

The Future
of Health is

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Five researchers share how their work
is shaping the future of human health



Engineering a bespoke gut microbe to treat inflammatory bowel disease



A single article shared by a colleague was all it took for **David McMillen** to think of a new way to treat inflammatory bowel disease (IBD).

But then again, interdisciplinary thinking comes naturally to McMillen, an associate professor of chemical and physical sciences at UTM. After earning a PhD in aerospace engineering, he completed his postdoctoral work in a synthetic biology lab and transitioned from conventional to biological engineering. Today, he leads a team of six researchers who are combining their exper-

tise in regenerative medicine, gut stem cell research, biological engineering and advanced genetic analysis to create a bespoke gut microbe that can sense bowel inflammation and release medicine as needed.

“Engineering is an applied field, motivated by trying to build useful objects,” says McMillen. “We’re engineering in a context where a lot of the basic science is still being discovered and that’s very exciting.”

One in 150 Canadians live with IBD, an umbrella term for Crohn’s disease and ulcerative colitis. The condition causes the lining of the intestinal wall to become inflamed, resulting in debilitating and sometimes life-threatening symptoms that include weight loss, stomach pain, fatigue and diarrhea. Current treatments include corticosteroids, biologics and immunomodulatory drugs that reduce inflammation. Unfortunately, these treatments lower the activity of the immune system in the whole body, making it harder to combat infections and some cancers.

The gut microbiome, the vast collective communities of bacteria and microbes that live in the intestine, is thought to play a major role in the disease. While the exact cause of IBD is still unknown, a major contributing factor was discovered by one of McMillen’s collaborators, an immunologist who discovered that gut bacteria promote the production of a molecule called muramyl dipeptide (MDP) that acts as a signal to intestinal stem cells, encouraging them to generate new cells to repair the gut lining.

Building on that insight, McMillen and his colleagues are engineering a bespoke bacterial system that can sense the level of MDP present in the intestine and produce more when required. “To work, the system needs a sensor, a molecule producer and a feedback system to regulate the release of the right amount of the therapeutic molecule,” says McMillen. “Too little would be ineffective, and an excess might encourage too much growth which could lead to potential problems.” Swallowing a bespoke gut microbe would provide targeted treatment directly in the intestine. When consumed, the bacterium would find its way to the intestinal tract and treat IBD directly at the source, promoting healing in the cells that are hit the hardest. “The key advantage of using engineered bacteria over a drug is that they work like an active agent that can go in and make simple decisions, sensing and responding based on what they encounter,” says McMillen.



David McMillen

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There are five other U of T researchers on the multidisciplinary team: using DNA sequencing to identify molecules that could work as inflammation sensors; studying how to integrate a synthetic gene network into a synthetic microbe system; investigating molecule production and how to engineer bacteria to produce high levels of MDP; and understanding the underlying biology of intestinal cells in more detail using “gut on a chip” and animal models.

Translating this applied research project to a drug is years away. If the team can successfully develop a new responsive gut microbe therapy, it will then need to be tested in clinical trials and approved by Health Canada before it becomes available. In the meantime, McMillen sees shorter-term payoffs: “If we can get the sensors working, that could lead to interesting ways to diagnose or characterize IBD in ways that are not currently possible,” he says. “For example, we could include the microbe in a yogurt drink and look for a colour change in bowel movements that would indicate the presence of inflammation.

“The project has put me in contact with a whole group of people I wouldn’t be working with so closely otherwise,” says McMillen. “It’s exhilarating to move from proof of principle demonstrations to trying to solve an actual problem because the field has developed to the point where that’s now within reach.”

The project is one of 19 supported by Medicine by Design, a seven-year initiative that began in 2015 to support transformative research in regenerative medicine and cell therapy. The initiative is funded, in part, through a \$114-million grant from the federal government’s Canada First Research Excellence Fund. —**Jane Langille**



Timing is everything: Encouraging more women to donate cord blood



Nicola Lacetera



Umbilical cord blood is a rich source of blood-forming stem cells that can be banked and used later to treat life-threatening diseases such as leukemia and lymphoma. But only a tiny percentage of parents donate cord blood—in the vast majority of cases, it is discarded as medical waste.

Nicola Lacetera, an associate professor of strategic management with UTM’s Department of Management, applies economic principles to study the motivations affecting blood, organ and tissue donations. He

recently collaborated with colleagues at the Università Bocconi and Buzzi Children’s Hospital in Milan, Italy, and Johns Hopkins University in Baltimore. They conducted the first randomized controlled trial

Empowering older adults to understand health information will help them better manage their health as they age.

examining whether informational and behavioural nudges could increase cord blood donations among 367 expectant women at an obstetrics clinic in Milan.

The decision to donate cord blood is made during pregnancy when parents tend to be experiencing an overload of information, emotions and choices. “We modified the timing when women were informed and provided them with a non-binding opportunity to indicate their decision for donating cord blood,” says Lacetera.

Only 2.3 per cent of women in the no-intervention group donated cord blood. However, donation rates were much higher in groups that received information and prompts to make a donation decision. Later timing and “repeat asks” had a positive impact—in the group that received information and prompts during the third trimester, 10 per cent donated, compared to 8.1 per cent in the group that received those interventions during the first trimester. Repeat interventions of information and prompts during both the first and third trimesters achieved the best results, a donation rate of 17 per cent.

“Awareness is important, but we found that the timing of the awareness mattered more,” says Lacetera. “With each pregnancy, there is only one opportunity to donate cord blood. If you miss it, you miss it.” —**Jane Langille**



Making digital health information accessible to older adults



Older adults are active information hunters when it comes to their health. But they tend to be fearful about looking for answers online. That’s a problem, given that more and more medical information is becoming digitally available.

Cosmin Munteanu is an assistant professor with UTM’s Institute of Communication, Culture, Information & Technology at the University of Toronto Mississauga and co-director of the Technologies for Aging Gracefully Lab (TAGlab) at the University of Toronto. His research

focuses on using technology to address common social and psychological issues faced by people as they age.

Munteanu’s research team is designing apps to make digital health information more accessible.

One app is human-powered: the user adds a text, audio or video “sticky note” to a passage they do not understand, and sends the query through the app to a trusted person like a friend or family member for interpretation. A second app uses artificial intelligence to automate explanations of complicated text. The apps could help users find the answers they seek while maintaining privacy and independence.



Cosmin Munteanu

“Hearing and seeing well helps people maintain social connections.”

A recent computer science graduate working with Munteanu in the TAGlab conducted ethnographic research to refine the design and test prototypes of the second app among small groups of older adults. Munteanu recently led a larger trial among 30 seniors to test two different formats for automated information. “We are trying to determine the sweet spot between completely translating an entire page or providing explanations for keywords on the side,” he says.

The researchers are evaluating the two different formats, noting the number of repeat queries, errors and time efficiency, as well as subjective measures including user confidence and whether they like the experience.

Empowering older adults to understand health information will help them better manage their health as they age. “We don’t want to replace text. We want people to be able to access the original, so they still feel connected,” says Munteanu. “Over time, we hope they will need less assistance.” —**Jane Langille**



Investigating the link between hearing and healthy aging

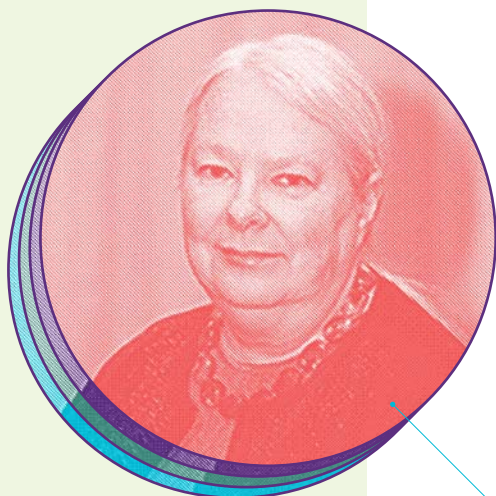


It can start gradually—a misheard word or the nagging feeling that everyone is mumbling. Then the television volume is up a little higher than it used to be and high pitch sounds—like the voices of grandchildren—become muted. These are typical signs of hearing loss, a phenomenon that can creep up on any of us as we age.

“Hearing loss is the second most common impairment, after vision loss. It increases with age and affects most older adults, but many people wait a decade or more before being assessed,” says psychology

professor **Kathleen Pichora-Fuller**. At UTM’s Human Communication Laboratory, Pichora-Fuller studies the link between auditory and cognitive processing during communication in everyday life, with a particular focus on aging populations. “This delay in being assessed can result in negative consequences, including social withdrawal and increased risk of dementia,” she says. There can be physical repercussions, too. “People with hearing loss are more likely to suffer falls.”

Pichora-Fuller hopes to discover why people experiencing hearing loss take that important first step to seek help. She and a former graduate researcher have launched a Canada-wide study to examine why people decide to get their first hearing aids and what may have prevented them from doing so earlier. Her research partner, Gurjit Singh, is now a senior research audiologist and program manager at international hearing aid producer Phonak. Funded by Phonak’s sister company, Connect Hearing, the national study will collect data from



Kathleen Pichora-Fuller

3,000 Canadians over the age of 50 who have not previously used hearing aids. “We hope to gain better understanding of key factors such as stigma and social support from family and friends that influence the decision to seek help and begin treatment for hearing problems” she says.

According to Pichora-Fuller, glasses and hearing aids can be important tools to keeping healthy as we age. “Hearing and seeing well helps people maintain social connections, which in turn increases opportunities for physical and mental activities—staying physically, mentally and socially active is what keeps us healthy,” she says. “We’d like to find ways to overcome stigma attached to aging and loss of vision and hearing because this is a quality-of-life issue.”

The industry-partnered project is a spin-off of other research on the links between sensory and cognitive aging that Pichora-Fuller is conducting as part of two national CIHR-funded studies, the *Canadian Longitudinal Study of Aging* and the *Canadian Consortium on Neurodegeneration in Aging*. —**Blake Eligh**

Using wearable health technology to improve performance



From the steps we take to the calories we consume, many of us track personal data through wearable gadgets and smartphone apps. We know how many hours we slept and how many minutes we spent in meditation, but what do those numbers really tell us about our overall health? A new study launched at UTM this fall will investigate how the data we collect today can be used to predict and improve our health and performance in the future.

“Dark data is data with no useful purpose,” says **Jayson Parker**, associate director of UTM’s Master of

Biotechnology program and associate professor of biology, teaching stream. “We collect biometric information but what are we doing with it? A better understanding of that information could help us to make better choices for our health.”

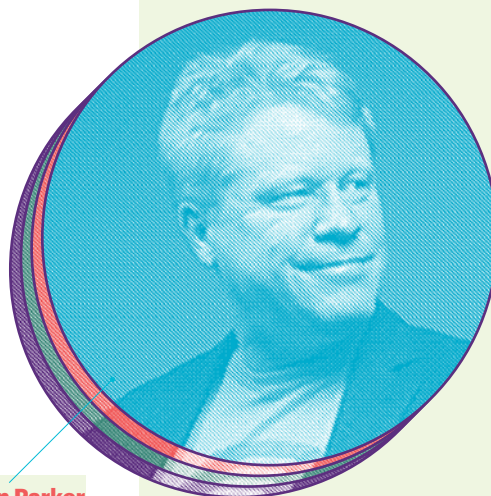
Parker wants to shine a light on our dark health data by creating a new way to aggregate and analyze this information. In the pilot phase of Parker’s study, volunteers wear devices to collect lifestyle and biometric information—including sleep patterns, heart rate and blood pressure—over a 36-hour period. They also undergo cognitive and other tests to measure the peaks and valleys of performance throughout the day.

Based on Parker’s analysis, participants will be able to apply the findings to modify their behaviour. This new method of looking at data could provide a clearer view of individual health and provide personalized guidance.

“This is a shift in how we think about data and its relationship to health and performance,” Parker says. “What time of day should you go to bed? When should you work out? What lifestyle choices should you make to optimize your performance?”

“We could use this information for illness prevention and to improve outcomes in concentration, productivity and fitness,” he says. “Through this data, we could see trends in how lifestyle choices today will benefit our health and wellness tomorrow.” **M —Blake Eligh**

“What time of day should you go to bed? When should you work out? What choices should you make to optimize performance?”



Jayson Parker