get misdiagnosed as unconscious. As a result, their treatment and care may be dangerously compromised.

The lab Danielle works in uses techniques to test for consciousness, specifically the electroencephalogram (EEG), a tool that measures the electrical activities of neurons in the brain. The information provided by EEGs may be used to develop neural networks, a visual diagram of neural connections to demonstrate the brain's communication patterns. The implementation of such models could reveal certain neuronal connectivity patterns to inform the patient's level of consciousness.

In addition to her research, as an undergraduate student Danielle was actively involved with a diverse interdisciplinary club called NeuroTechX, whose mission is to facilitate the advancement of wearable neurotechnology. In a fascinating short video, she showed a student wearing consumer-grade EEG electrodes on his head as he controlled the movement of his wheelchair using his brainwaves. Although these types of technology still need to be studied for their safety and efficacy, the implications of their future use are certainly astonishing.

Danielle is passionate about addressing the underrepresentation of marginalized groups in STEM (Science, Technology, Engineering and Math). Although the 21st century has seen tremendous strides in advocating for equity in the scientific community, a lot of work still needs to be done to ensure that individuals from all backgrounds are given a fair opportunity to become inspiring and influential leaders. As a person of colour who is engaged with equity, diversity and inclusion in STEM, Danielle shared her involvement with BlackInNeuro, an organization whose mission is to diversify the neuroscience community by celebrating and empowering Black leaders in the field.

To explore Danielle's excellent Instagram Takeover for yourself, head over to RCIScience's account, visit our Guides and scroll through our Highlights.

A DOSE OF HOPE
The COVID-19 Vaccines

CREDIT: rawpixel.com

by ANGELA ZHOU

THE COVID-19 PANDEMIC has given rise to the world's largest vaccination campaign. Never before have so many people been immunized in such a short period of time, and has so much information been available at our fingertips. A stroll down the street brings within earshot many casual conversations about mRNA, neutralizing antibodies and trial efficacy, sprinkled with name-drops of pharmaceutical companies previously unfamiliar to the general public.

While both traditional and social media have made science more accessible, vaccination and immunity are incredibly complicated, and the speed of new research and the sheer amount of data it generates is unprecedented. As researchers continue to investigate the unknowns and decision-makers strategize on how to best protect the general population, we need clear and responsible science communication to make informed health decisions.

MORE THAN ANTIBODIES

To understand the science behind these vaccines, it is important to know how the immune system responds to infection.

When SARS-CoV-2, the virus that causes COVID-19, travels into our airways, a spike-shaped molecule on its surface, aptly called the spike protein, starts the damage. “The spike protein is important for entry of this virus into our human cells within our airways and lungs,” explains Dr. Jennifer Gommerman, a Professor of the Department of Immunology at the University of Toronto. “Because of that, it’s really an ideal target for current vaccine strategies.” While the COVID-19 vaccines approved in Canada have their differences, they all target the spike protein, neutralizing it to prevent the virus from making initial contact with our cells.

When the spike protein attaches to the epithelial cells lining the inside of our lungs, these cells produce interferons and cytokines, chemicals that recruit immune cells. These chemicals form what Dr. Gommerman describes as an alarm system, which “signals to the rest of the immune system that something is going on and it’s not good.” This immediate response is part of the “innate” immune system, a first line of defense against the virus. But it needs reinforcement.

Enter: the “adaptive” immune system.

This adaptive response uses B and T cells. B cells produce antibodies to neutralize the virus and T cells kill other cells that are already infected by the virus, preventing the infection from spreading. These cells take about 7 to 10 days to activate and arrive on the scene. Through these cells and others, the immune system responds in a multifaceted way, using multiple strategies to fight infection.

"Your immune system will remember," elaborates Dr. Gommerman. When your body is infected by a virus that your immune system already recognizes, the immune response is much faster and stronger, “so you will more quickly get rid of that virus.” This means more B and T cells, and more antibodies. This immunological memory is the underpinning mechanism behind vaccination.

A vaccine supplies components of a virus or an inactivated form of the virus to trick your immune system into thinking you have been infected so that it is stimulated to act. You won’t actually get sick. Any virus components contained in the vaccine are unable to replicate. It is just enough to teach your immune system about the virus and be ready to respond the next time you are infected.

RISKY BUSINESS

Developing a vaccine is a challenging business. Out of hundreds of candidates, only a few make it. “When we were first discussing vaccines with our international counterparts, we were optimistically thinking that we would be very happy if we had one vaccine that would [...] work against COVID-19,” expresses Dr. Supriya Sharma,

The Pfizer-BioNTech and Moderna vaccines are mRNA vaccines. These consist of spike protein mRNA enclosed in fats, stabilizing the delivery of the vaccine into your arm. When injected intramuscularly, your muscle cells take up the mRNA, synthesizing spike proteins for presentation to your immune system. Your immune system detects these spike proteins and thinks an infection is occurring. Cue action from the B and T cells. This spike protein mRNA doesn’t last forever though, and quickly degrades when its work is done, leaving behind an immune system that has learned how to combat SARS-CoV-2.

The AstraZeneca-Oxford and Janssen vaccines function similarly, but rather than mRNA, they deliver the spike protein encoded in a non-replicating viral vector. Similarly, this allows your cells to produce spike proteins and activate the immune system. Since the viral vector is non-replicating, it will not make you sick and also degrades after its work is done.

CLINICAL TRIALS

Phase I tests the vaccine safety on a small group of healthy volunteers. The goal is to look for potential side effects and adverse reactions. Once determined to be safe, Phase II trials see the vaccine given to hundreds of volunteers. In addition to continuing to monitor for safety, the objective here is to also look at efficacy—how well does the vaccine do what it’s intended to do. Phase III trials take this to another level, using thousands of volunteers. In such a large sample size, rarer side effects may surface and the safety and efficacy of the vaccine in specific populations can be monitored. This phase continues to provide data on the efficacy of the vaccine in preventing serious illness as well.

the Chief Medical Advisor of Health Canada. Fast forward a year, and all the Health Canada-approved COVID-19 vaccines have shown extremely high efficacy in preventing severe infection, hospitalization, intensive care unit (ICU) admission and death.

Developing and testing a vaccine is a very rigorous process. It includes a preclinical phase in which the vaccine is studied *in vitro* (on cells in a dish) and in animal models, and three phases of clinical trials in humans. Only after the three phases of human clinical trials can a vaccine be submitted to Health Canada for authorization. Before a vaccine or therapy is authorized, it cannot be used outside of a clinical trial.

While Health Canada authorizes the use of vaccines to the general public, the distribution of the vaccine relies on other bodies. The National Advisory Committee on Immunization (NACI) is an external, independent expert panel that advises the provinces and territories on how to deliver approved vaccines. They advise which populations should receive a particular vaccine, the dosing schedule of a vaccine, and any additional recommendations regarding whether one vaccine should be given over another. Additionally, the Ministry of Public Services and Procurement and the Public Health Agency of Canada respectively coordinate the reception of vaccine doses into the country (navigating a wild west global environment where every country is trying to procure doses) and their deployment to each individual province and territory.

Health Canada conducts due diligence, with teams of experts in immunology, pharmacology and biomanufacturing. These teams assess not just the preclinical and clinical data, but also how and where the vaccine will be produced to ensure that *every single dose* meets the rigorous standards required to be distributed to the public.

Following authorization, Health Canada continues to monitor the effects of the vaccine—this is Phase IV of the trial. As vaccines are distributed widely amongst the population (nationally and internationally), there is a constant flow of new data that helps health agencies assess emerging side effects on various populations, as well as review their effectiveness in protecting against COVID-19. Health Canada pays special attention to specific considerations and contexts for the Canadian population that might be different from reviews conducted in other parts of the world.

In evaluating any vaccine or medication or therapy, Health Canada weighs the overall benefit against the potential risks. "This is extra important for vaccines," explains Dr. Sharma. "We accept a certain level of side effects in medications because they're used to treat a disease that's potentially fatal. For vaccines, our threshold for side effects is very low because they're given to healthy individuals to prevent a disease."

NO STEPS SKIPPED

Dr. Sharma describes the Health Canada review process as taking about 300 days, or 2,000-4,000 hours. It is natural to wonder how they felt confident in doing this so quickly for the COVID-19 vaccines and whether the speed compromised any part of the process.

Dr. Sharma explains that the compression of the review timeline is a result of cutting out inefficiencies and downtime. "We need to make sure we have a system in place that will quickly be able to assess the information and make decisions. The data itself and the rigour of that review did not change. We were just making sure that review was very, very efficient."

Part of the efficiency involved the researchers themselves, who normally spend time writing grants and waiting on funding decisions, leading to prolonged periods of downtime. Money and resources to support global vaccine development allowed researchers to get straight to work. Similarly, patient recruitment for trials was sped up given the urgency of the situation.

Additionally, Health Canada put in an interim order for rolling reviews. Normally, all trials would have to be completed before compiling a report for authorization. With rolling reviews, manufacturers submit data as they become available so that Health Canada can assess the information in real time.

Further, the National Advisory Committee on Immunization (NACI) was engaged much earlier in the process than usual, receiving data as it became available rather than waiting for approval. This allowed NACI to make faster recommendations for use. At the same time, procurement and deployment planning also started long before vaccine review even commenced.

The rigour of this process cannot be overemphasized by Dr. Sharma. Public trust in the review process is paramount. To make it as open and transparent as possible, Health Canada prepared a public web portal with summaries of all regulatory decisions and the data upon which they are based. Canada and the European Union were the first jurisdictions in the world to publish the raw data received from the individual pharmaceutical companies. "Even the most effective vaccines on the planet are only effective if somebody trusts it and agrees to take it," Dr. Sharma expresses.

GETTING VACCINES WHERE THEY'RE NEEDED MOST

With vaccines authorized on Canadian soil, choosing how doses are distributed can help rectify the inequities that have caused increased risks from COVID-19 in certain populations. "Everyone, ultimately, needs to get the vaccine," says Dr. Lisa Richardson, a physician and clinician-educator at the University of Toronto and the Strategic Advisor in Indigenous Health for the Faculty of Medicine and Women's College Hospital.

Prioritizing at-risk groups for vaccination can increase protection for the general population by reducing localized outbreaks that can spread. "We have seen [COVID-19 expose] major inequities that we have always known existed—it has [now been brought] to the surface," Dr. Richardson states.

Certain postal codes have higher risk for COVID-19—an 80-year-old in the highest risk postal code has a 27-fold increase in mortality risk compared to an 80-year-old in the lowest risk postal code. High risk areas tend to have high concentrations of essential workers who cannot work from home and are not supported to take time off when sick. These are often racialized individuals in multigenerational homes where an infection can have devastating effects on the entire family. Data from Indigenous communities in Manitoba have shown a 74% higher risk of disease on reserves, alongside higher rates of ICU admission and mortality.

In addition to ensuring priority access to vaccines, we need to also ensure community confidence in vaccines. Data from many jurisdictions show that lower socioeconomic groups are less likely to take the vaccine. "How do we create vaccine confidence?" asks Dr. Richardson. "How do we let people know that this vaccine is safe, particularly if [they're] from structurally marginalized groups where [historically] there has been forced experimentation, forced vaccination, or other unethical research that's been practiced on [their] community, such as is the case with Black and Indigenous peoples in Canada."

FIGHTING HESITANCY WITH EMPATHY

Combating vaccine hesitancy is a continual struggle, and the strategy taken must be rooted in empathy and understanding. "You have to meet people where they are," says Dr. Gommerman. She explains that people have their own reasons for why they don't want to take a vaccine and shaming them is counterproductive. She tries to ask questions to identify specific concerns, and from there, try to address the concerns one by one from an immunological perspective to debunk false beliefs.

"People are not [vaccine hesitant] out of malice," echoes Dr. Sharma. "They want to make a good decision for themselves and the people they care about." Starting the conversation by being open and actively addressing their concerns goes a long way.

Indeed, the COVID-19 pandemic has been a learning experience for all of us. It has highlighted a need to reconsider access to healthcare, not solely because it is a morally just thing to do, but also because ensuring equitable access to vaccines and public health education will end this pandemic much more quickly. This is a lesson we need to retain moving forward. ●

Click here to watch the full talk.

PUBLIC HEALTH REQUIRES US TO THINK OF THE SCIENCE AND HOW IT INFLUENCES PEOPLE IN SOCIETY. AND IF WE DON'T ADDRESS THE SYSTEMIC MARGINALIZATION, AND SYSTEMIC BARRIERS TO ACCESSING QUALITY HEALTH CARE, WE WILL NOT GET OUT OF THIS SITUATION. WE ARE DEFINITELY ALL AFFECTED IN THIS AND CAN ONLY GET THROUGH THIS IF IT'S TOGETHER.

DR. SAMANTHA YAMMINE
A Dose of Hope: The COVID-19 Vaccines

Timothy Caulfield is the Canada Research Chair in Health Law and Policy, a Professor in the Faculty of Law and the School of Public Health, and Research Director of the Health Law Institute at the University of Alberta. His interdisciplinary research on topics like stem cells, genetics, research ethics, the public representations of science and health policy issues has allowed him to publish over 350 academic articles. A celebrated author, his works include two national bestsellers: ***The Cure for Everything: Untangling the Twisted Messages about Health, Fitness and Happiness*** and ***Is Gwyneth Paltrow Wrong About Everything?: When Celebrity Culture and Science Clash***. Caulfield is also the host and co-producer of the award-winning documentary TV show, ***A User's Guide to Cheating Death***, which has been shown in over 60 countries.

CREDIT: Magda Zofia

STRANGER THAN FICTION

Fighting Misinformation *with* Timothy Caulfield

by ANGELA ZHOU

"An infodemic is an overabundance of information, both online and offline. It includes deliberate attempts to disseminate wrong information to undermine the public health response and advance alternative agendas of groups or individuals. Mis- and disinformation can be harmful to people's physical and mental health; increase stigmatization; threaten precious health gains; and lead to poor observance of public health measures, thus reducing their effectiveness and endangering countries' ability to stop the pandemic." World Health Organization (WHO)

OVER 100 YEARS AGO, people around the world were asked to stay home, wear masks and board up their businesses as a new strain of influenza virus emerged, killing at least 50 million people and infecting over 500 million globally. RCIScience, an institute of resilience that managed to stay open even amidst two World Wars, was forced to shutter between 1918 and 1921 because of the 'Spanish Flu'. No public science lectures or records of scientific activity were kept during this time by the Institute. Facing a similar situation in 2020 with the COVID-19 pandemic, developments in technology have kept us connected while physically apart, allowing RCIScience to remain as active as ever during a critical time when misinformation runs rampant online and scientific literacy is imperative to save lives.

It seems fitting then that the 2020 Fleming Medal of Excellence in *Science Communication* should be awarded to one of the most tireless combatants in the fight against misinformation and junk science: Professor Timothy Caulfield. The Honourable Elizabeth Dowdeswell, Ontario's Lieutenant Governor, describes Prof. Caulfield as a "strong and trustworthy voice in support of critical thinking... [whose] contributions to scientific literacy and particularly to fighting the war against misinformation are so very relevant and will surely be of assistance as we navigate the uncertain times that still lie ahead of us." In making science accessible and engaging, Prof. Caulfield leads the charge with empathy and mutual understanding, inspiring many to become part of his "debunking army" as he tries to equip the public with the knowledge and tools needed to protect against misinformation, and distinguish between real and junk science.

THE INFODEMIC

"What a time to be talking about science communication," Prof. Caulfield declares. "I've been involved in the battle against misinformation for a long time and I have never seen anything like this."

The COVID-19 pandemic has provided a great example of how social media and other online platforms have played a significant role in educating and informing the public on how to keep ourselves and others safe. Yet governments, health agencies and scientists are not the only ones taking to Twitter and Facebook during this time of crisis. The same tools that keep us connected are being used to disseminate misinformation and disinformation by nefarious parties with harmful agendas. The sheer volume of information that is now available at our fingertips is described by the World Health Organization (WHO) as an "Infodemic".

"There is misinformation about absolutely everything," says Prof. Caulfield, who notes that this has extended into every aspect of the pandemic, from the source of the virus to effective therapies and even the political response enacted to combat viral spread. While many may disregard the problem as only affecting a gullible few, misinformation—regardless of how absurd—has far-reaching consequences that have manifested in stigmatization, property damage, racism, and confused health and science policy. In the midst of a global health crisis, misinformation and conspiracy theories have led to preventable hospitalization and deaths.

Misinformation: the spread of false or inaccurate information, regardless of intent.

Disinformation: the deliberate spread of false or inaccurate information with the intention to deceive.

"In general, this is a social media phenomenon," Prof. Caulfield explains. While traditional news sources have contributed as well, a study from McGill University found that people who get their news from social media are more likely to be misinformed and more likely to believe that misinformation. Prominent individuals, such as a celebrity, athlete or politician, are often the source of misinformation on these platforms. Their influence cannot be understated, with 69% of all content that circulates on social media coming from all of us sharing their content.

In addition to spreading ideology, many people use misinformation to sell products. Prof. Caulfield and his team conducted a study recently looking at hundreds of websites talking about "immune boosting"—a rather unscientific health concept—and found that 85.5% of them inaccurately portrayed their product as effective in combating COVID-19. These commercial entities know how to sell junk science by using real scientific jargon (words like "microbiome", for example) out of context to make themselves appear credible.

In light of the dangerous repercussions of misinformation, stronger regulatory measures by governmental agencies, such as Health Canada, are required to tackle public health misinformation online. While we are starting to see some social media platforms take action, more is needed to ensure that misinformation is not widely circulated.

"We also need to make sure individuals out there have the critical thinking skills required to tease out what is real and what is not real," proclaims Prof. Caulfield. "[They] need to be able to deal with this chaotic information environment."

FEAR AND ANSWERS

So why does misinformation seem to spread more easily than real science, data and evidence? Often, it's the packaging. Those pushing false information to further their own agendas tend to wrap their message in a way that plays on human emotion, exploiting people's fears and anxieties to sell their products and brands.

"We should listen and understand why people are attracted to these," Prof Caulfield explains. "It's easy to say they're all nuts or foolish, but that's not the case at all. There's often a need there." Many people are frustrated or have been treated poorly by the conventional system and are searching for answers.

With their adeptness on social media and doting customer service, these disingenuous players swoop in on that negativity bias and offer much needed answers. In reality, they take advantage of deficiencies within the current system, and do it with a seeming sense of compassion often perceived to be lacking in conventional public health systems.

Prof. Caulfield does not hold back on his condemnation of these tactics: "I get furious when people say we're not listening to patients or don't understand—that's not true at all! We should be angrier at these other entities who are exploiting the problem."

DEBUNKING WORKS!

Combatting the pseudoscience camp is not an insurmountable hurdle. It just means we have to be better and more aware of how we communicate science. "[I want] to inspire everyone to become part of the debunking army," says Prof. Caulfield. "Because debunking works!"

So what makes for good debunking? Prof. Caulfield shares some tips:

1. **Use good science.** Talk about the scientific consensus and the body of evidence, and think about how to present that information in an interesting and digestible way on social media.
2. **Highlight gaps in logic.** People often use rhetorical tricks to get misinformation across, such as anecdotes or testimonials. Point these out and highlight how they're being used to mischaracterize risk or push conspiracy theories.

1/5 OF PEOPLE IN THE UK
believe that COVID-19 is a hoax.

28% OF AMERICANS
believe that Bill Gates started the pandemic so that he can force vaccination and plant microchips that track all of us.

46% OF CANADIANS
believe one of the four big conspiracy theories about COVID-19 (it's a bioweapon, it's caused by 5G, it's cured by hydroxychloroquine, regularly rinsing your mouth and nose with saline can help protect against COVID-19).

37.9% OF COVID-19 MISINFORMATION
is attached to Donald Trump.

3. **Be nice.** We need to have respectful discourse. Being nice, authentic and humble matters! Some studies have shown that these qualities make you seem more credible, and are effective in getting your message across.
4. **Creativity wins.** Narratives, humour, art, poetry—all of these things are new and interesting ways to present science that can make dense information a lot more accessible.
5. **The 'Movable Middle' is your audience.** There are a lot of hardcore science deniers out there—it's not worth your psychological energy to argue with them. You're not going to change their mind (don't ignore them though—it's important to know what messages are coming from those camps). Instead, direct your energy to working with those sitting on the fence and help them understand the science.

In addition to effectively communicating science, we also need to encourage people to stop spreading misinformation. "[Canadians] don't have a nefarious objective to spread misinformation," Prof. Caulfield explains. "They're just trying to do the best they can with the information that is bombarding them." Encourage everyone, therefore, to take a pause, relax and reflect before sharing information on the internet. They will be less likely to share misinformation. If we all just take a minute, we can be part of the solution moving forward.

Go Team Science! ●

CREDIT: Timothy Caulfield

Click here to watch the full event.

The Sandford Fleming Medal for Excellence in Science Communication

Connecting people with science is at the heart of what we do at RCIScience and why we recognize Canadians who do that so well. The first Fleming Medal was awarded in 1982 to renowned science communicator David Suzuki for his work promoting environmental awareness. Since then, the award has been given to many luminaries of Canadian science—those who felt it was important to talk about their work. Past winners include Helen Sawyer Hogg, Chris Hadfield, Ivan Semeniuk, Ursula Franklin and Bob McDonald.

Click here for more information.

WHEN CANADIAN UNIVERSITIES closed their campuses to limit the spread of the virus, then University of Waterloo student Ridhi Patel found herself back home in Niagara Falls, continuing her studies remotely. She noticed how COVID-19 misinformation was spreading rapidly among her friends and community. Wanting to create a resource to make finding and learning reliable information easier, she drew from her experiences as an avid gamer to develop an online game that would be both informative and fun to play.

"I was thinking it would be a good resource for younger kids to learn from, before I decided to combat misinformation with it," explains Patel. "I essentially thought of it being a game for the younger audience, but I think a game in itself can be a very captivating and engaging way to learn [for all ages]."

To make the game a reality, she partnered with Dr. Jozef Nissimov, an environmental microbiologist and aquatic virus ecologist at the University of Waterloo, to ensure that content would be accurate, credible and up to date. With Nissimov's guidance and additional help from various startup companies, Ridhi was able to develop *Quarantrivia*—a browser based game featuring quizzes and platform mini games. Hosted on the University of Waterloo's website, news of this engaging and innovative model of science communication was quickly picked up by CBC, CTV News and other media outlets.

In the game, the player becomes the titular hero Dr. Pixel, who must save his Pixel World from COVID-19 using knowledge of the virus. Early iterations of the game consisted of three rounds each with 15 multiple-choice questions. The questions tested players on their knowledge of the virus, including what it is, how it spreads and its symptoms. If the player can answer the questions correctly, they can advance to the next round. However, if three or more questions are answered incorrectly, the player is directed to resources from the World Health Organization and the Center for Disease Control and Prevention to brush up on their knowledge before restarting the game.

Ridhi envisions *Quarantrivia* becoming a resource that provides access to reliable COVID-19 information and education about the pandemic. She elaborates: "[T]his resource [...] is trying to promote the importance of knowing correct information [...] because it is so easy to get carried away with the amount of information that we are seeing circulating around us."

Since its initial release, the game has kept up to date with the changing events of the pandemic. This includes testing players on their knowledge on how to protect themselves when Ontario entered Phase 3 of reopening, and a "Myth vs Reality Bonus Round" to help debunk COVID-19 misconceptions. Ridhi hopes to expand the game further in the future to cover vaccination. Currently pursuing her pre-med studies at Brock University, *Quarantrivia* has drawn out Ridhi's creativity alongside her love for medical science and gaming. ●

Click here to watch the full event.

Student and game developer Ridhi Patel

ON THE BORDER

WHERE SCIENCE MEETS GAMING

by APRIL HRYNYK

IMAGINE EXPLORING THE INFINITE cosmos in all its mayhem-fuelled chaos while simultaneously providing crucial data for scientists back on Earth. Anyone can be a pioneer of genetic science aboard the Sanctuary III ship in the ***Borderlands Science*** minigame from ***Borderlands 3***, the latest instalment of Gearbox Software's best-selling video game franchise. ***Borderlands Science*** blurs the lines between science fiction and reality, connecting the gaming community with actual scientific research conducted in labs around the world. This first-of-its-kind, large-scale citizen science project is a testament to the great innovations that can emerge when industry leaders collaborate with the global community, taking a chance on creative, outside-the-box solutions to scientific problems.

While technology may advance quickly, breakthroughs in biomedical discovery are slowed by biological processes—how long it takes for them to be carried out, observed and interpreted by scientists. Advances in DNA sequencing, for example, have allowed scientists to generate genetic data at an unprecedented speed, but the lack of human processing power considerably impedes the analysis and interpretation of the information collected. Decoding this sequencing data is like putting together a puzzle. Developmental biologists like Dr. Jérôme Waldispühl, an Associate Professor in Computer Science at McGill University, compare DNA sequences from multiple species to piece together the purpose of different genes. Comparing sequence alignments allows scientists to identify areas of genetic similarity between species, which may point to an evolutionary, functional or structural relationship between the sequences. Although algorithms are often used to complete these alignments, their rigidity is insufficient to fully decode the sequence. This is because the human ability to recognize visual patterns and relate information is difficult to replicate using an algorithm, so scientists routinely serve as final quality control. Faced with the limitations in speed and efficiency of human processing power, Dr. Waldispühl sought to increase the workforce capacity and looked to massive multiplayer online gaming for solutions.

In an effort to expand citizen engagement in science, Dr. Waldispühl developed his first game, Phylo DNA Puzzles, which would become the basis for ***Borderlands Science***. In partnership with the Microsetta Initiative, Massively Multiplayer Online Science and volunteer science enthusiasts at Gearbox, the Waldispühl lab evolved the original game design to appeal to ***Borderlands'*** existing fan-base while maintaining its scientific integrity.

> "At its core, science is a collaborative process used to understand the world around us."

Borderlands Science lets players take a break from intergalactic fighting to explore the microscopic, and alien, world of the human microbiome. The Tetris-like game mechanics feel familiar to players as they match coloured tiles that represent real microbial DNA sequences. Solving these puzzles awards players boosters and collectables while providing data to Waldispühl's lab to improve alignment algorithms. Over one million players collectively solved fifteen million alignments in less than three months.

At its core, science is a collaborative process used to understand the world around us. Broader participation in this process through citizen science opens these traditionally gated spaces to diverse ideas and perspectives. ***Borderlands Science*** exemplifies the future of science, blending machine learning, game design, science communication and a dedicated community. Citizen science collaborations promise to bring new audiences revolutionary ways of engaging with, and learning from, science.

Click here to watch the full event.

CREDIT: FREEPIK

ADDICTI

CREDIT: Serj Tyaglovsky

THE MIND-BRAIN CONNECTION

by AALIYAH MULLA

OUR UNDERSTANDING OF ADDICTION has changed considerably over the course of history. It is a multifaceted issue, but understanding its complexity is key to finding effective solutions for prevention, support and treatment.

THE NEUROSCIENCE OF ADDICTION

Our brains are hardwired to respond to pleasure. This clever natural design ensures that we repeat behaviours essential for survival. Every time we complete a pleasurable action, such as eating food, the brain's reward pathways are activated, releasing the neurotransmitter dopamine. This chemical messenger activates regions in the brain to make us happy.

Neuroscientist Dr. Andra Smith, a Professor in the School of Psychology at the University of Ottawa, describes three general layers of the brain from an evolutionary perspective. Deep in the interior, we have the reptilian or early brain, responsible for basic, automatic functions such as breathing and swallowing. The second layer is the mammalian brain, which has more advanced abilities like emotion and reward. It is responsible for survival, activating our fight-or-flight response if, for example, we see a bear, and it ensures our essential needs are met by making behaviours, like eating, rewarding. It controls and regulates our ability to feel pleasure and as such, motivates us to engage in pleasurable activities. The new brain, most notably our prefrontal cortex, is responsible for higher-order executive functioning such as decision-making and focus. This part of the brain helps us reach for a banana instead of a cookie, or calm down when we are angry. We use the new brain to think beyond the instincts of the reptilian and mammalian brain.

While the mammalian brain develops in adolescence, our prefrontal cortex is not fully developed until our early twenties. This means that emotional reactivity and the search for reward outpaces cognitive control. It explains why teenagers are often prone to engaging in high-risk behaviours. It also explains why youth are more susceptible to addiction. The circuitry responsible for dopamine release doesn't distinguish between indulging in a slice of chocolate cake or responding to a social media notification. It also doesn't distinguish between legal or illegal highs. We need our prefrontal cortexes to come online to reinforce good decision-making in our everyday lives.

Unfortunately, much of modern society is designed to hack this reward network. Video games, social media, food, sex, exercise and drugs all exploit emotional triggers, activating the reward network and inducing repetitive behaviour. Addiction occurs when that behaviour continues despite negative consequences.

In the context of drugs and alcohol, the amount of dopamine released is far greater than that of a natural reward. As such, the prefrontal cortex becomes overridden and judgement becomes distorted. Rudimentary reward systems treat the substance as necessary for survival. A feedback loop develops where the more you use, the lower the dopamine response, causing further substance use until eventually nothing feels good. As Dr. Smith explains, "[Addiction] is not a failure of moral judgement or poor willpower...the brain truly is hijacked."

But why do some people get addicted and others don't? There are many factors at play, including environmental, social, medical and biological. Genetics alone seem to account for about 50% of it. Stress is a huge disrupter of healthy brain development. Everything from food insecurity to adverse childhood experiences (ACEs) and trauma puts the brain into a survival model. The new brain takes a step back, taking the prefrontal cortex offline at the most important time, and the old brain takes control. If addictive substances are introduced, as they so often are to ease tensions, susceptibility to addiction is dramatically increased.

There is hope, however, thanks to the brain's plasticity. Ceasing drug use and creating good habits can enhance motivation for other naturally rewarding, non-drug behaviours, strengthening the prefrontal cortex and reward pathways. Repeating an action over and over again creates brain connections which eventually work faster and more efficiently so habits become easier. Habits like mindfulness, exercise, healthy eating, following good sleep patterns, and fostering gratitude, creativity and having a sense of community and purpose all reinforce healthy brain patterns.

SOCIETAL IMPACTS OF SUBSTANCE USE

Addiction presents enormous costs to society. Dr. Matthew Young, a Senior Research and Policy Analyst at the Canadian Centre on Substance Use and Addiction (CCSA) and a Professor of Psychology at Carleton University, is assessing the collective social costs of addiction to various substances. This includes costs to the healthcare system, the criminal justice system and the workforce.

Every day, we lose valuable members of society to addiction. People are unable to work, relationships are destroyed and deaths occur from overdoses and poisonings. The healthcare system bears the burden of treating long-term health conditions arising from substance use and addiction, as well as overdoses, poisonings and related injuries. The criminal justice system also incurs significant costs, through illegal possession and associated acts like impaired driving, theft and violence.

> **"Addiction is not a moral failing, it's a health issue."**
>
> **MATTHEW YOUNG**

Dr. Young's data collection is part of a movement to develop better solutions to treat addiction. Currently, societal structures can exacerbate the problem. Substances are often classified as illegal to discourage their use, but in practice, for users, this makes obtaining and taking the

CREDIT: Sasha Freemind

> Substance use cost the Canadian economy $46 billion dollars in 2017, or about $1,258 for every individual in Canada. Legally obtained substances accounted for 63% of base costs. The greatest contributors were alcohol and tobacco.

substance more dangerous. Dr. Young describes the phenomenon in relation to the criminalization of oxytocin: "[When the amount of pharmaceutically developed oxycontin decreased], the demand did not decrease, and organized crime stepped in with [...] all kinds of other contaminants." On the illegal market, there is no quality control, making it easy for substances to be contaminated or misidentified. This leads to poisonings and overdoses. Harm reduction centres set up by organizations like the Canadian Community Epidemiology Network on Drug Use (CCENDU) can help reduce such risks by testing drugs for safety.

The COVID-19 pandemic brought additional risks to substance users. Disruptions created in an already unpredictable illegal drug market, coupled with reduced access to treatment and harm reduction services, resulted in dramatic increases in drug-related deaths across the country, alongside harms associated with substance use. Moving forward, we need to provide wider access to virtual care and other treatment options, as well as a more reliable and safer drug supply, and additional harm reduction services and tools.

THE POTENTIAL FOR BETTER POLICY

Dr. Patrick Fafard, a Professor at the Graduate School of Public and International Affairs at the University of Ottawa and Associate Director of the Global Strategy Lab, describes the complexity of developing policies to address addiction. Policy development is influenced by a number of factors, including interplay between different levels of government, international treaties, public support and education, and resources. It takes time to garner enough support and resources to make change. As Dr. Smith describes, addiction is particularly difficult to address with policy, as "[it] falls between mental health and physical health, despite the fact that they should be one." This uncertainty, paired with the stigma associated with addiction and mental health challenges, makes it difficult for people to seek support. Additionally, in order to understand why governments in different countries make different decisions, we need to look beyond the basic physiology of addiction or differential costs and understand the local context.

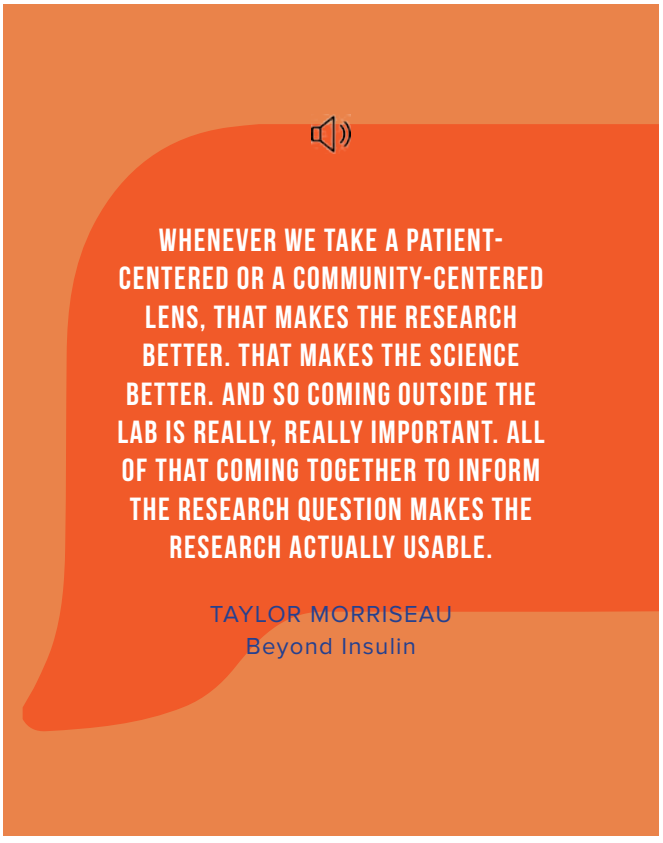
REDUCING STIGMA

Perhaps the biggest change in our understanding of addiction in recent years has been in adjusting our perceptions that addiction is not a moral failing but a health issue, and as such addicts are patients in need of healthcare interventions. Dr. Pafard sees hope in the next generation. He believes the willingness of his students to openly discuss mental health and lead with compassion will have positive effects over time, reducing stigma. Dr. Smith says she "believes in prevention...[and] in teaching youth they have control over their brains." While recovery can be challenging, it is possible. So too is societal change.●

Addiction: The Mind-Brain Connection *was delivered in partnership with the University of Ottawa's Institute for Science, Society and Policy.*

Special thanks to the National Research Council Canada for supporting this event.

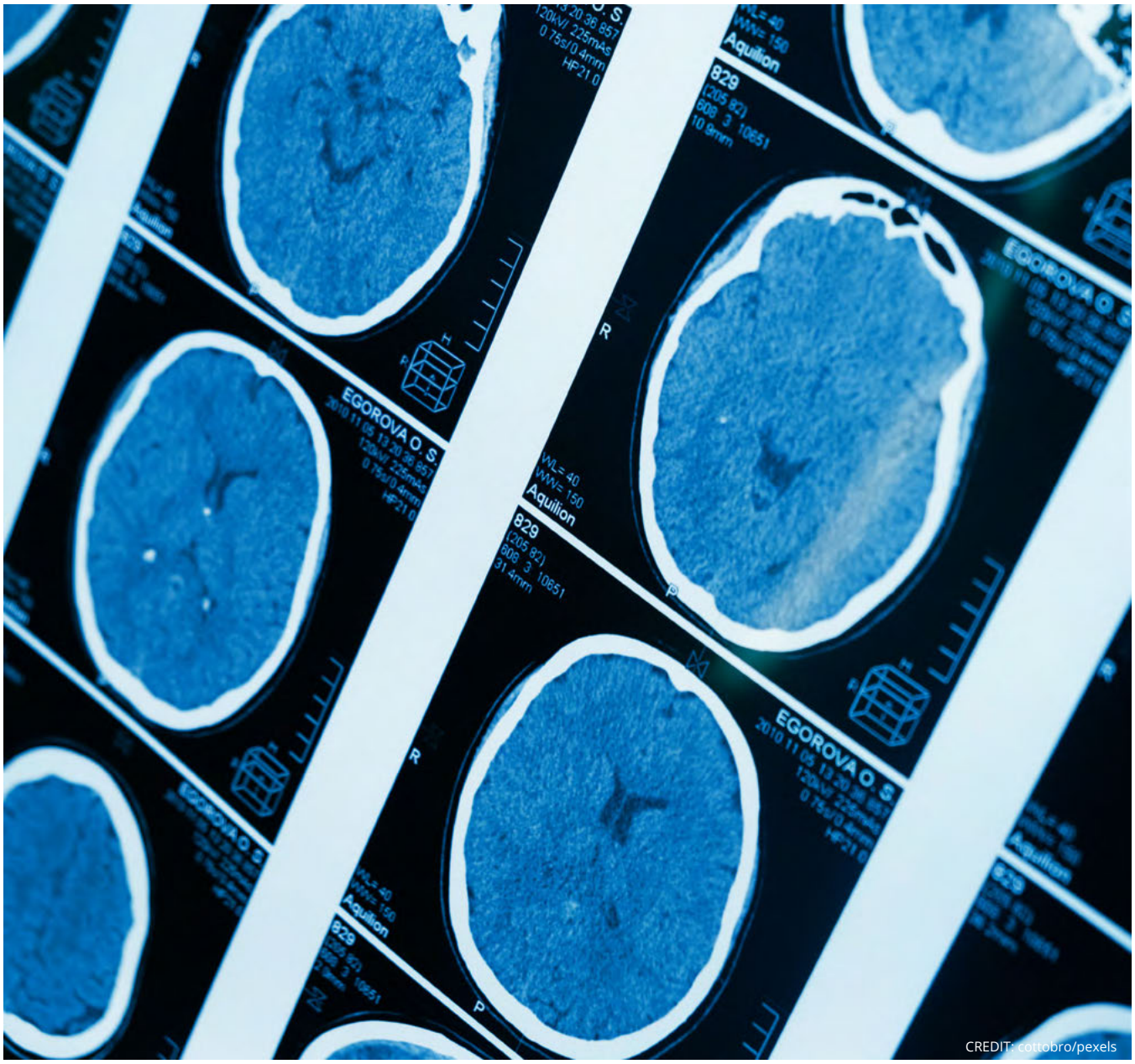
Click here to watch the full event.



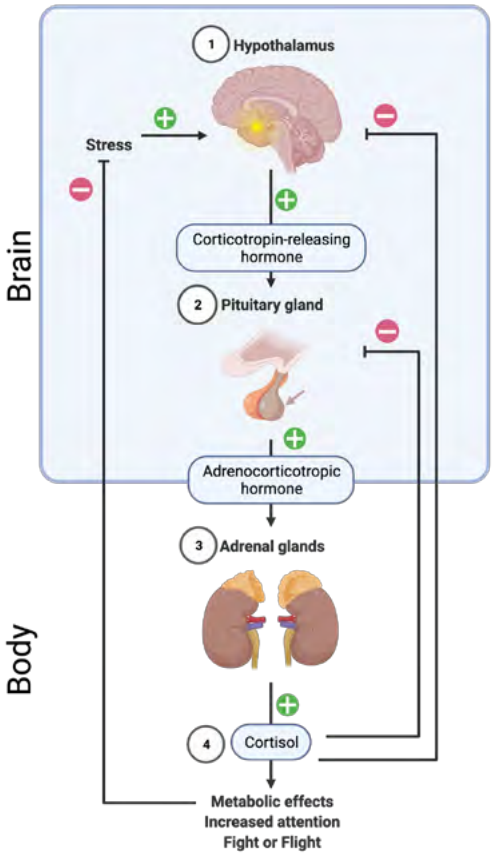
Your Brain on Stress

by ELIZA ALI

THE PANDEMIC CREATED UNEXPECTED CHANGES THAT CHALLENGED THE WAY WE FEEL, COPE AND ADAPT.



CREDIT: cottobro/pexels



One of the key brain response pathways for stress is the hypothalamic-pituitary-adrenal (HPA) axis. When confronted with a stressor, hormones released from the hypothalamus (1) and the pituitary gland (both in the brain) (2) stimulate the adrenal glands (3) (located just above the kidneys) to release cortisol (4). These hormones are called corticotropin-releasing hormone and adrenocorticotropic hormone, respectively. Cortisol alters metabolism and increases attention to help the body 'fight or flight.' When the stressor is gone, cortisol goes back to the hypothalamus and the pituitary gland to stop the production of corticotropin-releasing hormone and adrenocorticotropic hormone. The adrenal glands stop making cortisol and the stress response stops. This is called a negative feedback loop.

ILLUSTRATION: Eliza Ali, created with BioRender.com
Template adapted from: Camilla Maria Fontana, PhD Student, University of Padova

THE COVID-19 PANDEMIC familiarized us all with lockdowns, mask wearing and physical distancing. Work and school moved online while essential workers risked their lives to ensure basic services remained available and kept us safe. These changes contributed feelings of uncertainty and of being overwhelmed to many. This was exacerbated by the social unrest that took place in the same year. The murder of George Floyd, systemic racism, the economic downturn and misinformation all made it feel like society was falling to pieces. During these trying times, understanding stress, our brain's response to it and coping strategies to manage it can help us build resilience as we encounter difficult situations.

THE N.U.T.S. AND BOLTS OF STRESS

Our ancestors faced many obstacles that threatened their survival and the human brain evolved to detect and respond to these threats. When triggered, the brain initiates the stress response to release a hormone called cortisol. Cortisol shifts the body's energy and attention to either 'fight or flight' in preparation to confront or flee the situation. Once the threat passes, cortisol levels decrease, returning the body back to normal. Today's stressors, however, are not predators; they are deadlines, bills, being overworked, and most recently, surviving a global pandemic.

Dr. Sonia Lupien, founder and Director of the Centre for Studies on Human Stress (affiliated with L'Université de Montréal), investigates the effects of stressors on the brain from early-life to adulthood and old age. Dr. Lupien explains that, in the past, most threats were absolute, meaning they were a matter of life and death. Today, relative stressors, which are subjective and personal, are more common. These can be tight deadlines, pressure at work, writing exams and even traffic. While not a matter of life and death, these stressors release cortisol to the same degree as if you were about to be attacked by a predator.

Dr. Lupien coined the term N.U.T.S. to describe the components that make a relative stressor; Novel, Unpredictable, Threat to ego and Sense of low control. A relative stressor must be composed of at least one of these components. The current pandemic is unique as it comprises all of the N.U.T.S. elements. It is a novel crisis experienced globally and each week seems unpredictable with uncontrolled viral spread and new lockdown measures. It is a threat to our ego, where we fear judgment from others as we take precautions like physical distancing or disengage from social activity. We also have a sense of low control when it comes to the availability and pace of vaccination and how 'COVID-safe' other people are behaving.

Understanding the N.U.T.S. of stress can help identify ways to cope. For example, when there is a sense of low control, shifting the focus to what we do have control over (such as staying home or wearing masks) can help reduce feelings of stress. The relative stressors caused by the pandemic may differ from one person to the next, but everyone is experiencing them.

IS STRESS CONTAGIOUS?

Your stress is not isolated to only you. It can be experienced by those around you indirectly through subliminal cues. This means that negative and traumatic events seen on the news, social media and even experienced in conversation can stress us out. That being said, surrounding ourselves with meaningful people can buffer some of these effects.

Dr. Jaideep Bain is a Professor of Physiology & Pharmacology at the University of Calgary and a member of the Hotchkiss Brain Institute. Dr. Bain's research investigates the physiological and psychological impacts of stress and how it can transfer between mice. In his study, a mouse that was interacting with a stressed mouse experienced the same activation in the hypothalamus (a brain region involved in stress) to similar levels as its stressed companion.

Dr. Bain discovered that the stressed mouse passed on signals, such as alarm pheromones, to the other mouse during the interaction. Pheromones are chemicals that are secreted from the body and provide social information, such as the emotional state of the secreter. Importantly, these signals are processed by the hypothalamus, the region of the brain that initiates the stress response. In humans, other signals like sweating, pupil dilation, skin colour changes (like blushing) and body language are also unconsciously processed by the hypothalamus to activate stress responses and emotional states. This is one of the reasons why we may feel upset after watching or hearing distressing news or feel inspired to support others through protest or charity.

Sharing emotional states with one another facilitates meaningful interactions that can alleviate some of the effects of stress. Bains notes that while stress can be transferred from a stressed to unstressed mouse, social interaction with the unstressed companion also led to stress buffering effects, like reduced stress hormone levels, in the stressed mouse. Interestingly, this stress buffering only occurred in female mice. The reason for this sex difference requires further investigation and is largely unknown.

COPING WITH STRESS

Social media has highlighted how different people cope with the pandemic. With more time at home, some were baking bread, going on adventurous walks, taking up new hobbies or binge-watching TV shows. Though many have found positive ways to cope, others leaned on more detrimental methods with disruptive changes in eating, sleeping and physical activity.

Coping is the collective cognitive and behavioural efforts by a person to help manage specific external and/or internal demands that are considered stressors. Dr. Alexandra Fiocco, an Associate Professor in the Department of Psychology at Ryerson University and the Director of the Stress and Healthy Aging Research Laboratory, explains that these coping efforts can be divided into problem-focussed coping and emotion-focussed coping. Problem-focussed coping involves methods that are used to manipulate the stress so that the individual feels a level of control. Emotional-focused coping involves changing the perception of the stressor. This is beneficial when the sense of control is lacking. These coping strategies are influenced by different lifestyle activities.

Dr. Fiocco emphasizes that creating positive coping strategies takes time, training and consistency. Healthy eating, physical activity, social engagement and contemplative practice can help us thrive during any stressful situation, but especially during the pandemic.

The pandemic created unexpected changes that challenged the way we feel, cope and adapt. While stressors are inevitable, Dr. Lupien explains that we must build resilience by not being afraid of them. Yes, the pandemic is a stressful time but sharing our experiences and learning from others can get us through it. Learning how to appropriately manage modern stress will ultimately help us thrive in the future. ●

Click here to watch the full event.

LIFESTYLE ACTIVITIES THAT INFLUENCE COPING STRATEGIES

DIETARY INTAKE
Emotional eating is a common form of coping. Although it acts as a temporary escape, it can become maladaptive. Unhealthy food choices can increase the risk of type II diabetes and cause metabolic changes. Maintaining a healthy diet consisting of important nutrients to support a healthy body and immune system is a better way to cope with stress.

PHYSICAL ACTIVITY
In addition to the cardiovascular benefits of physical activity, aerobic training can reduce levels of stress hormones, decrease negative emotions, and promote better recovery after a stressful event. It also strengthens the brain connections in areas responsible for stress regulation and memory.

SOCIAL ENGAGEMENT
Stay-at-home orders, physical distancing, no group gatherings and Zoom fatigue have left many feeling socially isolated during the pandemic. Dr. Fiocco notes that having meaningful and beneficial social interactions (that are safe during the pandemic) can promote a healthy immune system and reduce levels of stress. Social engagement is effective in uplifting mood and positive emotions when it is supportive.

CONTEMPLATIVE PRACTICE
Mindfulness, meditation and compassion training is becoming a major part of self-care to build resilience and develop better emotional control. These practices have shown to decrease the physiological effects and the perception of stress. Deep diaphragmatic breathing (belly breathing) can have almost an immediate effect in decreasing the feelings of stress. It slows down the activity of the stress response, thereby reducing cortisol.

BEYOND OPIATES

New Horizons in Pain Research

by DARREN CHENG

CREDIT: vecteezy.com

PHYSICAL PAIN IS HARD TO FORGET. The memory is often associated with a specific experience, place or emotion. But even for something so universal, a lot of research is still needed to better understand what causes pain and how best to treat it.

Many people develop painful health conditions during their lives, especially as they get older. It is important to find effective ways of preventing these conditions, and treating them when they do occur. However, existing drug treatments for pain can also lead to negative side effects like reliance and addiction. As such, researchers aim to find alternative ways to target pain with fewer side effects.

WHAT IS PAIN AND WHY DOES IT EXIST?

"We always think of pain as something negative," says Dr. David Julius, a Professor at the University of California San Francisco and 2021 Nobel Prize laureate. "But the pain system is so important for maintaining our health because it is our main warning and protective system that tells us when we've injured ourselves or when we're about to injure ourselves."

Pain is detected through special cells called pain neurons that exist throughout the body—in our skin, within our muscles and even surrounding some of our internal organs. Moreover, these cells have different receptors that allow them to detect different things, like pressure, temperature and

even specific molecules. When these pain receptors are activated, they can send information to nearby parts of the body and to the brain.

The first pain response is fast and automatic. Think about a time when you accidentally touched a hot stove, or stepped on a small toy. Did you pull your hand back, or jump away immediately? These are situations where your pain neurons quickly cued nearby muscles to react and move you away from the painful stimulus.

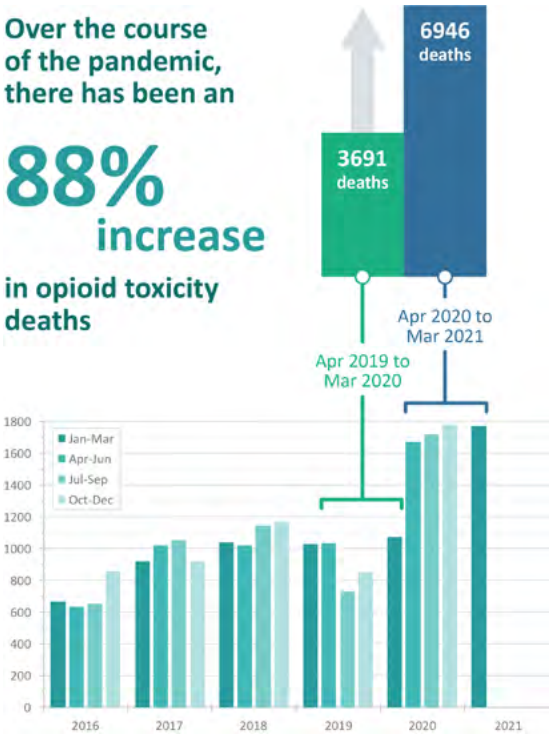
The second, slower type of pain response sends information to your brain about what you experienced. You can probably remember a lot about the last time you experienced something painful. Perhaps you recall where you were and how it made you feel? Did your hand or foot turn red and ache afterwards? Giving your brain more information and prolonging the experience of pain as your body heals helps you to form a memory that will reduce the chances of you repeating the actions again in the future. Dr. Julius explains, "individuals who cannot sense pain are at great risk of injuring themselves."

These dual roles of pain help protect you in the moment and in the future. But pain goes far beyond occasional accidents and injuries—sometimes, pain can outlive its usefulness. "While acute [short-term] pain is very protective and essential for our bodily health," Dr. Julius explains, "this system can become persistent and debilitating." Sometimes pain continues long after the cause is gone, and other times, pain exists without a source of danger or injury at all.

WHEN PAIN OUTLIVES ITS USEFULNESS

Some estimate that persistent or chronic pain affects up to a fifth of the general population; it can take on many forms, such as arthritis, fibromyalgia and low back pain. These conditions involve pain that lasts months, if not years, and often prevent people from functioning comfortably or easily in their everyday life. Because of the negative impacts of persistent chronic pain, many researchers are working to find effective treatments for alleviation.

Some of the most common and well-known treatments for pain are medications like aspirin, ibuprofen or codeine, which reduce inflammation in our body and how much pain we feel. Unfortunately, these treatments don't always work for everyone or for every type of pain, and can result in negative side effects when used frequently.



According to the Public Health Agency of Canada (PHAC), opioid-related overdose deaths have seen an unprecedented increase during the COVID-19 pandemic. The Agency cites a number of factors contributing to this, such as increasingly toxic drug supply, increased feelings of isolation, stress and anxiety, and limited availability or accessibility of services for people who use drugs. ILLUSTRATION: Darren Cheng, with publicly available data from PHAC.

OPIOIDS AND CHRONIC PAIN

Historically, opioids like morphine were used to treat pain in specific situations, such as after surgery or during end-of-life care. However, a shift occurred in the medical field during the late 1990s and physicians were encouraged to prescribe opioids for long-term, chronic pain. This change stemmed from a flawed understanding of the addictive properties of long-term opioid use in combination with promotion from large pharmaceutical companies. Unfortunately, this increase in opioid prescription led to widespread reliance on the medication and similar substances, and an increased risk of overdose that persists today.

Public health and medical experts now describe this phenomenon as the opioid epidemic or opioid crisis, and much work has gone into providing services and treatment for those living with substance use disorder. The repercussions of opioid prescriptions have only spurred pain research further. Nowadays, large pharmaceutical companies produce fewer pain medications, with focus shifting to expanding the existing toolbox of pain treatments including pharmacological and non-pharmacological interventions.

THE CUTTING EDGE OF PAIN RESEARCH

The pathways responsible for different kinds of persistent pain aren't completely understood, making it difficult to identify effective treatments. "A big goal in [our] work is to understand how this transition from acute to persistent pain occurs," says Dr. Julius. "What are the underlying physiological and molecular mechanisms? The ultimate goal is to either reverse this or to prevent it from happening altogether."

Researchers and scientists are now equipped with new and emerging advanced techniques for conducting pain research that didn't exist at the beginning of the century. Techniques like computational chemistry use computer modelling and simulations to study drug candidates and how they might trigger cellular pathways to reduce pain while avoiding pathways that lead to negative side effects.

Interventions like acupuncture, cannabinoids, and naturopathic medicines are promising pain treatment candidates to investigate, but more rigorous and controlled studies are still needed to provide evidence of their effectiveness. Online psychological programs and acceptance and commitment therapies are showing early promise in improving depression in those living with chronic pain.

Dr. Julius' lab is mapping pain neurons that have become hyperactivated in certain chronic pain conditions and identifying specific molecules that can deactivate them. The hope is that these molecules can then be developed into drug treatments to minimize pain.

Researchers have also been working on a subset of neurons that dull the sensation of pain by inhibiting other neurons that signal pain to the body. In some chronic pain conditions, these helpful neurons may become injured or disrupted, leading to overactivation in painful sensations. Some pain research labs employ stem cell and bioengineering techniques to restore these helpful inhibitory neurons. Other researchers use electrical or magnetic devices to stimulate or modulate the inhibitory pathways that normally help to minimize pain.

Pain research now harnesses modern technology to investigate potential treatments found in the natural world. Plant toxins and animal venoms can be composed of hundreds of different compounds, some of which are promising candidates for pain treatment. Common pain medications such as aspirin and morphine were derived from willow tree bark and opium poppies respectively. Investigating these natural products builds upon and connects with traditional experiences and knowledge and it's important to continue this work with cultural, ethical and social sensitivity.

BEYOND OPIOIDS, AND THE FUTURE OF PAIN TREATMENT

With advances in scientific research, there is a lot of hope for finding effective pain treatments moving forward. Opioids are no longer the default pain treatment available, and the evidence-base supporting other interventions only continues to grow. With the understanding that pain pathways may vary from one person to another, treatments will also need to become more personalized. Indeed, treating pain may eventually include a combination of treatment methods, including non-pharmacological options. ●

Click here to watch the full event.

CAROLINE EL KHOURY, Astronomy

Astro Caro

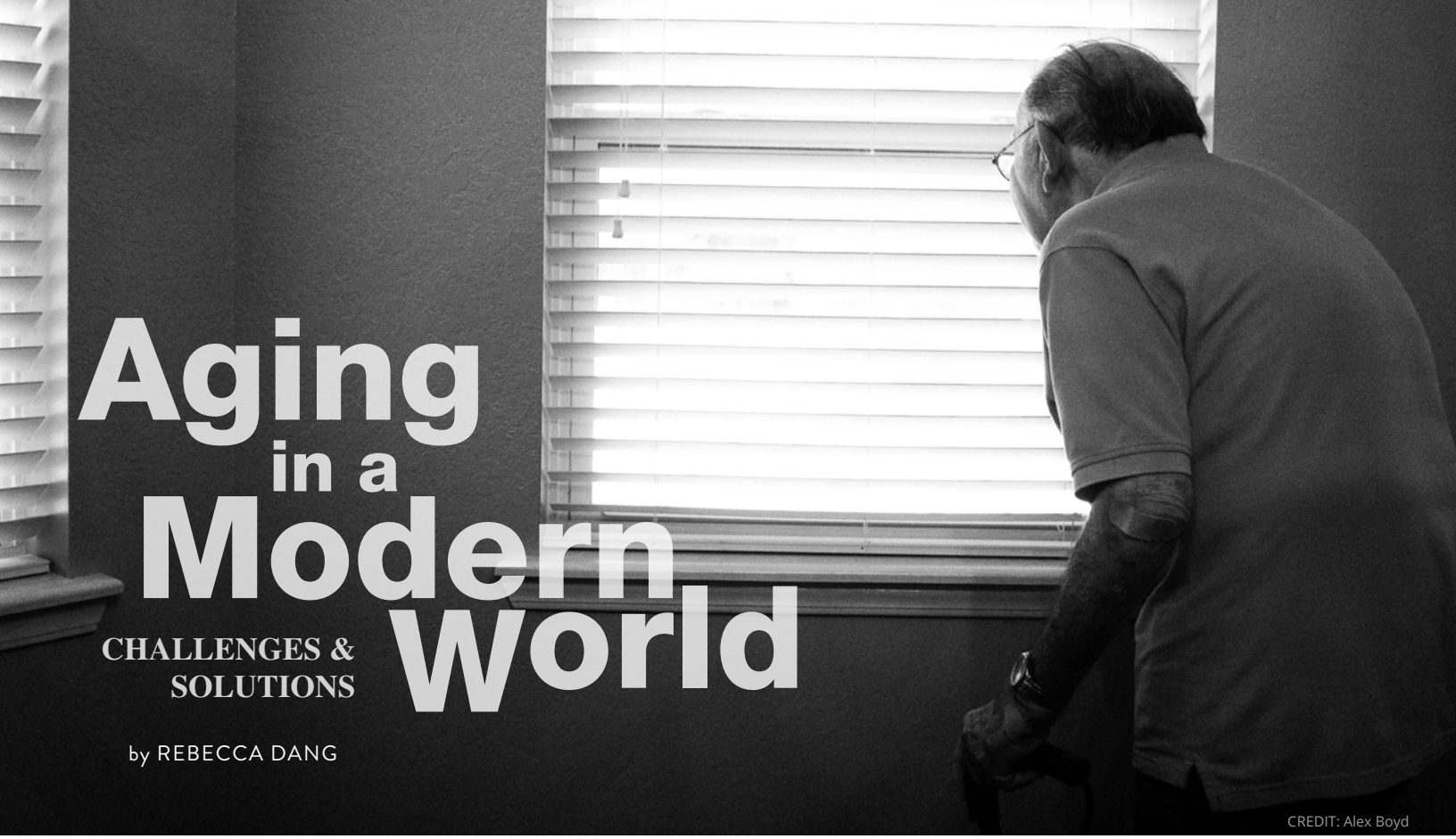
by REBECCA DANG

From radio waves to telescopes to dead stars, Caroline El Khoury introduced the majestic universe of radio astronomy during her takeover of RCIScience's Instagram account. Caroline is an astronomer who completed her BA at the University of New Brunswick in Philosophy and Mathematics before graduating from the University of Toronto's Physics and Astronomy program. During her time as a graduate researcher, she studied invisible electromagnetic waves released from pulsars and their behaviour in the galaxy.

Pulsars are fast rotating neutron stars that were once live stars and weighed more than 10 times the sun. While technically dead stars now, pulsars still emit a strong radio wavelength that can be captured on Earth as signals. Through radio astronomy, a subfield of astronomy that examines the wavelengths of light, astronomers can examine pulsars to identify new planets in the galaxy, measure cosmic distances and even inform future space navigation. Caroline had the opportunity to continue her exciting research on understanding pulsars when she interned at ASTRON, the Netherlands Institute for Radio Astronomy in 2019.

Caroline's Instagram page, @astro.caro, provides followers with a glimpse of her daily life as an astronomer and updates from the intergalactic world of astronomy. She aims to connect the astronomy community with the public and communicate space research to others. Follow her for fascinating posts about telescopes, life as a working astronomer and profiles of female figures in astronomy. In addition to her research and science communication initiatives, Caroline enjoys exploring the outdoors, hiking and climbing mountains with her optical telescope to stargaze.

To explore Caroline's out of this world Instagram Takeover for yourself, head over to RCIScience's account, visit our Guides and scroll through our Highlights.



Aging in a Modern World

CHALLENGES & SOLUTIONS

by REBECCA DANG

CREDIT: Alex Boyd

STRATEGIES TO HELP ADAPT TO AGING VISION

Getting daylight outdoors or sitting near a window can help the eyes receive illumination. Natural lighting is particularly important for a person's circadian rhythm.

A task light indoors can help to provide general illumination when searching for items.

Having a magnifier or a cell phone that you can use to zoom in on labels can help in reading the fine print on pill bottles. Purchasing items with bright colours or high light and dark contrast can also help with identification.

Transitional lighting between dark and light settings gives eyes time to adjust to changing environments.

ACHES AND PAINS, MEMORY LOSS AND BLURRED VISION are common symptoms that many aging adults experience. While younger generations may not grasp these difficulties, the reality is that everyone is aging. The current world's population is the largest and oldest in history. There are over 4.8 million Canadians over the age of 65 today, a number that Statistics Canada predicts will grow to 9.9 million by 2036. This puts immense pressure on Canada's healthcare system to care for this increasing vulnerable population.

In addition to physical stresses, today's digitally-connected society poses more cognitive, social and sensory challenges to an aging population that risks being left behind by fast-paced, constantly changing technology. These pressing issues need to be addressed, with innovative solutions to engage older adults and help them navigate new physical, mental and social struggles.

VISUAL ACUITY AND AGING

Our vision undergoes natural changes over time. Older adults experience three common conditions in normal aging:

1. the failure to autofocus—or "presbyopia";
2. impaired vision from reduced light reaching the retina; and
3. slower adaptation to changing light levels.

As we age, the lens of the eye becomes stiffer. Lost flexibility makes it harder for the eye to adjust for focus, resulting in presbyopia. "Not only does the lens of the eye get less flexible as we age, but it also starts to yellow and becomes denser, so less light goes through it," explains Dr. Fran Wilkinson, an Emeritus Professor in the Psychology Department at York University. The small amount of light that does go through the lens is from the longer wavelengths—those on the yellow side of the colour spectrum—thus putting a yellow filter on a person's colour vision and making it difficult to see blues and purples. Aging also slows

Many factors associated with natural aging can lead to impaired vision. Cataracts can form in extreme conditions, reducing and scattering light, and making focusing more difficult. Our pupils also enlarge with age, causing even less light to enter the eye, especially in dim settings. The collective reduction of light to the retina makes it difficult to view fine details and requires higher contrast to properly see certain things.

neural processing, making visual acuity more difficult since it takes more time for a person to adjust to changing levels of light.

The York University Centre for Aging Research and Education was established in 2014 to focus on aging-related research at the individual and societal level. The goal of the Centre is to tackle the challenges of aging using an active and positive approach through research and education. Dr. Wilkinson has conducted research on vision and migraine headaches, and is currently examining how LED lighting can help create more user-friendly environments for the older population. "Our goal is to make vision as effortless as possible for our older eyes," proclaims Dr. Wilkinson. To help ease the eyes from constraint, there are multiple strategies that can help seniors with daily tasks (see sidebar). While every pair of eyes age at different rates, Dr. Wilkinson recommends, "be your own vision scientist and try changing your environment to help you see better," actively adopting different strategies to assist the eyes through the aging process.

COGNITIVE SHIFTS WITH AGING

With some areas of cognition declining and other aspects improving as we age, a cognitive shift occurs. For example, speed of processing or memory begins to decline at the age of 20, while verbal ability and knowledge of the world increase with age. Shifts in cognitive aging result from declines in fluid cognition, which uses new knowledge collected from our continuous interactions with the world, towards a reliance on preserved crystallized cognition, which relies on previously acquired stored knowledge.

The brain can be visualized as a combination of networks working together. There are three important networks:

1. the default network,
2. the attention network, and
3. the control network.

The default network is involved in internal thinking, such as remembering plans and retrieving memories. The attention network helps us navigate the external world around us. For example, looking at the surrounding environment, taking in information and acting or reacting to that stimulus. The default and attention networks are anti-correlated so when one network is active, the other network is suppressed. The control network helps us focus on certain aspects of interest, so that random thoughts don't spontaneously intrude. It helps the brain toggle between the default and attention networks.

"The default network seems to be particularly susceptible to age-related decline in older adults," explains Dr. Dale Stevens, Associate Professor in the Department of Psychology at York University. "There is a reduced suppression of the default network when older adults are doing externally focused tasks such as looking at images." There is a link between the default and control network because older adults rely more on crystallized cognition and less on fluid cognition.

Preliminary studies from Dr. Stevens' Cognition & Aging Neuroscience Laboratory have shown that neurofeedback training can help increase cognition in older adults. Participants are attached to an electroencephalograph—a machine that reads electrical impulses from outside of the skull that reflect brain activity. Through implicit learning, using rewards like compliments or deterrents, to form associations with certain behaviour, the participant can exert control over their own cognitive activity. "It is sort of a positive feedback loop. Participants can learn to increase or decrease activity in certain parts of the brain [to improve cognition]," explains Dr. Stevens.

Dr. Stevens is collaborating with a mobile technology company called Xsensa Labs to develop real-time neurofeedback software that brings his lab work into the real world for seniors. The software asks participants to complete a virtual activity like riding a bike on a mountain. The software tracks the participants' progress throughout multiple sessions and increases the virtual bike speed or the moving scenery as a reward if the participant is enhancing activity in certain areas of their brain. If participants are not stimulating the right areas of their brain, the software responds by slowing down the bike speed or scenery. Through these neurofeedback train-ing sessions, participants learn to control their brain activity to combat age- related cognitive decline.

Fluid cognition is the ability to think, reason, and solve problems using new knowledge or information. For example, travelling to a new city utilizes fluid cognition since it requires the brain to use problem-solving skills to navigate an unfamiliar place.

Crystallized cognition is stored knowledge rooted in experience or facts that people have acquired. Memorizing famous historic event dates involves using crystallized cognition.

IS THIS A SCAM?

While life experiences can typically inform better decision making, Dr. Gary Turner, Associate Professor in the Department of Psychology at York University explains, "there are some processing skills that are relevant for financial decision-making that decline, [such as] processing speed and episodic memory, that interfere with the ability to make good decisions." The Baby Boomer generation (born between 1946 and 1964) is becoming the wealthiest generation in human history. But aging may make them vulnerable targets of financial exploitation by fraudsters. The internet has provided an easy avenue to

scam seniors, who, contrary to the common stereotype, are fairly active online. "About 97% of seniors at an average age of 75 are doing activities online, whether it is social media or email," says Dr. Turner. The financial exploitation problem is predicted to grow in the coming years, with many experts calling it a "public health crisis and even a virtual epidemic."

There are various reasons why some adults find themselves at higher risk for financial exploitation. Research suggests that as people age, they are naturally more trusting and have increased difficulty distinguishing untruthful behaviour. "Older adults tend to see the future through a more positive lens," elaborates Dr. Turner. "That mindset increases the risk of exploitation." With aging, there is a general increase in empathic response, while social isolation may further result in vulnerability to scammers. "The best financial decisions are made with the consultation of people in your circle and who you trust like family members and friends," says Dr. Turner.

To help older adults recognize and avoid online exploitation via email, Turner's lab is developing a software called Merlin. Seniors are recruited as participants into a study where they are sent spam emails with a clickable link for one-month. Data reflecting the number of link clicks is subsequently collected and analyzed. The goal of the project is to identify categories of deceptive cues, so that they can warn older adults at higher risk of exploitation by emails.

While there are many challenges associated with aging, it's important to remember it is a natural process that is welcomed and gracefully embraced by many people. Many cultures rely heavily on their elders' extensive life experiences to guide and advise the next generation. In addition to wisdom, positivity and empathy are some of the many positive traits that older adults develop and impart on society. "There is a lot to gain that occurs with aging," says Dr. Turner. "It is both cognitive gain and social gain, [which includes] emotional functioning. The positive aspects of aging is what really gets me excited about [my research]." ●

Special thanks to the National Research Council Canada for supporting this event.

Click here to watch the full event.

SPOTLIGHT: Board Member

MATHIEU RANGER, Science Communicator/Molecular Biologist

Meet Mathieu Ranger, one of our favourite Board trustees! You may have chatted with him to help us shape RCIScience in recent years. He fell in love with talking about science during his Masters in Molecular Genetics at the University of Toronto. From there, he completed a Masters in Science Communication in Bristol, became an Educator at the Ontario Science Centre, and then joined Bridgeable Inc. Now he's building his business creating story-based tabletop science games for adults.

One of his more memorable moments with RCIScience came recently, as the Board was coordinating its response to the COVID-19 pandemic and a member asked, "Well, what did we do during the 1918 pandemic?" As Mathieu puts it, "I don't think there are many organizations who can look back to how they responded to a similar crisis that happened over 100 years ago!"

WE CAN BE PART OF MAKING SCIENCE. THERE'S CITIZEN SCIENCE, WHICH IS HAPPENING NOW THAT IS REALLY POSITIVE. SCIENTISTS ARE GETTING INVOLVED IN THE POLITICAL PROCESS, WHICH I THINK IS HUGELY POSITIVE. BUT WE REALLY NEED TO THINK ABOUT SCIENCE AS SOMETHING THAT IS FOR EVERYONE, AND NOT JUST SOMETHING THAT ONLY EXPERTS CAN DO.

SONIA SHAH
Pandemic: In Conversation with Sonia Shah

Modern chocolate did not really exist until the 1800s, when paste from the cacao plant was mixed with sugar to create what we now recognize as "chocolate". Before this, the cacao plant was enjoyed by the Aztec and Inca peoples dating back to 600 CE. In this case, the cocoa beans would be roasted and ground using mill stones to produce a paste, which would then be added to water with spices and honey to produce a much-revered beverage.

WHEN YOU ASK SOMEONE what their favourite type of chocolate is, most people have a specific answer. There are strong proponents who push the extremes of pure chocolate, swearing 95% cacao is the only option, while others love the creamy sweetness of a white chocolate bar.

Regardless of what camp you are in, the delights of chocolate are held near and dear to many people's hearts—and bellies. But what really is chocolate and how is it produced? What do the many varieties of chocolate have in common? Food scientist Selvyn Simones shares his love of chocolate and the science behind it.

HOW IS CHOCOLATE MADE?

Chocolate production starts with cocoa pods grown on the *Theobroma cacao* plant. Selvyn explains, "[these thrive] in the hot and humid climate of countries that fall along the Earth's equator." This includes major chocolate-exporting regions like Brazil, Indonesia and West Africa. When the pods are harvested and cracked open, they reveal 30-50 seeds encased in a white substance called pulp, which has a pithy, lemon taste.

The pulp is then fermented by microbes for several days using the yeast and bacteria that naturally exist in the environment. That's right, just like wine and bread, we have microbes to thank for chocolate. These microbes digest the pulp, producing many complex compounds that are critical to the chocolate flavour. These are absorbed by the seeds (now referred to as beans) over a period of days. The fermented beans are then laid out in the hot open air and dried out before roasting.

Roasting is a critical step involving a myriad of chemical reactions between the proteins and sugars within the beans. The shells are then removed, and the beans are broken into small pieces called cacao nibs. These are ground up further and sugar and spices are added. As the nibs are ground into miniscule particles, the fat, called cocoa butter, begins to separate out. First resembling wet sand, the mixture slowly evolves into a smooth, viscous, melted chocolate masterpiece. By this stage the true chocolate has taken form, and the chocolate particles, called cocoa solids, are so small that they have essentially dissolved into the cocoa butter, creating the smooth creamy sensation you experience when eating it. "One of the most remarkable things about chocolate is that it stays solid at room temperature, but becomes liquid at body temperature," Selvyn pointed out. "[This creates] that luxurious melt-in-your-mouth quality."

TYPES OF CHOCOLATE

What constitutes chocolate is a contentious subject. While many would agree that the three major types are white, milk and dark chocolate, white chocolate doesn't actually contain any cocoa solids, only cocoa butter and added milk fats, such as powdered or sweetened condensed milk. Cocoa solids and cocoa butter can be separated out during processing to create specific types of chocolate. As you increase the proportion of chocolate solids, you transition from milk to dark chocolate. The high percentage of milk fats in white chocolate lowers its melting temperature. This makes it melt faster in your mouth and gives it a creamy texture.

The relative absence of these fats in dark chocolate results in a higher melting temperature and a waxier texture. In reality, every country has different regulations that determine what can legally be called chocolate and how these three core types are distinguished. This is why chocolate bars in the United Kingdom or the U.S. taste different from those in Canada.

	WHITE	MILK	DARK
cocoa butter	> 20%	> 15%	> 18%
cocoa solids	-	> 25%	> 35%
milk fat	> 3.5%	> 3.39%	-

Components of chocolates types in Canada.
SOURCE: Government of Canada

TEMPERING

"One of the most fascinating things about chocolate is that it can exist in six different solid states, called forms I to VI," Selvyn explains. Each state is associated with a different organization of particles within the bar that presents different properties. Tempering chocolate is the process of adjusting the temperature to ensure that the chocolate hardens in form V, which produces shiny

Cacao pod. CREDIT: Rodrigo Flores

chocolate bars that snap when you break off a piece. If the temperature is just a little off the bar can solidify in form IV or lower, which takes on a crumbly texture, or form VI, where the chocolate has a white coating on the surface called a chocolate bloom. Most of us will have seen the chalky chocolate bloom on old, forgotten Halloween candy, or if you leave chocolate in your hot car. Despite all the time and money invested in understanding chocolate, we still don't know exactly how chocolate adopts its form VI state.

The production of chocolate spans numerous disciplines, encompassing the intricacies of its scientific manufacturing, the nuances of its legal definitions and the economic and environmental implications of its popularity. For a substance that has been around for centuries, the world of chocolate is still shockingly dynamic. In 2017, after more than a decade of development, the Belgian-Swiss company Barry Callebout unveiled a brand new class of chocolate to the world called Ruby chocolate. Derived from a different variety of cacao pod which undergo a slightly altered fermentation process, this chocolate has a sour, fruity flavour, and most strikingly, a naturally brilliant pink colour. Its development only highlights how much more there is to explore and understand about this much revered substance, by both professionals and chocolate enthusiasts alike. ●

Click here to watch the full event.

How do cacao plantations contribute to climate change?

Next time you are looking for your sugar fix and find yourself staring at the extensive options in the chocolate aisle, consider all that went into producing each bar. Like any large-scale farming operation, cacao plantations have led to the destruction of natural landscapes and diminished local biodiversity. Considering the socioeconomic status of the regions in which cacao farming is most prominent, environmental consequences are rarely taken into account. Recent strides by organizations such as the World Cocoa Foundation and The Rainforest Alliance have been made to educate local farmers on sustainable practices. These practices improve cacao quality and yield, and help to build a community of cacao farmers who can work together to prevent deforestation and support sustainable production and reforestation. That said, far more needs to be invested in such programs to ensure chocolate production is sustainable and equitable, both socioeconomically and ecologically.

SPOTLIGHT: Board Member

DR. SAMANTHA YAMMINE, Science Communicator/Neuroscientist

RCIScience was over the moon to officially welcome Dr. Samantha Yammine, aka Science Sam, to our Board in Fall 2020.

Dr. Yammine is a neuroscientist and popular science communicator. She gained her PhD from the University of Toronto where she studied how stem cells build and maintain the brain. More recently, however, she has been doing a fantastic job of distilling COVID-19 information and misinformation during the pandemic.

You might recognise Sam from talking about science on Netflix, TVO Kids, CBC GEM, Discovery UK, CBC Radio, AsapSCIENCE, 3Qs at the U or any number of news appearances over the past year.

Dr. Yammine is an active member of our Program Committee and co-produces *Science is a Drag* with us. You may even recall she moderated a fantastic #RCITalks panel exploring the prospects of stem cells in Fall 2019. We think she'll be a fantastic liaison between the Board and the needs of our community, helping us to build an even stronger network of science enthusiasts across Canada that's continually challenging the traditional stereotypes of who belongs in STEM (science, technology, engineering and math).

Her favourite memory about RCIScience is a 3-way tie between:

1. Tasting her way around the *Science of Cheese* in 2019.

2. Eva Bloom (@whatsmybodydoing) teaching us about sex education at 2020's *Spark After Dark* by having blindfolded volunteers identify mystery objects related to sexual health.

3. Witnessing @DynaCockusRose weave pop culture lip syncs into a lesson on antimicrobial resistance at 2019's *Science is a Drag*!

in a pickle THE SCIENCE OF FERMENTED FOOD

by GLORIA MANGA-EBENGUE

CREDIT: KTRYNA/UNSPLASH

ALMOST ALL CULTURES have a tradition of eating and drinking fermented foods. Everything from wine to sourdough, kombucha to chocolate, involves fermentation. These foods can pack more than just a tasty punch—they may be good for you, too! As we preserve the manna from our COVID-19 gardens, it should come as no surprise that there is a lot of science lurking in our kitchens.

WHAT IS FERMENTATION?

Fermentation is the chemical breakdown of a substance by bacteria, yeasts or other microorganisms for energy. This process typically involves the release of heat and effervescence—the escape of gas from a liquid resulting in foaming or fizzing. While fermentation is commonly practiced by communities living in northern climates, many foods from our diet come from equatorial regions where, historically, food needed to be preserved in the stifling heat. Fermentation allows this by facilitating biochemical reactions in food that reduce the chance of spoilage. Today, whether it's *Saccharomyces* yeast in bread and beer or *Lactobacillus* bacteria in milk, these unsung microbial heroes facilitate fermentation to add a depth of flavour and boost nutritional value in our food products.

WHAT CAUSES FERMENTATION?

"In the most basic type of fermentation, we are seeing glucose broken up [to produce] ethanol and carbon dioxide," explains Dr. Amy Proulx, Professor and Academic Program Coordinator for Culinary Innovation and Food Technology at Niagara College. "[The ethanol produced] is how we're creating the alcohol that we enjoy as wine, as beer and as distilled spirits." This is known as the glycolytic pathway. Bread can also be made from this simple reaction, where the carbon dioxide gas produced inflates the dough and gives bread its spongy texture.

Microorganisms like *Saccharomyces* yeast, meaning 'sugar fungus', ferment glucose and multiply by ballooning and budding off another yeast cell. They are instrumental in baking, as well as in wine and beer making. Dairy products, on the other hand, enlist the activity of two different reactions called the Leloir and Embeden-Meyer-Hoff pathways. These processes work in tandem to split the lactose in milk into two simple sugars: galactose and fructose. Galactose produces lactase salts, while fructose is shunted into a separate process that produces ethanol, acetate or vinegar, and lactic acid. Sourdough bread is made this way when sugars are converted to lactic acid. The Leloir and Embeden-Meyer-Hoff pathways can be performed by *Lactobacillus* bacteria, a common agent in manufacturing fermented dairies like milk, cheese and yogurt. Additionally, *Lactobacillus* is found in cabbage and is a particularly important component in producing sauerkraut, pickles and kimchi.

Many different types of bacteria and yeast are used in fermentation. This rich biodiversity allows food scientists to experiment and enrich flavour in fermented foods. "There are so many more diverse fermentation pathways," Dr. Proulx elaborates. "We are leveraging all of these different passageways to create the food that we want."

FERMENTATION IN THE KITCHEN

Although fermentation is a heavily industrialized process, it is accessible to home cooks and is a great way to highlight science in the home. Fermentation alters the flavour of foods and makes them bioavailable—that is, available to be absorbed and used by our bodies. Rebekka Hutton, a pickle maker and owner of the Alchemy Pickle Company, is an expert at making sauerkraut, and explains the reasoning behind the flavours of this European fermented cabbage. With just salt, the community of bacteria living on the cabbage ferment it and produce acid to create that unique sour flavour. When acidity decreases, more bacteria can grow, creating a cycle in which more fermentation happens to produce more acid. The final pH of sauerkraut is around 3, which provides natural preservation and layers of flavour. Rebekka recommends using salt without additives, such as sea salt.

Temperature plays a significant role in fermentation. Depending on your environment, the fermentation process can vary in speed; a cooler house will cause slower fermentation than a warm house. This is why you should pop the sauerkraut in the fridge when you are ready to eat it—to slow down fermentation. "The microbes that we're creating an environment for [during fermentation] love about 18 degrees," Rebekka elaborates. In fact, a microbe's ideal growth temperature is typically around 18-20°C, depending on the flavour profile and texture you want to achieve.

The type of vegetable used can impact fermentation and how well it is stored. Rebekka explains, "If you're using a vegetable that is firm and harvested in cooler weather, it will store a lot longer than a vegetable harvested in the

Saccharomyces cerevisiae with budding scars.
CREDIT: Mogana Das Murtey and Patchamuthu Ramasamy Mog

summer." A sea cucumber harvested in the summer, for example, will be softer and storable for a shorter period of time. Also, the way a vegetable is cut and sliced impacts fermentation. Rebekka mentions that at Alchemy Pickle Company, their sauerkraut uses a 4mm cut which keeps it crunchy. The smaller the cut/slice, the faster the fermentation, with larger cuts slowing down the process.

All of these variables impact the duration of the fermentation process. Rebekka recommends tasting your sauerkraut as you go along to see how the flavour profile changes over time. That way, you can decide when it is done based on how quickly you reach your desired flavour and texture.

Fermentation is an easy science experiment that you can do in the kitchen at home. "We're capturing the life and all of the enzymatic activity of living cells and we're converting it into an art form," Dr. Proulx proclaims. "Food science is awesome. [...] We get to eat our experiments!" Indeed, cheap, affordable tools are also available if you want to monitor and understand more about what's happening while you're fermenting your dinner. A hydrometer, which measures the brine concentration of salt, and a refractometer, which tracks soluble solids content, can provide insight into how changing parameters affect the taste of your fermented foods. Dr. Proulx also recommends delving into fun recipe books focused on fermentation science, such as *Wild Fermentation* by Sandor Elix Katz and *Norma Guide to Fermentation* by David Zilber and Rene Redzepi. Even Health Canada has detailed instructions for the fermentation of different foods.

> There are two kilograms of bacteria and fungi living within the human gut at any given time. This community is biodiverse and its composition is influenced by our diet. Consuming fermented foods can increase the biodiversity of these gut microorganisms, which may help prevent certain diseases. Many organic acids produced during the fermentation process can increase metabolism and antioxidant production, as well as decrease gut inflammation.

With an abundance of resources at hand, anyone can be a food scientist! From a fun science experiment to a provider of potential health benefits, fermentation brings tasty and beautiful results to our everyday foods and drinks. ●

Click here to watch the full event.

RECIPE **SAUERKRAUT**

INGREDIENTS:

1 head of cabbage (green, red, or a combination)

Sea salt, or non-iodized kosher salt

Filtered or tap water boiled and cooled, or well water or spring water (for dill pickles, sauerkraut does not need a salt brine)

Spices and herbs (e.g. chilli, dill, caraway, cumin, juniper, oregano, thyme, lemon—anything you like really!)

Other crunchy vegetables (e.g. carrot, radish, turnip, onion, beets, leeks, green onion)

EQUIPMENT:

Glass jar that is washed and rinsed well, then rinsed with boiling water and cooled to room temp. Ideally a wide-mouth 2L or 3L jar, but you can use one or a few 1L jars, if necessary.

Smaller jars to fit inside the mouth of the larger jar

Long wooden/metal spoon

Mixing bowl

Ideally a scale

DIRECTIONS:

1. Rinse the cabbage, cut the stems and remove the outer leaves (save them to use as weights for the end).
2. Cut the cabbage in quarters, and remove the core as it can be bitter. Slice the cabbage to your preference.
3. Mix your seasoning blend with salt. Some ideas for your blend include garlic paste, dried spices, chilli flakes, dill seeds, cumin and smoked paprika. Salt should be 2% of the weight of your cabbage; for every pound of cabbage you use, you should add 1½ to 2 teaspoons of salt. Sprinkle seasoning mixture onto your cabbage, making sure to incorporate it well.
4. Let everything sit for 30 minutes, then transfer the sauerkraut into a mason jar, making sure to pack it down. Use the leftover outer leaves to protect the sauerkraut from the air.
5. Ideally, sauerkraut should sit for about two weeks at around 20°C to ferment, but you can leave it as long as you want till you get the flavour you like. Check periodically for mould or particles. Once you reach the desired flavour profile, put it in the fridge to slow down the fermentation process until you're ready to eat it!

CREDIT: freepik

THE GREAT PANDEMIC BAKE OFF

The Science of Baking

by SHIVANI SETH

CREDIT: canva

WHAT MAKES A GOOD CAKE? For self-taught baker Dr. Sachin Seth, it all comes down to combining ingredients in the right way. "Baking is one of those amazing things—you can take three simple ingredients—sugar, flour and eggs—and combine them in a multitude of different ways, and you get very different outcomes every time," Sachin says.

For many of us, being at home during the pandemic has created opportunities to try our hand at baking. In Fall 2020, RCIScience explored The Science of Baking with Sachin Seth, Season Two runner-up of *The Great Canadian Baking Show*. More than a star baker, Sachin is a dentist and educator at Dalhousie University. While it may seem counterintuitive to be both an avid baker and a dentist, it is the precision of baking that appeals to Sachin's scientific and analytical side. "Baking is just a chemistry experiment—if you don't have all the right chemicals that you need in the right quantities, your experiment is not going to work out very well."

BAKING BASICS

A good foundation to any cake is in the combination of butter and sugar. Tiny sugar crystals punch through the butter to create air bubbles. Fat from the butter surrounds the air pockets and protects them. In the oven, these air bubbles help the cake rise.

After creaming the butter and sugar together, we add egg. "Eggs add lecithin," food scientist Frédéric Ah-Kahne tells us. "Lecithin is an emulsifier. It is a compound with both a water affinity and fat affinity." Lecithin allows liquids that would not traditionally mix, such as the butter and water in this recipe, to blend with one another. "This will stabilize the butter fats with the other ingredients," Frédéric elaborates. Flour adds further structure to cake. Flour contains gluten proteins, which expand within the air pockets and assist with the rise. Sachin's gingerbread cake recipe calls for all-purpose flour, which is an important distinction as not all flours are made the same. "There are different amounts of protein in different flours," explains RCIScience Virtual

Engagement Coordinator and event host, Celia Du. Cake flour has lower levels of gluten, while bread flour contains higher levels of gluten. The different levels of protein provide a different texture to our baked goods, which is why cakes are usually lighter and bread is denser.

While sugar, flour and eggs provide the base for our cake, there is an important chemical reaction that helps the cake leaven. Our gingerbread cake recipe calls for molasses, which is acidic. When combined with baking soda, which is a base, carbon dioxide gas is formed. Before combining your wet and dry ingredients, make sure that your baking pan is prepped and your oven is ready to-go! The acid-base reaction will begin as soon as you combine your ingredients.

If you leave the batter for too long, the carbon dioxide will escape and the cake will not rise as expected.

SUBSTITUTIONS—NO SWEAT

Baked goods can be adjusted to accommodate different dietary restrictions. Dairy-free? No worries! You can substitute butter with vegetable oil, vegetable shortening or margarine. Sugar can be replaced with Stevia or other artificial sweeteners. And if you are replacing the sugar, Sachin suggests using xylitol. Xylitol is a sugar substitute favoured by dentists because it prevents the bacteria in your mouth from metabolizing sugars.

For those who have gluten allergies or sensitivities, science communicators and PhD and MD/PhD candidates Sandhya and Swapna Mylabathua (aka the STEAM Sisters) share their secrets for gluten-free baking. "Possible alternatives include oat flour, sorghum flour or even brown rice flour—which has an increased starch content and elasticity," the STEAM Sisters say.

However, these flours bake a little differently, and you may have to experiment. "You are going to want to decrease the baking temperature by 25 degrees and increase your baking time," suggest the STEAM Sisters.

TOP TIPS

As our guests and audience baked along, Sachin shared plenty of tips for new bakers, from measuring out all of the ingredients before you start to remembering to add salt. But his most important advice for novice bakers is to keep practicing and experimenting with baking. "The mistakes are the best part, because that's where you learn." Sachin's time on *The Great Canadian Baking Show* encouraged him to be more innovative with this baking. Similarly, he urges bakers not to give up when things go wrong and to continue to try new recipes and ideas.

The Science of Baking is full of interesting science facts and tasty treats, culminating in gingerbread cake fresh from the oven. Sachin suggests whipped cream as a nice side to enjoy with a slice of this cake. And if you accidentally over-whip the cream, don't panic! You'll end up with some fresh, home-made butter for your morning toast, and some buttermilk for delicious pancakes.

If we learned anything, it's that Sachin continues to inspire the latent home baker and chemist in all of us. Follow along with Sachin's baking experiments on Instagram at @sweetoothhfx and watch The Science of Baking on YouTube now. ●

Click here to watch the full event.

A SPICY TALE

The History of Gingerbread

by KALI IYER

No gingerbread cake would be complete without its namesake ingredient: ginger. Derived from the Greek zingiberis, the underground stem (rhizome) of the *Zingiber officinale* plant produces this potent spice.

Originating in ancient China, ginger has been used to cure ailments, add flavour and produce a festive decoration. The Romans brought ginger to the Mediterranean and used it in various tonics and concoctions as a digestive aid, treating nausea, colic, flatulence and congestion. It is thought that the earliest recipe for gingerbread dates back to 2400 BCE, and consisted of almonds, old bread, rosewater and sugar.

The main purpose of this "spiced bread" was to preserve ginger. But when Rome fell, so too did the spread of ginger. In the 11th century, Crusaders brought spices back from the Middle East and the story of gingerbread in the West resumed. Monasteries were well known for producing gingerbread, often using pre-cut wooden molds to shape the bread. In fact, gingerbread became so popular that it resulted in a boom in the woodworking trade!

By the end of the Middle Ages, gingerbread guilds had sprouted across Europe, with the craft taught and production regulated. Gingerbread was the pinnacle of luxury and elegance in Elizabethan England, largely due to the high value of the precious spices within the bread. Gingerbread fairs were held throughout the year, where ginger biscuits were enjoyed dunked in wine and port. At these events, maidens would gift their favoured knight a gingerbread wrapped in ribbon for good luck, and unmarried women would eat "gingerbread husbands" to encourage future prospects. Queen Elizabeth I herself is credited with creating the first gingerbread men, when she gifted visiting dignitaries their likenesses in gingerbread.

Gingerbread didn't become associated with Christmas until the 16th-18th century in Germany, where gingerbread houses were first constructed. These intricate decorations provided a focal point for families to gather around. It is unclear if gingerbread houses were popular before or after the brothers Grimm wrote of Hansel and Gretel. Nevertheless, this fairy tale immortalized the gingerbread house forever.

CREDIT: Oriol Portell

RECIPE **GINGERBREAD CAKE WITH WHIPPED CREAM**

INGREDIENTS

1/2 cup white sugar
1/2 cup butter
1 egg
1 cup molasses
2 1/2 cups all-purpose flour
1 1/2 teaspoons baking soda
1 teaspoon ground cinnamon
1 teaspoon ground ginger
1/4 teaspoon ground cloves
1/2 teaspoon salt
1/2 teaspoon vanilla
1 cup hot water

For whipped cream topping:

1 cup whipping cream
1/4 cup icing sugar
1/2 tsp cinnamon
1/2 tsp vanilla

EQUIPMENT

Stand mixer or hand mixer
Measuring cups and spoons
Spatula
Whisk or fork
8-9" square baking pan
Parchment paper
Cooking spray

DIRECTIONS

1. Preheat the oven to 350°F. Spray the edges of 8-9" square baking pan with cooking spray and line the pan with parchment paper.
2. Cream together butter and sugar using a stand or hand mixer. Mix on high for approx. 3-4 minutes.
3. Beat the egg on medium-high into butter and sugar until well-combined.
4. In a separate bowl, combine flour, baking soda, cinnamon, ginger, cloves and salt. Set aside.
5. To the butter-sugar-egg mixture add molasses and vanilla.
6. Add dry ingredients into the wet mixture. Mix on low speed until just combined.
7. Add a cup of hot water while mixing on slow.
8. Pour batter into prepared pan. Bake for 45-50 minutes or until a toothpick inserted in the centre comes out clean.
9. Let cake cool in the pan for 10 minutes.
10. Dust with powdered sugar if desired.

Whipped Cream

1. In a chilled mixing bowl, add whipping cream. Mix until slightly thickened.
2. Add sugar, cinnamon and vanilla. Whip until stiff peaks form. Serve over cake.

TRIBUTE
EXECUTIVE DIRECTOR KIRSTEN VANSTONE

Kirsten (center) with Samantha Yammine (left) and Carrie Boyce (right) celebrating another successful event at *Science is a Drag*

As if the pandemic hasn't brought enough changes, Kirsten Vanstone stepped down from the role of Executive Director of *RCIScience* after seven great years! During her tenure, Kirsten supported the expansion of RCIScience into new cities across Canada, helped diversify our science-themed programming and steered us deftly through the initial months of an unprecedented global pandemic.

In her own words:

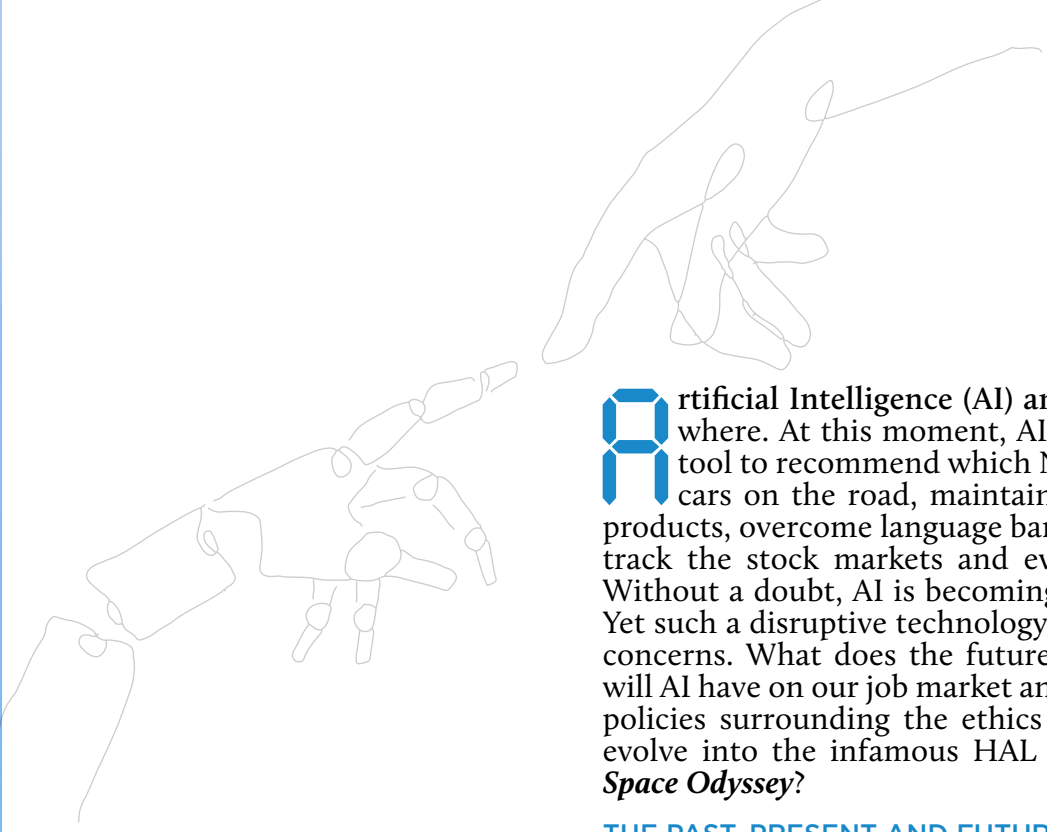
> *"It has been a great privilege to help steer RCIScience onto its current path. Over the last seven years, interest in communicating science has grown tremendously. This is at the heart of RCIScience and the pandemic has demonstrated that what we do is critical to the future of society. I am proud of the platform we have built to connect Canadians with science, one that is actively sought out by people across the country and from beyond our borders. I am very pleased that Carrie will stay on and continue to work towards the vision of RCIScience that she has been instrumental in shaping.*
>
> *Personally, being surrounded by RCI's history all day has been a dream! And, of course, I've had the great pleasure of meeting and working with all of the wonderful Board members, volunteers and Institute members, not to mention an array of speakers and table hosts that makes my inner nerd very dizzy! Thank you to all who gave their time to this great organization and for supporting the work we've done over the last seven years."*

MIND THE GAP

Bridging Human Creativity and Machine Learning

by MICHAEL ZARA

CREDIT: Tara Winstead



Artificial Intelligence and **Machine Learning** are everywhere. At this moment, AI is using Machine Learning as a tool to recommend which Netflix series to binge next, drive cars on the road, maintain security systems, manufacture products, overcome language barriers, detect cancerous growths, track the stock markets and even work amongst the cosmos. Without a doubt, AI is becoming integrated into our daily lives. Yet such a disruptive technology comes with valid questions and concerns. What does the future of AI look like? What impacts will AI have on our job market and economy? How do we develop policies surrounding the ethics and the use of AI? And will it evolve into the infamous HAL 9000 from cult classic ***2001: A Space Odyssey***?

THE PAST, PRESENT AND FUTURE OF AI

Despite its widespread use, AI is still very much in its early days according to Professor Matthew Guzdial, an Assistant Professor in Computing Science at the University of Alberta and Canadian Institute for Advanced Research (CIFAR) AI Chair.

AI and Machine Learning are traditionally known to be extremely good at recognizing patterns in data—even more so than humans. In its current state, AI takes things one step further. Rather than simply recognizing patterns, it can create its own. This type of Machine Learning/AI is seen in Generative Adversarial Networks (GANs), which garnered public interest recently by creating images that looked deceptively like real people.

Artificial Intelligence: *Intelligence simulated by machines.*

Machine Learning: *A branch of Artificial Intelligence that improves automatically through experience with data and algorithms. We can think of Machine Learning as a tool that Artificial Intelligence uses.*

There are some limitations to our current AI, however. First and foremost, it's data hungry. AI needs huge amounts of data (or examples) to learn. Secondly, the patterns that AI creates are highly structured. GANs can create realistic human portraits, because the human face generally follows a certain structure. Typically there are two eyes, a pair of ears, a nose, a mouth and some hair on top. When faced with small amounts of data and very little structure, AI has difficulty understanding its inputs and cannot create meaningful or useful patterns.

"We'd love for AI to be able to learn well from small amounts of data, and to be able to handle novelty and surprise," remarks Prof. Guzdial as he describes the next generation of AI. To achieve these aims, Prof. Guzdial is working towards combining AI and Machine Learning with the concept of "Human Creativity"—the ability to generalize well from a few examples and to produce novel and valuable work.

One form of creativity that he incorporates is "Combinational Creativity", which is modelled by the cognitive process of "Conceptual Blending". Conceptual Blending combines different conceptual elements into one. As an example, Prof. Guzdial asks us to create a new animal, a task often imagined by taking elements of existing animals and putting them together.

Although still in its infancy, future AI technology may have some aspects of Human Creativity embedded somewhere in its programming.

THE RISE OF AI AND AUTOMATION: FEAR OR FICTION?

While the prospect of advancing humankind with AI is exciting, some fear that all of these advancements in AI will negatively impact the job market

by making humans obsolete. Prof. David Cropley, a Professor of Engineering Innovation at the University of South Australia, acknowledges that robots and AI can perform repetitive and algorithmic tasks more effectively and efficiently than any human can. Roles that fit this description will undoubtedly be automated. This begs the question: is the future of work all doom and gloom for humans? "Probably not," argues Prof. Cropley.

The driving force behind human progress lies in asking open-ended questions, which frequently do not have a single correct answer. Asking these types of questions is an essential characteristic of human creativity and creative problem-solving. At its core, the notion of creativity and innovation aims to find new and effective solutions to problems. This begins and ends with human needs and satisfaction of those needs.

Fundamentally, AI lacks auto- nomy and the human experience. For this reason, it cannot define the problem, nor can it validate any solutions. However, Prof. Cropley suggests that AI can play a significant role in technological innovation by generating ideas once the problem has been defined. In fact, a synergy between humans and AI can come from working together. By letting AI handle idea generation, humans can shift their focus towards asking more open-ended questions, narrowing the problem space and making use of what the AI has uncovered. Thus, it is crucial that education systems around the world teach and develop creativity in students as a general competency to prepare for the future job market.

SOCIETAL IMPACTS OF HUMANIZING AI

It is undeniable that modern life will continue to be transformed by AI. But as we try to humanize AI, questions surrounding ethics, policymaking and impacts on society need to be addressed.

Dr. Val Walker, CEO of Business+Higher Education Roundtable (BHER), cautions that if our goal is to have AI take on more uniquely human qualities such as creativity, it will likely take on human biases as well.

Human processing such as judgment and decision-making are imperfect and complicated. Policymakers and decision-makers need to be intimately aware that introducing human biases to AI runs the risk of replicating our own imperfections.

Biases in AI can emerge in different ways. Human decisions can influence the way AI learns—through biased data collection, training AI on datasets that are not representative of a diverse population, or even coding the AI's program. Incorporating human biases into AI can have profoundly detrimental effects on society, such as amplifying health inequities or exacerbating disparities in the criminal justice system.

Does this mean AI is destined to replicate humanity's "dark side"? There is hope that this is not the case.

"If we are aware, aligned and intentional in what we're doing when it comes to developing AI to have these [human] traits, then we're more likely to succeed in reducing the bias that exists," says Dr. Walker.

Machine Learning and AI still have a long way to go before they can mimic the way the human mind works. It is safe to say that AI will not be antagonizing humans the way HAL 9000 did, at least not yet. While the gap between Human Creativity and Machine Learning is slowly but surely closing, only time will tell how AI feels about humankind. ●

Click here to watch the full event.

SIDEWALK SCIENCE

Science is all around us and by the same token, so are scientists! That's why we started a summer Sidewalk Science campaign, creating an opportunity for scientists across Canada to share their research and connect with their neighbours in an age of social distancing, using only a piece of chalk and a patch of sidewalk. Some even caught the eye of CBC News!

Photos courtesy of: Roopali Chaudhary, Parshati Patel, Lorena Paras, STEAM Sisters, Rebecca Yardley

AMANDA VERI, Molecular Genetics

Fungi 101

by MICHAEL ZARA

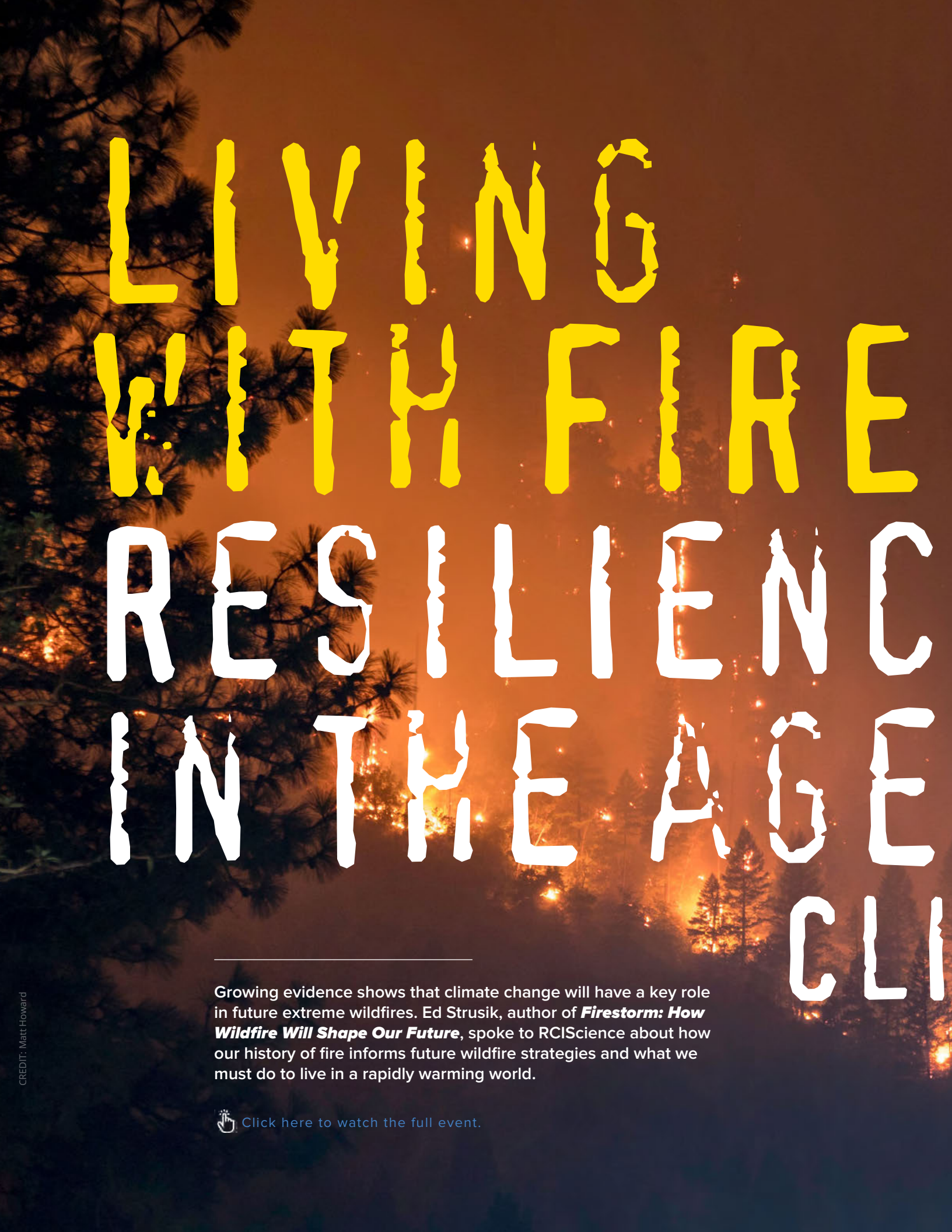
Dr. Amanda Veri quickly became one of RCIScience's favourite microbiologists and mycology experts, and her Instagram Takeover showed us how microbes may be small but mighty, scary and safe, necessary and astonishingly beautiful.

Her PhD research investigated the clever tricks, including shape shifting, that fungi use to evade our immune systems. While it's easy to think about microbes as negative, disease-causing agents—especially as we navigate a global pandemic caused by a fast-spreading virus—Amanda is quick to point out that they play a pivotal role in many aspects of our lives. Without microbes, we would not be able to enjoy food and drinks like bread, beer and wine. But the impacts of a microbe-less world go far beyond losing our favourite guilty pleasures. We'd experience widespread malnutrition in humans and animals because microbes living in our intestines help digest food and release nutrients. Plant growth would be stunted because of waste buildup and a lack of nutrition. Our air supply would be depleted since microbes in the ocean release oxygen as a byproduct of photosynthesis. Further, we'd see an increase in global warming effects because excess carbon dioxide cannot be used up in photosynthesis.

Fungi are a particular category of microbes that fascinate Amanda and she shared some of her top **Fungi Facts** with us:

- Estimated to be the largest organism on the planet, fungi include much more than mushrooms.
- Fungi are more evolutionarily conserved with animals than plants, making fungal infections very hard to treat.
- Many medicines including antibiotics, immunosuppressants and statins were first isolated from fungi.
- Things like LEGO, plastic car parts and synthetic rubber are made from itaconic acid, a compound derived from a fungus called Aspergillus.
- Fungi are increasingly being explored for bioremediation, degrading toxic chemicals in soil and water.
- Some species of fungi are parasitic. Ophiocordyceps fungi infect insects, leading them to display zombie-like behaviour. The fungus forces infected insects to climb up plants before growing long spikes that protrude from the corpse. The spikes release fungal spores into the air and spread the infection.

Dr. Veri is well known on social media for her living microbial art—vibrantly coloured fungal colonies that she grows into shapes and patterns. Popular designs include the SARS-CoV-2 virus, toilet paper, mountainous scenery and Halloween icons. You can find more of her microbial art on Instagram @AmandaVeri.



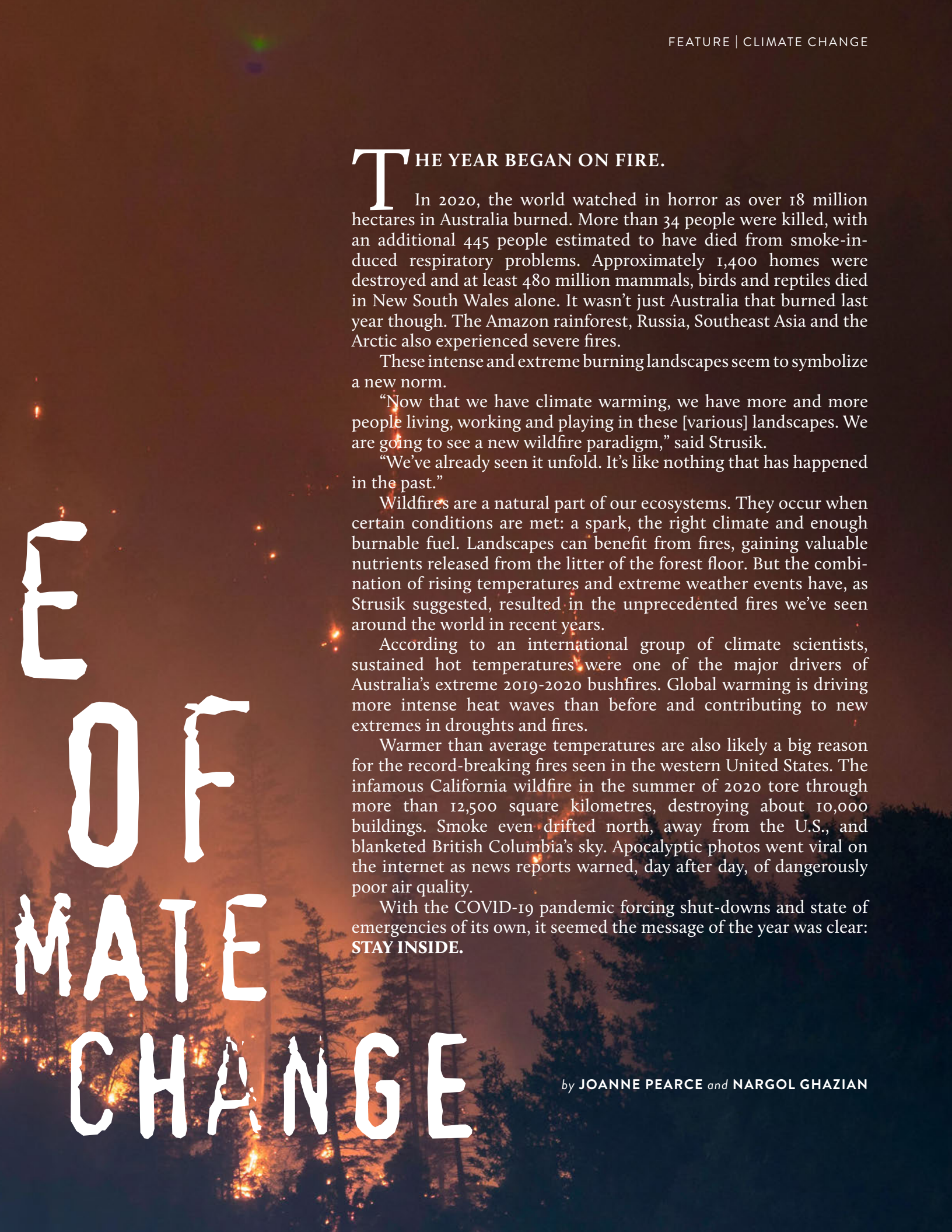
LIVING WITH FIRE

RESILIENC IN THE AGE CLI

CREDIT: Matt Howard

Growing evidence shows that climate change will have a key role in future extreme wildfires. Ed Strusik, author of ***Firestorm: How Wildfire Will Shape Our Future***, spoke to RCIScience about how our history of fire informs future wildfire strategies and what we must do to live in a rapidly warming world.

Click here to watch the full event.



E OF MATE CHANGE

THE YEAR BEGAN ON FIRE.

In 2020, the world watched in horror as over 18 million hectares in Australia burned. More than 34 people were killed, with an additional 445 people estimated to have died from smoke-induced respiratory problems. Approximately 1,400 homes were destroyed and at least 480 million mammals, birds and reptiles died in New South Wales alone. It wasn't just Australia that burned last year though. The Amazon rainforest, Russia, Southeast Asia and the Arctic also experienced severe fires.

These intense and extreme burning landscapes seem to symbolize a new norm.

"Now that we have climate warming, we have more and more people living, working and playing in these [various] landscapes. We are going to see a new wildfire paradigm," said Strusik.

"We've already seen it unfold. It's like nothing that has happened in the past."

Wildfires are a natural part of our ecosystems. They occur when certain conditions are met: a spark, the right climate and enough burnable fuel. Landscapes can benefit from fires, gaining valuable nutrients released from the litter of the forest floor. But the combination of rising temperatures and extreme weather events have, as Strusik suggested, resulted in the unprecedented fires we've seen around the world in recent years.

According to an international group of climate scientists, sustained hot temperatures were one of the major drivers of Australia's extreme 2019-2020 bushfires. Global warming is driving more intense heat waves than before and contributing to new extremes in droughts and fires.

Warmer than average temperatures are also likely a big reason for the record-breaking fires seen in the western United States. The infamous California wildfire in the summer of 2020 tore through more than 12,500 square kilometres, destroying about 10,000 buildings. Smoke even drifted north, away from the U.S., and blanketed British Columbia's sky. Apocalyptic photos went viral on the internet as news reports warned, day after day, of dangerously poor air quality.

With the COVID-19 pandemic forcing shut-downs and state of emergencies of its own, it seemed the message of the year was clear: **STAY INSIDE.**

by **JOANNE PEARCE** *and* **NARGOL GHAZIAN**

NOTHING YOU CAN IMAGINE

In November of 2016, Struzik traveled to the top of Sulphur Mountain in Banff National Park with some wildfire specialists. The trip was not just for fun. Rather, Strusik wanted to imagine what would happen if a fire broke out down below.

"If Banff burned, I realized, the world would pay attention because so many people worldwide have been there at one time or have dreamed about going," wrote Struzik in Firestorm.

It has only been three years since Struzik's book came out but fires, such as the one he imagined in Banff, no longer seem improbable. In a webinar with RCIScience and THEMUSEUM in Fall 2020, Struzik highlighted how historical fire events can easily grow into moments that defy current imagination.

The 1988 wildfires in Yellowstone National Park mark one of these moments. Until this point, European-centric thought suggested that fires had to be put out and suppressed at all costs. However, new thinking in the '80s suggested that letting fires run their course could, in fact, benefit the environment. The practice, a "let-burn" policy, was embraced by the National Park Service.

That year, to stop the previous demonization of fire as always bad, fire officials at Yellowstone decided to let fires which had originated from a series of lightning storms burn.

"It was a great idea, but the timing was really unfortunate," said Strusik.

That summer ended up being one of the hottest and driest years for Yellowstone. Large, destructive fires broke out quickly and consumed more than a third of the park. According to a 1994 report issued by the U.S. Department of the Interior, the fires grew so large they were no longer fires but "complexes."

In the end, the fire overwhelmed all efforts to suppress it until on September 11, 1988, with the help of a quarter-inch of snow, the fires finally died out.

A few decades later, our preconceived notions of what wildfires are capable of were broken again, this time with the Canberra, Australia wildfire of 2003. It was the first time a fire had been documented to have created a tornado. In 2017, experts were shocked again after seeing multiple pyrocumulonimbus, or pyroCbs, thunderstorms created by intense fires, occur simultaneously in the forests of British Columbia and Washington.

"In just five hours, fire scientists from around the world were in awe. They just could not believe that this rare event like a pyroCbs could happen four times. Actually [it] was five times because another one erupted simultaneously in Washington State, and since then we're seeing pyroCbs occur in places where we've never seen them," said Strusik.

Experts estimate that the Australian wildfires last year generated at least 18 pyroCbs.

Worldwide attention on wildfires no longer seems unusual. Is it possible to ignore them, as news organizations report on how record after record seems to break each year? Even individuals who aren't within the country where the fires originated are impacted; the wildfires from Australia blew smoke 19 miles into the sky. The Washington Post likened it to a nuclear blast.

PROFOUND CHANGES TO LAND AND LIVES

A growing body of research shows that climate change has drastically increased the risk of many of the conditions, such as dry vegetation, that help wildfires start and spread. A California research paper released last year found that the number of autumn days with weather suitable for wildfires has doubled since the 1980s as a result of climate change.

"A new reality has come into play, and that's climate change. With warmer temperatures, just one degree [can result in] a 12 percent increase in lightning strikes. You also have extended droughts, more disease and insects moving in," said Strusik.

"You could see this happening in British Columbia and also places like Jasper, where the mountain pine beetle was not really a problem until really fairly recently."

The federal government announced in October 2020 that they would fund $68.4 million over three years to help control, research and mitigate the impacts of the mountain pine beetle on Canada's forests. More than 18 million hectares of Canada's national parks forests have been infected by the pine beetle since the early 1990s. But while it may seem obvious to connect more dead trees with more wildfires, research suggests it's more nuanced than that.

The reality is, living with fire is complicated. In a changing climate the risk of ignition is only one factor to consider. Ecological and human factors like infrastructure are also important.

A notorious example is the Pacific Gas & Electric Company (PG&E), California's largest utility provider. PG&E's power lines have been accused of causing more than 1,500 California wildfires in the past six years. Last year, the company pleaded guilty to manslaughter charges from the infamous 2018 CampFire wildfire, which remains one of the deadliest wildfires in California's history. Today, the organization is under criminal investigation for 2020's Zogg fire, which claimed at least four lives and leveled hundreds of structures.

The failures of PG&E highlights just how devastating infrastructure can have on wildfire management, especially as experts already have to deal with climate change's disastrous impact.

Managing vulnerable populations, such as the growing number of communities living in high-risk areas, is just another key consideration for fire managers and policy experts. Taking steps to prevent damage during a disaster rather than eliminate the disaster altogether, and coming up with strategies that help protect homeowners rather than relocate them, may mean changing the way we systematically address fires.

STRATEGIES FOR RESILIENCE

Over the years, a number of strategies have been developed by officials to tackle wilderness issues. Sometimes, the ideas can seem a little strange.

Sixty years ago, for example, Idaho Fish and Game got the idea to fly beavers out into the backcountry so they could build dams and wetlands that could help stop fires. The problem was there were no roads to get to those remote areas. In the end, the officers came up with the idea of parachuting down the beavers in wooden crates, assuming that the crates would break open and the beavers would survive and walk out. (View link.)

In the 1950s, the Canadian government came up with a PR strategy to address wildfire that involved a black bear rescued from a forest fire. They named him Smokey, and the bear became the North American symbol of the effort to prevent forest fires.

The main message behind Smokey and the beavers has not been lost even in today's strategies: forest fires **can** be prevented. Wildfire specialists target a number of different areas when addressing wildfires: prevention and mitigation, preparedness, response and recovery. Regulatory tools allow agencies to issue things such as fire permits and permit conditions, fire advisories and bans, and other kinds of restrictions.

But the tools and technologies they have to tackle extreme events caused by climate change are still limited.

"I really admire wildfire specialists because they are faced with a challenge now that's increasing, and they really do not have all the tools they need to be able to get control of it for managing. It's amazing to watch them," said Strusik.

What is urgently missing right now in Canada, according to Strusik, are strategies and tools that focus on helping to make communities fire resilient, instead of trying to eliminate the problem.

"At some point we're going to have a fire in Canada where we're not going to be that lucky, and I fear that it's going to be in some retirement community like Salt Spring Island, which is forested from one end to the other and no easy way of getting off the island. I think that...[it's these] things that we've got to start considering right across the country," said Strusik.

A CALL TO INVEST MORE IN SCIENCE

Looking ahead, Strusik proposes that the biggest effort Canada can make to prepare for a world with more extreme wildfire events is to put more money into science.

"Canadian Forest Service used to have one of the best wildfire science programs in the world. In the 1970s it employed 2,400 people. Less than 700 work there today, only 100 to 110 are research scientists but only a dozen of those are working on wildfire science," said Strusik.

The question is, do we have time? In British Columbia, Alberta and beyond, we are seeing how forest fires can become larger and a lot more difficult to handle. There is also a projected doubling of forest fire activity in North America, according to Strusik.

It can be overwhelming even for experts to imagine what is to come.

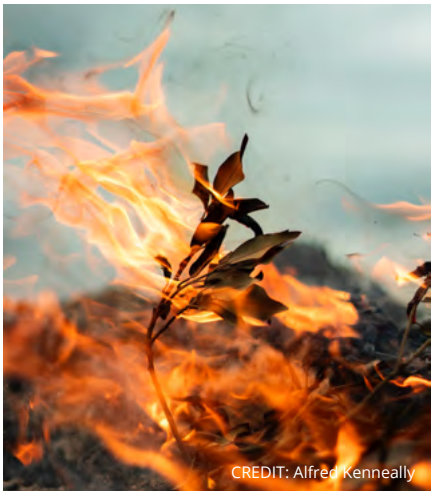
"This is a bigger issue than it was just five years ago and it is one that is becoming increasingly complicated and head-spinning in a way. You know, this is the term that I hear from fire scientists all the time: that it's just a head-spinning event, that we just didn't... imagine that some of these intense events could happen but the rapidity with which they're happening has just really raised a lot of eyebrows."

What is abundantly clear, however, is that how we choose to live with fire depends on us. ●

Misty Mountain in Banff. CREDIT: David Brooke Martin

The Canadian town of Banff receives approximately 4.18 million visitors annually, most of whom come to see the national park, lodge in town and generate income for the local economy. Banff National Park is not only an ecological treasure but has direct economic benefits for the province of Alberta.

Jane Park, Fire and Vegetation Specialist in Banff National Park, suggests building resiliency through fire management in three major ways: prescribed fires, managed wildfires and fuel management. Prescribed burns use fire to intentionally burn an area for management or restoration, whilst managed wildfires occur naturally with management professionals nearby to stop the burn from spreading to unwanted areas. Fuel management further ensures the same implementation of prescribed fires by creating landscape-level fuel breaks. The three methods work in conjunction to limit the spread and define a parameter for the fire, as well as allowing for rapid detection and full suppression when needed. Over the years, Park and her colleagues have collaborated with municipal government officials and academics to educate the public and gain support for prescribed burns, in addition to promoting the construction of more fire-resistant building structures in the community.



CREDIT: Alfred Kenneally

HEALTH IMPACTS OF WILDFIRES ON INDIGENOUS PEOPLE AND COMMUNITIES

WILDFIRES CAN DISPLACE PEOPLE IN COMMUNITIES, making them refugees in their own place of residence. It can impact vulnerable people, such as Indigenous communities, both physically and mentally. This is why Dr. Stephanie Montesanti, an applied policy and systems researcher of health systems planning and improvement at the University of Alberta, created Indigenous Health and Resilience through Disaster (IHRD). IHRD is a community-based study exploring health impacts and resilience of Indigenous peoples in Fort McMurray following the 2016 fire. She strives to understand how the province responds to vulnerable and underserved groups post-natural disaster. Dr. Montesanti believes that all Indigenous peoples are unique and that their coping and recovery mechanisms rely on a sense of culture and community.

According to Dr. Montesanti, it is important to find and elect people in Indigenous communities for hazard and community assessment. Furthermore, a good communication system between officials and communities reduces the risk of natural disasters. While there are resource inadequacies and disparities between reserves and urban areas, solutions can be found through cohesion and relationship building. **The natural disaster response system can be greatly improved by incorporating Indigenous ways of thinking, their values and their ethics into the framework, alongside mutual respect and consultation in the development of these policies and practices.** Most importantly, Dr. Montesanti believes that federal and jurisdictional issues need to be clarified in the best interest of reconciliation. "These are all important considerations in a disaster and emergency response plan," she says.

CREDIT: Marcus Kauffman

PEATLAND WILDFIRES IN CANADA

The boreal peatland system in Canada is one of the largest, continuous forests left on earth. Peatlands are wetlands defined by their thick layer of peat, a partially decomposed organic matter that makes them the most carbon-rich system on earth. This decomposition is very slow because peatlands are generally cold and wet. Dr. Sophie Wilkinson, a postdoctoral fellow at McMaster University, is researching the processes influencing the severity of peatland fires. She describes wildfires as a natural part of the boreal ecosystem adding, "[Wildfires] work to regenerate the ecosystem, which helps to maintain their health and their long-term carbon uptake."

Wildfires in a healthy peatland generally remain on the surface and burn vegetation such as shrubs and trees. Spruce trees, for instance, need these fires to spread their seeds. However, in drier-than-normal peatland, now more common given extended drought periods from the changing climate, fire can move deeper into the peat, burning slowly and releasing centuries of stored carbon. This is commonly known as smouldering, a slow-burning, difficult-to-detect fire that appears as smoke. Peatland smouldering increases particle emissions and greenhouse gases in the atmosphere; further contributing to climate change.

Peat bog. CREDIT: Peupleloup/Flickr

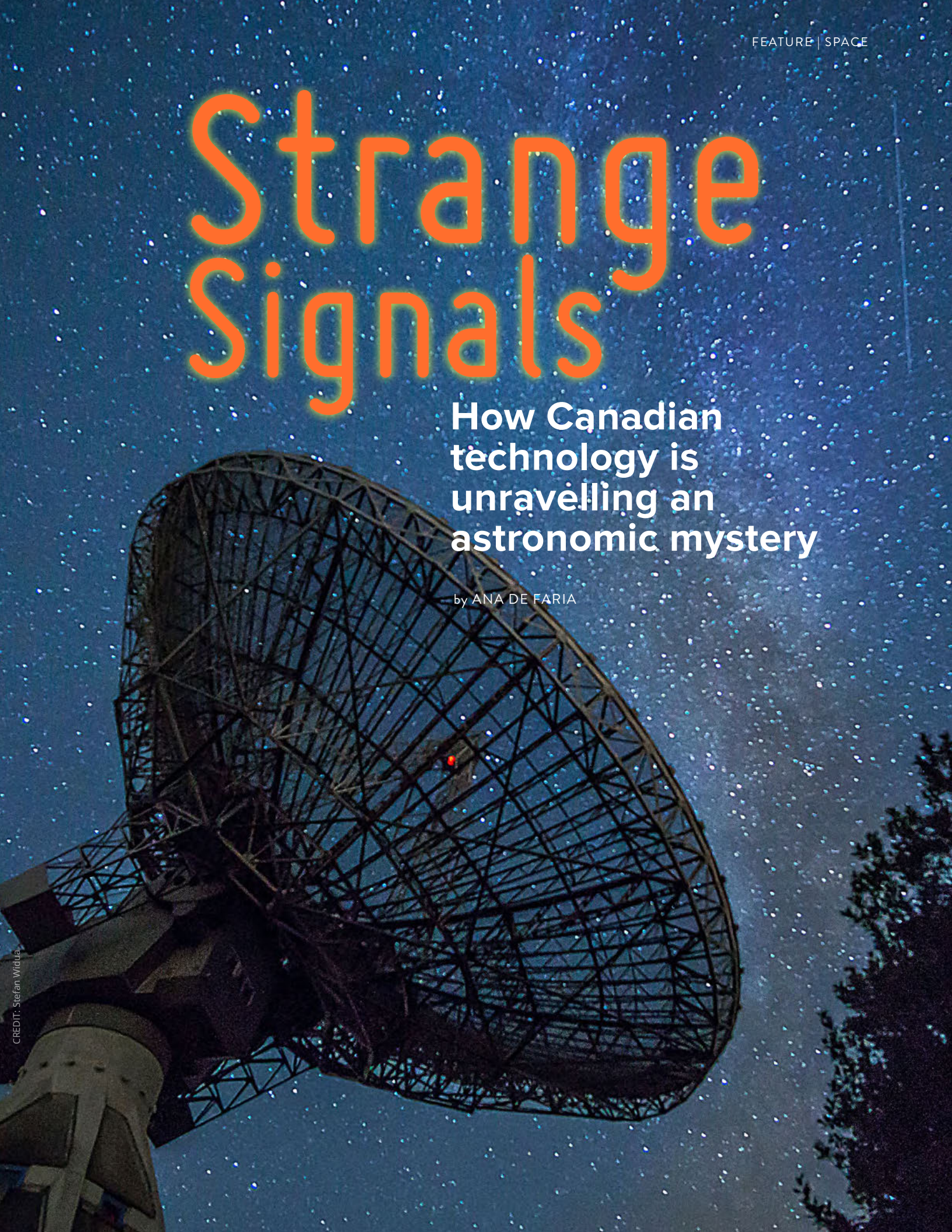
Peatland Pool. CREDIT: David Glass

Dr. Wilkinson and her colleagues have found a proactive management strategy through a plant called the sphagnum moss (or "super moss"). Sphagnum mosses can withstand severe wildfires and help reduce the intensity and severity of peatland fires by making connectivity gaps—natural fragmentations within the ecosystem that stop the continuous burning of the landscape. This is especially important for preventing the spread of fires to nearby communities and infrastructure.

Strange Signals

How Canadian technology is unravelling an astronomic mystery

by ANA DE FARIA



CREDIT: Stefan Widua

IN 2007, AUSTRALIAN SCIENTISTS were looking through archival data from 2001 taken by the Parkes Radio Telescope in New South Wales, and found signals different from anything ever detected before. These bursts of radio light, later known as Fast Radio Bursts (FRBs), remain a mystery. They carry huge amounts of energy, last only a few milliseconds and seem to come from billions of light-years away. In the last few years, Canadian technology has been investigating these signals and may have finally found an explanation for this phenomenon.

A BRILLIANT FLASH, THEN NOTHING

For years, it was not clear if FRBs even existed. In the few years following its initial discovery, the Parkes Telescope detected a handful of potential FRBs that were later found to be false alarms. It turned out that if you open a microwave too early, it lets out a burst of radio light not unlike FRBs. It was not until 2013 when the Parkes Telescope found four more FRBs in their archival data that the skepticism lessened.

In 2014, two other telescopes detected similar signals, each in their own archives. These were the Arecibo Telescope in Puerto Rico and the Green Bank Telescope in West Virginia. These discoveries finally convinced astronomers that FRBs are real.

Many theories arose to explain the origin of FRBs, ranging from well-known astronomical phenomena to an entirely new physics. The handful of examples were not enough to go on. Astronomers needed to find more of these strange signals.

Interestingly, thousands of FRBs occur all over the sky every day. So why have we detected so few? The reason is simple. Radio telescopes sensitive enough to catch an FRB can only see a small region of the sky at a time. Smaller telescopes can see larger areas of the sky, but are not sensitive enough to catch an FRB. What scientists needed was a very sensitive telescope that could look in a lot of different directions at once. That's how Professor Keith Vanderlinde and the Canadian Hydrogen Intensity Mapping Experiment (CHIME) entered the scene.

FROM MAPPING THE UNIVERSE TO REVEALING MYSTERIOUS RADIO SIGNALS

The CHIME project was developed to study the universe using radio frequencies.

Prof. Vanderlinde is an experimental cosmologist and long-wavelength instrumentalist at the University of Toronto and one of the coordinators of CHIME. He spent the first decade of his career studying the Cosmic Microwave Background (CMB), the first light emitted when the universe was born. Scientists can detect CMB using microwave light and capture it in pictures that map out the universe. "The whole sky glows all the time and it is just filled with microwave light leftover from when the universe was really just a baby," Dr. Vanderlinde elaborates.

Looking at neutral hydrogen, which can be mapped by collecting the radio waves it emits (a glow with a wavelength of 21cm), is one strategy employed to better understand the universe. This would take a long time using traditional radio telescopes—decades, if not centuries. But, a new breed of telescope can be built using off-the-shelf technology that can collect the light from neutral hydrogen glow (H1) in a matter of years. The result will provide a more detailed picture of the early universe, in particular, the time during which the mysterious 'dark energy' arose and sped up the universe's expansion.

Professor Vanderlinde and his team built a telescope using parts commonly found in cell phones and video game consoles. The CHIME telescope works quickly by looking in a lot of different directions at once. It achieves both sensitivity and a large field of view. Serendipitously, this is also the perfect telescope to search for FRBs.

THE END OF A MYSTERY OR THE BEGINNING OF A NEW ONE?

"[The astronomers working on FRBs] came along and talked to us, [and we said] yeah we could probably repurpose CHIME to do this—we could build a CHIME/FRB," recalls Prof. Vanderlinde. "And it turns out, you don't even need to repurpose it; you can run both of these studies completely in parallel. You upgrade the computer, you rewrite the software and suddenly this is

CHIME is a collaboration between the University of Toronto, University of British Columbia, McGill University, and Canada's Dominion Radio Astrophysical Observatory. Originally conceived to map the most abundant element in the universe, hydrogen, this unusual telescope has no moving parts and is composed of four large cylinders, 100 meters long and 20 meters wide each, arranged north-south, with a thousand detectors spread across them.
CREDIT: Wikimedia Commons

searching for FRBs. We did that and at the instant it came on, we started seeing them." In 2019, CHIME/FRB was featured on the cover of *Nature* with its first series of results.

CHIME/FRB has since detected over a thousand FRBs. We now know that while most FRBs are one-offs, some of them actually repeat, turning on and turning off with some periodicity. "This is a relatively new discovery and discovered by Canadian technology as well," says Nicole Mortillaro, the Senior Science Reporter for CBC News who reported one of the first stories about CHIME/FRB.

We still don't know how to classify one-offs and repeaters. Qualitatively they are slightly different, but it is unclear if there is one class of objects or multiple. As we investigate further and collect more samples, we may be able to answer this question. That's why an experiment like CHIME, which detects hundreds of FRBs a year, stands in a great position in the field.

In 2020, CHIME/FRB detected an incredibly bright burst that was traced to a magnetar—a super, highly magnetized neutron star—only 30,000 light-years away in our galaxy. "When things are near, you can see fainter bursts," explains Prof. Vanderlinde. "So, it makes it a little bit easier [to study]." A magnetar has a magnetic field a million billion times stronger than Earth's, strong enough to pull atoms apart. Studying how FRBs are produced in this environment and how they travel through it can additionally help us study the wider universe and learn about dark matter and dark energy.

"It is quite an achievement though, and it's definitely something I think that we can be very proud of in Canada," says Mortillaro. "When I first did my interview with one of the CHIME scientists, [they said] we went from detecting a few [FRBs] to the possibility of detecting hundreds in a week. That's just amazing." ●

CREDIT: M. Kornmessor/ESO

NEUTRAL HYDROGEN GLOW

Hydrogen is the most abundant element in the universe—three-quarters of all matter is hydrogen. Despite this, mapping the neutral hydrogen glow (H1) across large spans of the universe is a challenge. There are three basic problems:

- All hydrogen was neutral at the start of the universe, but the birth of galaxies resulted in processes that lead to hydrogen being ionized. For example, as early stars formed, they turned hydrogen into glowing plasma. Glowing nebulas like the Orion Nebula are made of ionized hydrogen. As such, the vast majority of the universe's hydrogen isn't neutral, and doesn't emit this radio glow.
- The glow itself is produced by a change between two states in the atom which happens rarely. It takes on average about 10 million years for a single hydrogen atom to emit a single photon of 21cm radio light. It is so rare, in fact, that it has been posited that extraterrestrials would use the 21cm frequency to communicate with us.
- This very rare radio glow is produced at very distant regions in the universe.

This is why finding H1 using traditional radio telescopes would take decades or centuries.

THE PHYSICS OF LIGHT

Let's take a few steps back and talk about light. Everybody knows the colours of the rainbow (red, orange, yellow, green, blue, indigo and violet) but that's not all of it. There are many more "colours" of light out there, known as wavelengths or light bands. If we zoom out of the visual "rainbow" and view the entire light spectrum, we see (from one end to the other) gamma rays, X-rays, UV-light, visible light (the rainbow we can see), infrared, microwave and radio waves. Gamma rays are shorter, faster, more energetic and more dangerous. Radio waves, on the other hand, are longer, slower, less energetic and less dangerous. But all of these wavelengths are the same phenomena: they're all just light. The only thing that makes visible light special is that our eyes can see it. FRBs belong to the longer end of the light spectrum—radio waves—and can be detected by radio telescopes, like CHIME, Arecibo, Green Bank and Parkes.

ZOONIVERSE

Interested in becoming an FRB hunter? CHIME/FRB can be found in Zooniverse, a citizen science web portal hosted by the Citizen Alliance. Due to the incredible amount of data that CHIME/FRB generates (about 1 Terabyte per second), it is hard for software to differentiate real FRBs from electronic noise. A human, however, can do this easily. You can help by visiting CHIME Zooniverse. No sign up is needed, and the platform will give you all the training you'll need to start looking at the data and classifying FRBs. According to Prof. Vanderlinde, the FRB realm is an exciting field to be in.

Click here to watch the full event.

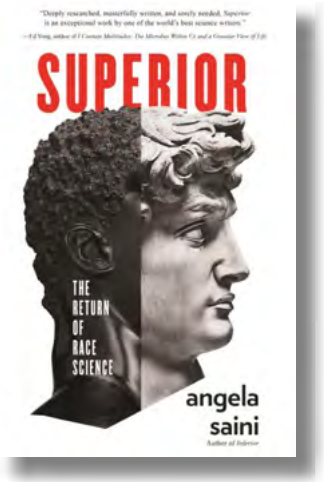
History is Never Over

Every part of your upbringing makes you believe that you are different.

by KIRSTEN VANSTONE
with thanks to Dr. Ronald Pearlman

A REVIEW OF

Angela Saini's Superior: The Return of Race Science



This feeling of being different, yet belonging, may be what motivates many of us to delve into our ancestry, even mobilising science to decode our genetic past. But what can science actually tell us about that? Pretty much nothing beyond what might be found in a typical family tree. Certainly not much about our racial identity. Race, like a family tree, belongs more to culture than to science.

In the book *Superior: The Return of Race Science*, Angela Saini explores what science tells us about race and, more importantly, what it does not. As she outlines in great detail, science can tell us about ancestry, but race, as we usually think of it, is not something determined by DNA. There is no gene that all members of a racial group, and only that group, share. There are some statistical relationships that arise through simple inheritance, but you cannot, for example, do a genetic test to determine skin colour. More than 90% of human difference exists between one person and the next, rather than between major population groups around the world.

Yet, in face of this, possibly driven by a need to prove their own superiority, there are still researchers toiling away at uncovering a scientific basis for race. Operating at the outer margins of science, Saini shows how this small group has little influence within the establishment, but surprising clout outside of it.

They have managed to build a thin veneer of scientific credibility that comes from getting published and cited almost entirely by publishing and citing each other.

The problem is not that race science creeps into mainstream science. The main journal the practitioners use has a very low impact factor, which is the measure of how often its papers are cited by others. The journal in question's impact factor is less than 1, versus *Nature*, with an impact factor of about 40. That means that hardly anyone outside of this small group cites their work.

The problems arise when this work is cited by people outside of the scientific community. People who have no tools to judge the research other than by the sole criterion that it appears in a peer-reviewed journal. It must be said that peer review is a criterion often offered up by scientists as a measure of credibility. Of course, those scientists know that the peers are key—who is reviewing the work. In this case, the race scientists are all reviewing their own work. There is no outside measure of credibility. Non-scientists, or scientists working in other areas, quote this work and point to the peer-reviewed journal in which it appears as evidence that the conclusions are properly "scientific." Often with a political motivation.

Mainstream science does not escape. Studies that were never intended to be used as a basis for racial discrimination become judged and quoted that way. The effect is that mainstream science, in particular genetics, has had to become

extremely careful about the lines of inquiry it pursues, lest the work become further ammunition for those who wish to, as Saini puts it, weaponize science. This has been seen by some as stifling inquiry.

Saini also argues that the very questions scientists ask can be part of the problem. This is particularly acute when the scientists are restricted to certain cultural or demographic groups, or when they are operating in a political environment that favours a particular ideology. That ideology may change, but the mark it leaves can persist in science for a long time. Anthropology gives us an example. In the ideology of the British Empire, the measure of a civilization's advancement was against European benchmarks. Entire complex societies were labelled as "primitive". Though mainstream anthropology has moved on, vestiges of the old thinking remain. Saini notes, "...highly sophisticated societies emerged independently elsewhere. This came as such a shock that some to this day still believe their cities were the work of aliens." In other words, just because you or I cannot imagine building Machu Picchu and Nazca without machines does not mean that the Incans enlisted ET's help. (History Channel, Ancient Aliens is not just pseudoscience, it is racist pseudoscience.)

There are many things we should learn from this. Not the least of which is that a lot of people do not understand the scientific process, no matter how much they might appreciate it. The messy, sometimes unfair way in which experiments proceed and the even messier ins and outs of scientific publishing and peer review, for example, are both issues that have come to the fore during the pandemic. This is not fun stuff to discuss. We prefer to think of science as a force for good, but as *Superior* shows time and again, science can be enlisted and weaponized towards undesirable political ends.

The good news is that we can turn to science to help us out of this quagmire. Science already shows that discrimination by race has no basis. In this way, it tells us that we need to change the conversation from one that uses race to describe a community, to the more accurate descriptors: marginalized, oppressed and underrepresented.

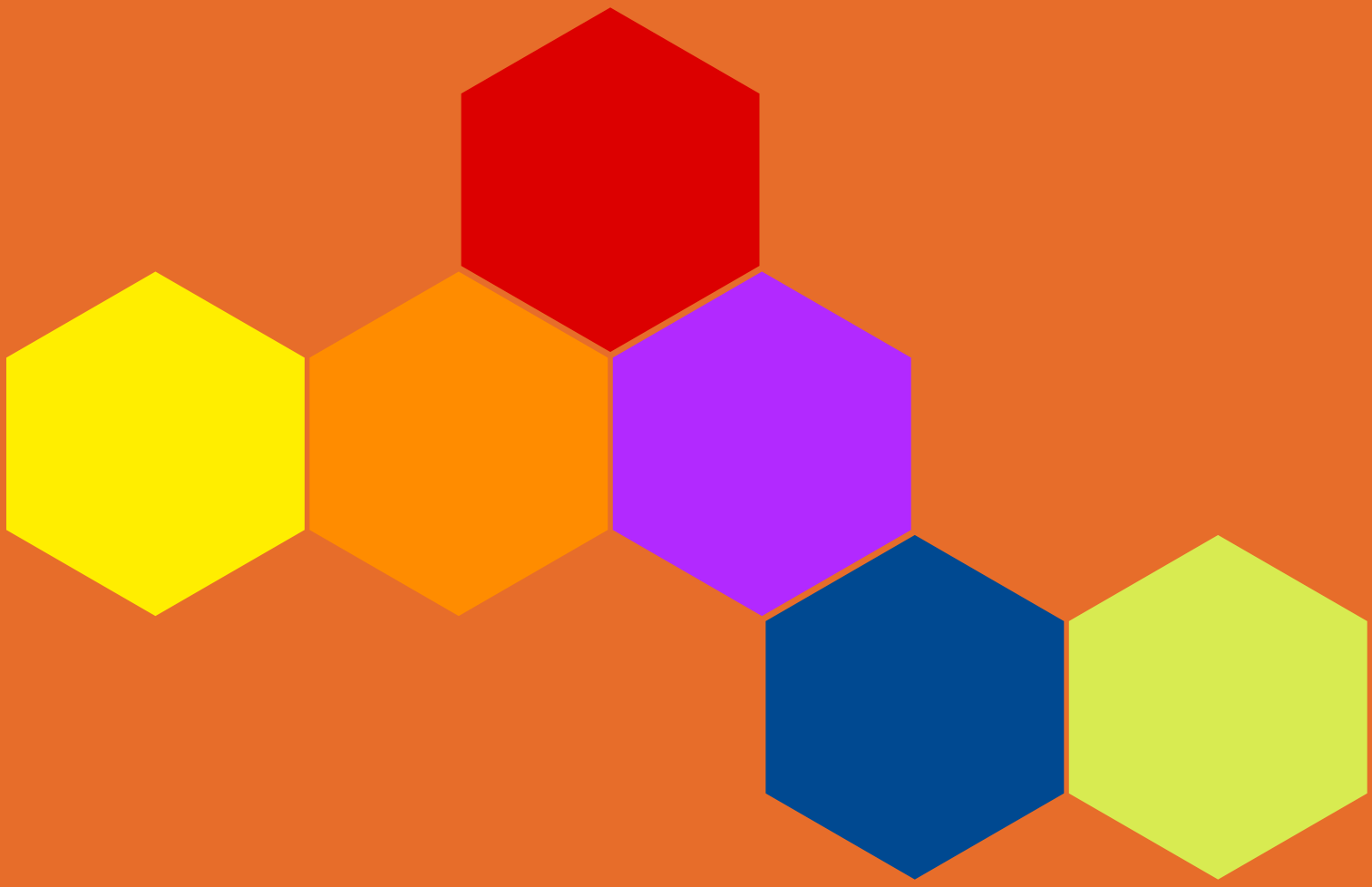
Secondly, at its most basic, science is inclusive. Or it should be. After all, participation requires only a belief that you can access the world accurately through your senses, and that questions can be answered by systematically gathering data. For hundreds of years, however, Western science has excluded entire communities, including women, Black, Indigenous and People of Colour. Partly due to this legacy, some of these groups remain underrepresented in science to this day. As new voices become accepted in science, the ideas upon which systemic superiority structures are built crumble. Good science will continue to add as many new voices as it can.

I want to end on Angela's very personal answer to a question about stereotypes. The question asked what causes stereotypes to persist in society and whether there is any truth behind them. She said that, for the most part, all a stereotype does is gloss over a person's individual qualities. And that when she meets a new person, she actively tries to see what is different about that person. What is unique and interesting and worth getting to know.

We conclude that, even though there are myriad ways we are different, we should all remember that we share a common origin. We share humanity and empathy, both of which are critical for progress in these difficult times. ●

THE EVOLUTIONARY NATURE OF GOOD SCIENCE IS ALSO SOMETHING THAT WE'RE TRYING TO REALLY EMPHASIZE THROUGH THIS GAME. AND WHAT WE MEAN BY THAT IS THAT IN THIS PANDEMIC, IT'S EASY TO, AGAIN, FORGET THAT SCIENCE IS NOT JUST A COLLECTION OF FACTS THAT WILL NEVER CHANGE. THAT'S NOT WHAT THE SCIENTIFIC METHOD IS. AT ITS CORE, SCIENCE IS TO TAKE NEW INFORMATION THAT WE'RE LEARNING TO INCORPORATE IT AND TO REVISE OUR ALREADY ESTABLISHED PROCEDURES, METHODS AND OUR PROJECTED OUTCOMES AND TO REVISE THEM TO REVIEW THEM AND TO SEE IF THAT'S GOING TO CHANGE OUR METHODS AND OUR BELIEFS.

RIDHI PATEL
Pixel Perfect: Fighting Misinformation with Video Games



RCIScience
Royal Canadian Institute for Science

2021 FINANCIAL STATEMENTS

STATEMENT OF FINANCIAL POSITION (AS AT JUNE 30)

	2021	2020
ASSETS		
Cash, receivables & prepaid expenses	**161,225**	122,708
Investments	**1,301,046**	1,193,355
Portraits	**3,200**	3,200
	$1,465,471	$1,319,263
LIABILITIES		
Current		
Accounts payable and accrued liabilities	**134,782**	25,681
Deferred grants	**65,880**	133,067
	200,662	158,748
Loan payable	**40,000**	30,000
	$240,662	$188,748
NET ASSETS	**$1,224,809**	$1,130,515
	$1,465,471	$1,319,263

STATEMENT OF OPERATIONS AND CHANGES IN NET ASSETS (YEAR ENDED JUNE 30)

	2021	2020
REVENUE		
Sponsorship	**102,000**	-
Grants	**79,374**	46,594
Investment income	**43,219**	51,453
Donations and membership fees	**25,738**	27,851
Government assistance	**10,000**	10,000
Fundraising and events	**5,811**	5,755
	$266,142	$141,653
EXPENSES		
Staffing costs	**133,997**	142,244
Lectures and events	**128,107**	63,398
Professional fees	**19,147**	18,780
Office expense	**9,965**	4,554
Investment management fees	**9,094**	9,290
Insurance	**5,473**	5,393
Space rental	**2,767**	2,352
	$308,550	$246,011
Excess of expenses over revenues before other item	**(42,408)**	(104,358)
Unrealized gain (loss) on investments	**136,702**	(84,296)
Excess of revenue over expenses (expenses over revenue) for the year	**94,294**	(188,654)
Net assets, beginning of year	**$1,130,515**	$1,319,169
Net assets, end of year	**$1,224,809**	$1,131,515

> I'M HOPING ONE OF THE LEGACIES OF THE PANDEMIC IS THAT WE'RE GOING TO RECOGNIZE THE VALUE AND THE IMPORTANCE OF GOOD SCIENCE; THE VALUE AND IMPORTANCE OF DEBUNKING MISINFORMATION; AND THE VALUE AND IMPORTANCE OF PUBLIC TRUST IN SCIENCE AND THAT, THEREFORE, WE'RE GOING TO SUPPORT THE INSTITUTIONS THAT ALLOW THOSE THREE THINGS TO HAPPEN.

PROF. TIMOTHY CAULFIELD

Stranger Than Fiction: Fighting Misinformation with Timothy Caulfield

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