



**NRC-CNRC**

# **RESPONDING TO CANADA'S NEEDS**

**from COVID-19 to Climate Change**



Annual report **2019-2020**



National Research  
Council Canada

Conseil national de  
recherches Canada

**Canada** 





For more than 100 years, the National Research Council of Canada has been called on to help the country face its greatest challenges — from food security to world wars to long-distance communications and transportation.

As Canada’s largest federal research and development organization, we address those needs through science, technology and innovation.

We answer the call by drawing on our broad, multi-disciplinary R&D expertise and world-leading facilities, working collaboratively with partners

and stakeholders to conduct mission-oriented, transformational research.

In 2019–20, we focused our efforts on several critical issues, including the immediate crisis of the **COVID-19** pandemic and long-term challenge of **climate change**.

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# MESSAGE FROM THE PRESIDENT



For more than 100 years, the NRC has supported Canada and Canadians in their time of need. We provided science and technology support and during the First World War, the Great Depression, the Second World War and the 20<sup>th</sup> century's sustained period of nation building. Public good NRC innovations included concrete for a harsh climate (1920s); redesigned steam locomotives (1930s); wartime innovations like radar and atomic energy (1940s); electric wheelchairs and the pacemaker (1950s); air safety developments like the crash position indicators (1960s); anti-counterfeiting technology for Canadian currency (1970s); the inaugural Canadian astronaut program and the Canadarm (1980s); the synthetic meningitis C vaccine (1990s); medical devices like brain surgery simulators (2000s); and the first non-military biofuel test flights (2010s).

Over the past year, the NRC was once again been called upon to support the public policy needs of an evolving Canada. Recent years have been the hottest on record. Although climate change is a long-term phenomenon, the effects and impacts are increasingly pressing. Canada needs to transition to a more sustainable economy to reverse the strains that modern life has placed on the environment. The NRC's five-year integrated strategic plan elaborates on how our organization supports this shift with research on clean energy, the environment, natural resources, buildings and infrastructure, food and transportation. In 2019–20, the NRC used leading-edge

science to take action with partners in government, academia and industry to push the limits of what's possible for a more sustainable future.

In addition, the world as we knew it changed dramatically in the last quarter of the year, with the COVID-19 pandemic hitting Canada and the rest of the world with force. The NRC had the capacity and expertise to mobilize quickly to protect the health of Canadians and



our workforce, and support our clients, collaborators and Canadian businesses so that they could continue to provide essential services, contribute to the fight against COVID-19, and ensure our country could put its best foot forward amidst this global crisis. The NRC's response in the early weeks of the pandemic is outlined in the first pages of this report.

The NRC also continued to implement initiatives with partners across a variety of sectors. Our researchers worked with more than 45 collaborators on Ideation projects, and the NRC established three additional collaboration centres with the Fields Institute, CHU Sainte Justine and the

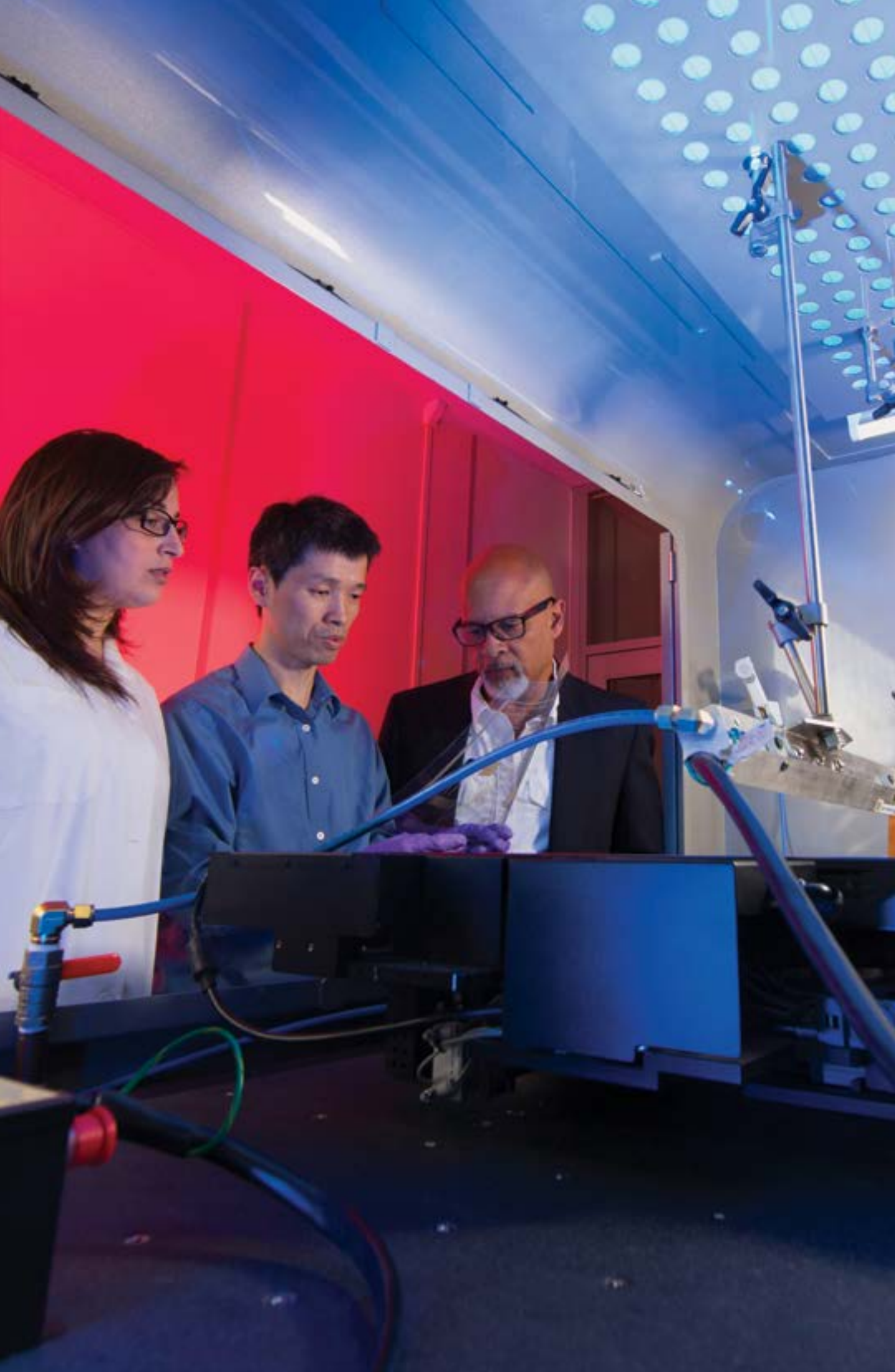
University of Manitoba. In June, we launched four new bold, seven-year collaborative Challenge Programs to benefit Canadians, focused on disruptive technologies including AI-assisted design, cell and gene therapies, faster and more secure digital networks for rural and remote communities, and the development of new materials that will be used in the production of clean and sustainable energy.

From a governance perspective, the NRC welcomed six new council members in June: Dr. Susan Blum, Ms. Norma Beauchamp, Dr. Steven Murphy, Dr. Karen Bakker, Mr. Ray Hoemsen and Dr. Pierre Rivard. They join the council's chair, Dr. Douglas Muzyka, and the other members in bringing a wide range of experience and expertise to their role of overseeing the performance of the organization.

Responding to opportunities and challenges important to Canadians, often in collaboration with others, is what deeply motivates employees across the organization. The NRC is fortunate to count on dedicated, knowledgeable and proud employees who continually rise to the challenge. Each and every one, whether they work in one of our research centres, NRC IRAP or in a corporate branch, contributes to advancing the NRC's agenda and delivering results.

Iain Stewart, President





# THE NRC AT A GLANCE



## OUR VISION

A better Canada and world through excellence in research and innovation.

## OUR MISSION

To have an impact by advancing knowledge, applying leading-edge technologies and working with other innovators to find creative, relevant and sustainable solutions to Canada's current and future economic, social and environmental challenges.

## OUR VALUES

**Integrity:** Behaving at all times ethically, honestly and objectively; being impartial and transparent with our colleagues, collaborators, stakeholders, clients and the people of Canada; and exercising sound stewardship of our resources.

**Excellence:** Pursuing excellence in all that we do: in our research and innovation, in our collaborations, in execution of our programs, in our support to firms and in our delivery of our common corporate services.



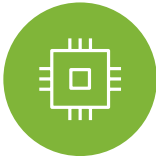


**Respect:** Valuing and respecting the knowledge, expertise and diversity of our colleagues, our workplace, our collaborators, our stakeholders and our clients to have an impact on Canada and the world.

**Creativity:** Harnessing our imagination, passion for excellence, scientific exploration, technology and innovation to generate new knowledge, new technologies, new business processes and new collaborations for a better NRC and a better world.

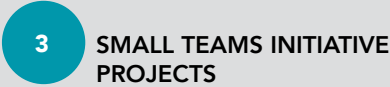
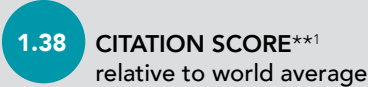
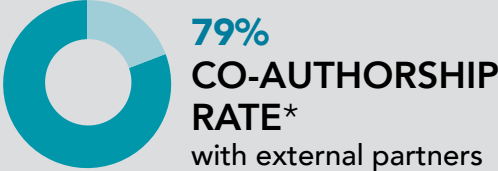
\* Developed bottom-up through a whole of NRC process in 2017-18 in which 1,200 employees participated.

## OUR RESEARCH CENTRES

Our research spans **14** research centres across **5** divisions, with facilities in **22** locations across Canada. By collaborating and working across our research centres, we can take a more comprehensive, multidisciplinary approach to tackling the great challenges of our age.

Life Sciences	Emerging Technologies	Digital Technologies	Transportation and Manufacturing	Engineering
				
Aquatic and Crop Resource Development Human Health Therapeutics Medical Devices	Advanced Electronics and Photonics Herzberg Astronomy and Astrophysics Metrology Nanotechnology Security and Disruptive Technologies	Digital Technologies	Aerospace Automotive and Surface Transportation	Construction Energy, Mining and Environment Ocean, Coastal and River Engineering

## SCIENTIFIC ACHIEVEMENTS



\*Calendar year 2019

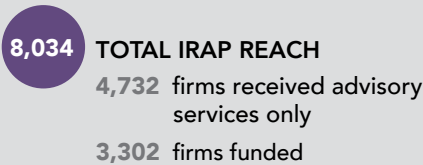
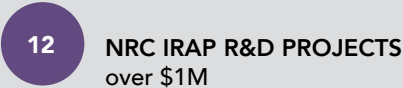
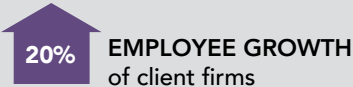
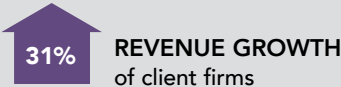
\*\* Three-year average (2017 to 2019 calendar years)

<sup>1</sup> The citation score is the three-year average Field-Weighted Citation Impact (FWCI) of NRC publications. The FWCI is a standardized measure of citations in a particular field that is normalized to 1.0.

## PEOPLE

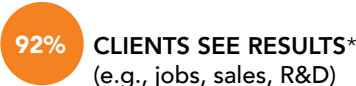


## NRC INDUSTRIAL RESEARCH ASSISTANCE PROGRAM (NRC IRAP)





## CLIENTS

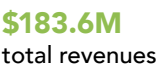


\* 27% client feedback response rate  
\*\* Collaborative Science, Technology and Innovation Program

## FACILITIES



## FINANCIALS (unaudited results)



### THE NRC GOES INTERNATIONAL

In late 2019, we opened our first international offices in Tokyo and Munich. By working more closely with research institutions and innovation programs in Japan, Germany and also in the United Kingdom (through our increased involvement with the EUREKA network, for example), we can accelerate R&D collaborations with researchers and businesses around the world.

Seen speaking at the Tokyo office opening in October is Shigeru Sasaki, Head of the NRC's Japan office.

# CREATING A REPRESENTATIVE WORKFORCE



A representative workforce is a critical enabler of science and research excellence, and better equips us to address Canada’s great challenges.

## BRINGING INSIGHT TO THE HIRING PROCESS

NRC IRAP wanted to diversify its roster of Industrial Technology Advisors (ITAs) but realized it was attracting candidates from the same pools. Through staff and candidate consultation, NRC IRAP gained a better understanding of the profile of its ITAs and the barriers it faced in recruiting from under-represented groups. With those insights and a more targeted approach to outreach and engagement, NRC IRAP’s

hiring profile shifted significantly last year. Nearly half (48 percent) of the ITAs hired in 2019–20 self-identified as part of an equity, diversity and inclusion (EDI) group.

## ENGAGING MORE EFFECTIVELY WITH INDIGENOUS COMMUNITIES

To help advance Canada’s process of reconciliation with Indigenous peoples, in 2019–20 we began work on an Indigenous engagement strategy that responds to specific Calls to Action from the

2015 Truth and Reconciliation Commission report. Through a process of co-design and co-creation (supported by an external advisory committee on Indigenous engagement and culture), this strategy will connect science to the needs of Indigenous peoples; catalyze economic growth of Indigenous businesses; engage in dialogue, knowledge-sharing and R&D projects with Indigenous communities; and attract, retain and advance an Indigenous workforce at the NRC.



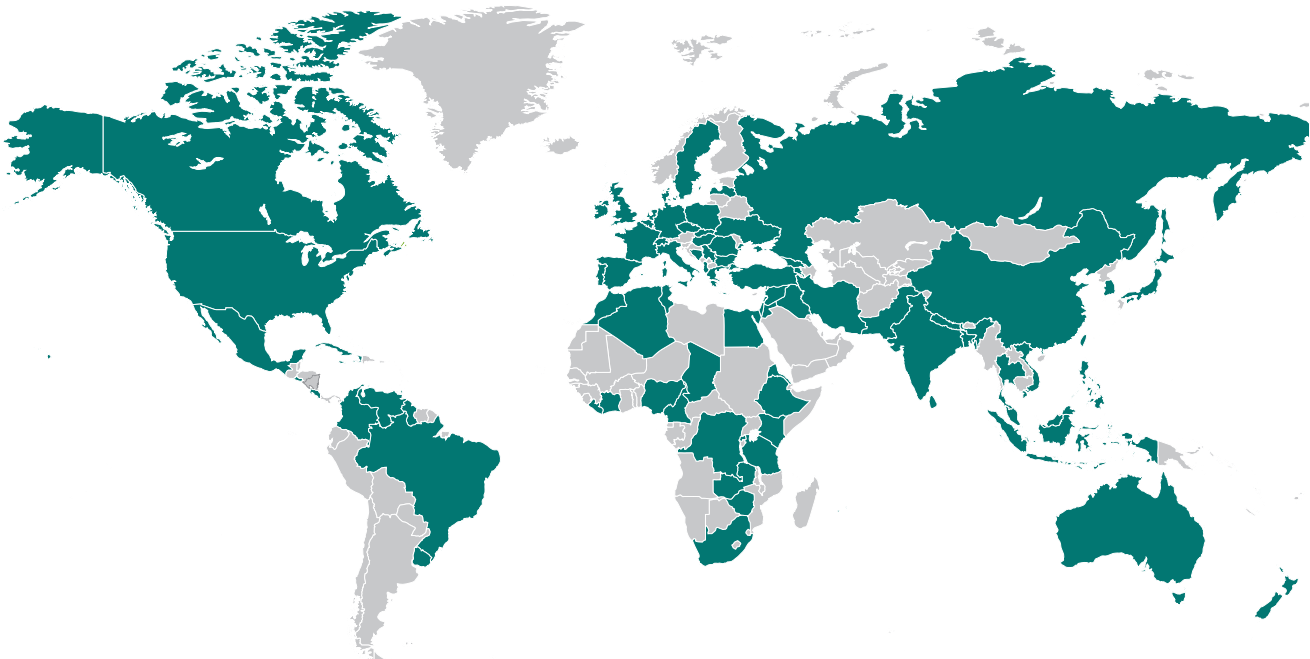
88

nationalities represented in the NRC workforce



26.1%

women in STEM (Canadian market availability = 25.8%)





Participating in the Women in STEM Symposium were 12 agency Presidents and Deputy Ministers, and the Chief Science Advisor, Dr. Mona Nemer.

### ENRICHING SCIENCE BY SUPPORTING WOMEN IN STEM

When more women are involved in STEM (science, technology, engineering, math), more diverse perspectives are brought to the challenges facing Canadians. To showcase how women researchers are at the heart of so many scientific achievements and technology breakthroughs, we hosted a Women in STEM Symposium on February 11, 2020 (the International Day of Women and Girls in Science). The event brought together close to 300 women from 12 federal departments and agencies to share information about their projects, celebrate each other's success, form networks and discuss ways to improve EDI across the federal government.

As part of the event we endorsed the Dimensions Charter, a program led by the Natural Sciences and Engineering Research Council to address the systemic barriers faced by under-represented and disadvantaged groups in post-secondary research institutions — and improve EDI in science and research over the long term.

We also held six Women in STEM events in Ottawa, Montreal, Edmonton and Vancouver last year, providing a platform for our women researchers to share ideas and learn from each other.

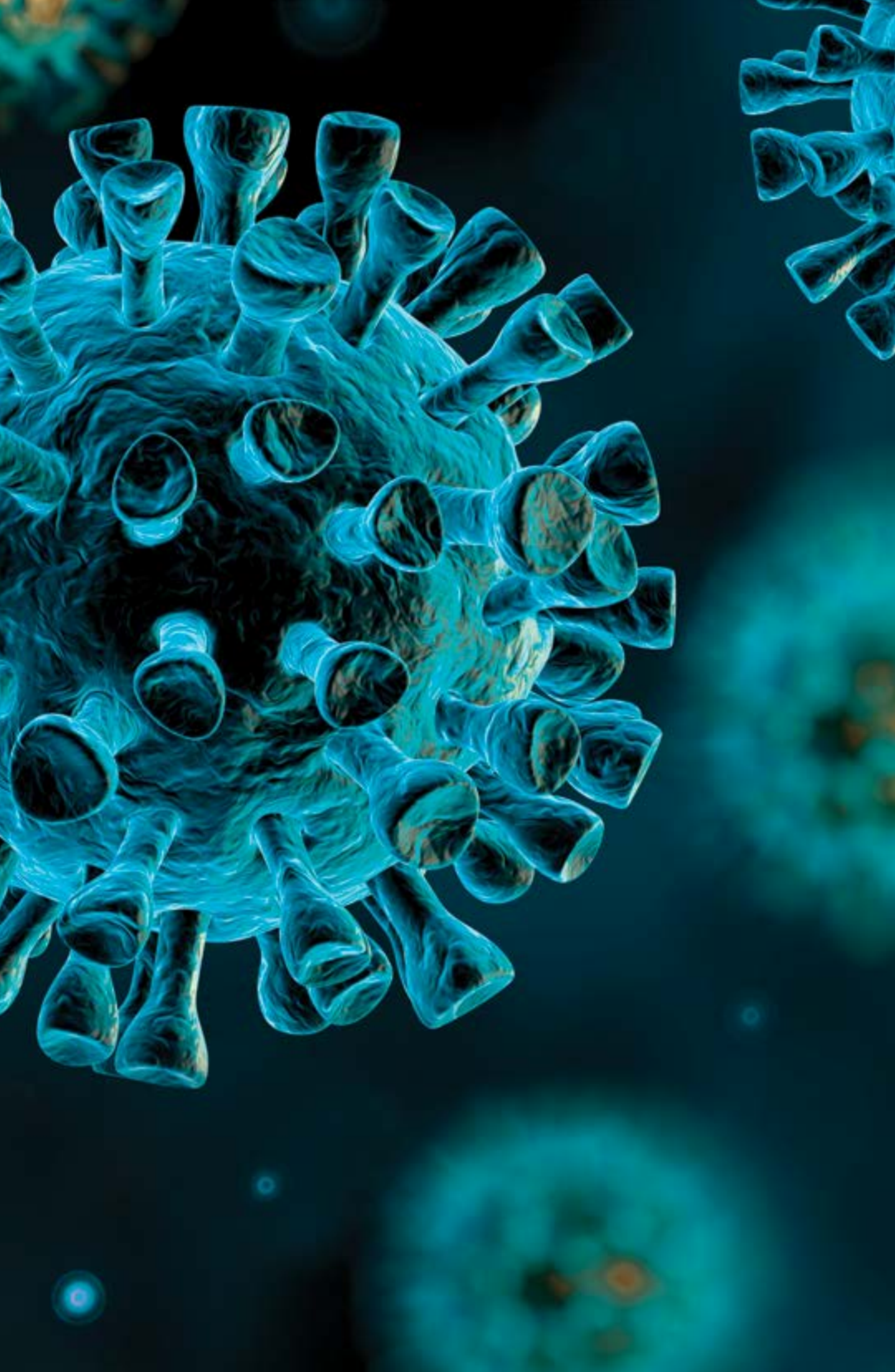
"The Government of Canada is home to many brilliant women working in STEM. These women are shaping science — finding solutions to some of the most complex challenges Canadians face. We can certainly rejoice in Canada because we are one of the more progressive countries in encouraging women to participate in all areas of society including STEM."

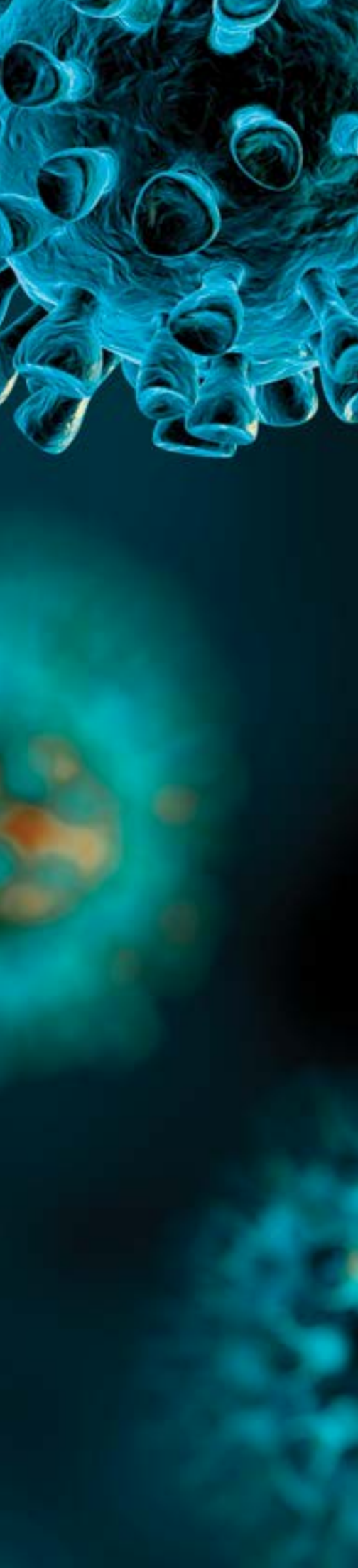
Dr. Mona Nemer, Chief Science Advisor of Canada

### OUR COMMITMENT TO TALENT DIVERSITY AND WELLNESS

Our new five-year integrated strategic plan (2019–24), which includes a human resources plan, sets out the strategies we will use to ensure a diverse and representative workforce, accessible employment and programs, and an inclusive culture at the NRC.







# FIGHTING BACK AGAINST COVID-19



When COVID-19 disrupted the world in early 2020, the NRC pivoted to support the massive government-wide response and to help protect the health and safety of Canadians.

## NEW FUNDING TO ACCELERATE FRONTLINE SOLUTIONS

When COVID-19 broke out, we mobilized quickly to tap the ingenuity of Canada’s small and medium-sized enterprises (SMEs) by launching the NRC Industrial Research Assistance Program Innovative Solutions Canada COVID-19 Challenge Program: a collaboration between government and the private sector to address COVID-19-related needs, including the most pressing needs of frontline healthcare providers.

Through this program, Health Canada and the Public Health Agency of Canada issued COVID-19-specific “challenges” to the SME community. Companies with relevant near-to-market solutions were encouraged to

apply for funding from NRC IRAP, which would help them develop proofs of concept and working prototypes for products that could ultimately be purchased by federal departments and deployed in the field.

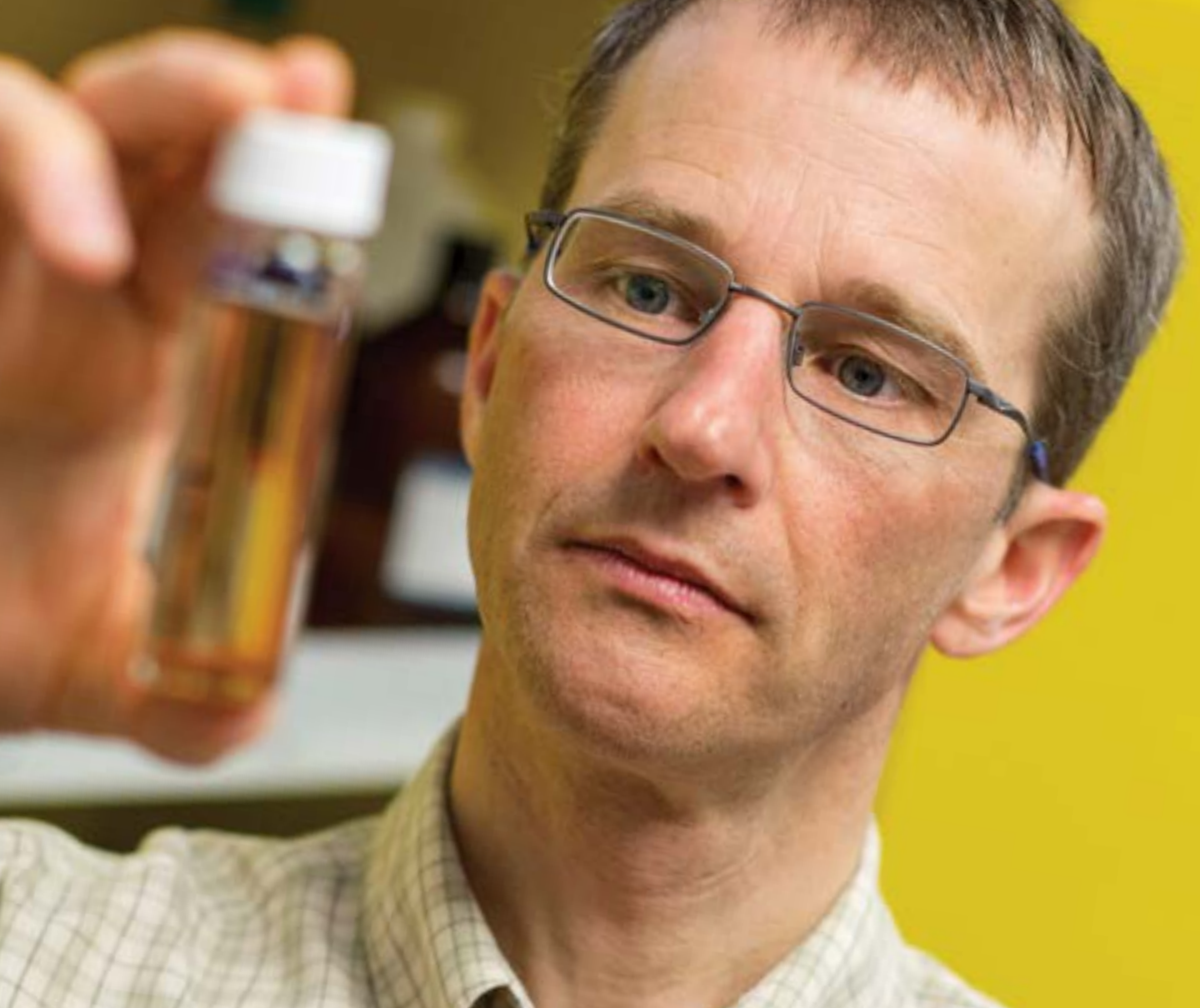
The most promising applicants were invited to participate in “pitch sessions” to present their companies, teams, innovations and technologies for consideration before a panel of experts.

This work aligns with one of the main goals of our new five-year integrated strategic plan: to advance leading-edge health technologies that will help create a healthier future for Canadians.

## GOVERNMENT OF CANADA SUPPORT FOR NRC COVID-19 INITIATIVES

NRC IRAP ISC COVID-19 Challenge Program	\$15 million
NRC IRAP support for SME COVID-19 research projects	\$12 million
Pandemic Response Challenge Program	\$15 million
Increased biomanufacturing capacity at Montreal facility	\$44 million
Innovation Assistance Program	\$250 million
Support for student and post-doctoral research placements	\$7.5 million
Youth Employment Program	\$15 million





### **ACCELERATING R&D TO STRENGTHEN PANDEMIC RESPONSE**

Some solutions to COVID-19-related challenges require further exploratory research and technological advances before a near-to-market product or service can be made available. To expedite the R&D needed to address specific gaps in COVID-19 response, in March 2020 we established the Pandemic Response Challenge Program. This program brings together Canadian and international researchers with SMEs in three main research areas: rapid detection and diagnosis, therapeutics and vaccine development, and digital health.

### **AT THE FOREFRONT OF COVID-19 VACCINE DEVELOPMENT**

While vaccine development typically takes five to 15 years, with COVID-19, researchers from around the world are aiming to have a viable vaccine ready in 12 to 18 months. In March 2020, several efforts were launched to help make that happen.

We began collaborating with North American biopharmaceutical company VBI to test vaccine candidates that will protect against COVID-19 as well as the SARS and MERS coronaviruses. VBI is using unique COVID-19 antigens designed by the NRC to accelerate the evaluation and selection of its optimal candidate vaccine. Pre-clinical studies will be conducted at both NRC and VBI facilities, with the goal of starting clinical testing by Q4 2020-21. We have also partnered with VIDO-InterVac (based in Regina, Saskatchewan) and China's CanSino Biologics Inc. to help those companies develop their vaccine candidates.

Once a vaccine is developed, it will need to be scaled-up. A \$44-million investment granted to the NRC by the Government of Canada will be used to expand production capacity at our bio-manufacturing facility in Montreal — and to certify the facility for compliance with good manufacturing practices, a necessary step for developing materials that can be used in human clinical trials.



## NRC IRAP'S FIRST THREE FUNDED COVID-19 CHALLENGES

### Made-in-Canada filtration materials for N95 respirators and surgical masks



Protecting healthcare workers by manufacturing more masks and respirators here in Canada.

### Point-of-care and home diagnostic kits



Diagnosing COVID-19 with tools as easy to use as a home pregnancy test.

### Low-cost sensor systems for patient monitoring



Transmitting patient data such as temperature and respiration rate to wireless base stations for monitoring by healthcare workers.

### BETTER PATIENT OUTCOMES WITH INNOVATIVE NEW THERAPIES

Beyond our work on COVID-19, last year we created the Disruptive Technology Solutions for Cell and Gene Therapy Challenge Program. Through this program, NRC researchers are leading a national effort to design disruptive technology platforms that support the development and delivery of safe, affordable and accessible biologic therapies for treating (and potentially curing) chronic diseases and rare genetic disorders.

In its inaugural year, the program engaged eight businesses, 17 academic institutions (universities and research institutes), 14 not-for-profit organizations or consortia, and five government departments and agencies. A total of \$4.1 million in funding was awarded to university partners — the first step in creating an ecosystem for health innovation in cell and gene therapies.

### HELPING CANADIANS IN TOUGH TIMES

In late April, the Government of Canada announced a wide range of measures to help people and businesses struggling from the economic impacts of COVID-19. Included in that was \$250 million for the NRC IRAP Innovation Assistance Program, which provides a wage subsidy to innovative, early-stage companies that can't maintain their capacity to perform R&D due to supply chain and cash flow problems. Following the review of applications, over 2,000 firms were identified to receive IAP funding, which will support over 24,000 jobs.

As part of the Government of Canada's support for youth and students, \$7.5 million is being provided to the NRC to support student and post-doctoral research placements. The NRC IRAP Youth Employment Program also received funding to support the placement of 300 additional graduates with SMEs across Canada. This will help new graduates gain the real-world experience that is critical to developing the next-generation of researchers.





**A MADE-IN-CANADA  
RESPONSE TO THE GLOBAL  
RESPIRATOR SHORTAGE**

The COVID-19 pandemic created an unprecedented surge in demand for N95 respirators, resulting in a global shortage of both finished products and the raw material required to make them. To support the national availability of much-needed PPE, our Metrology Research Centre and researchers from across the organization helped establish testing capabilities that enabled the Public Health Agency of Canada to ensure that imported respirators from lesser-known suppliers were safe for use by Canada's front-line health care workers. This was the first step towards building a robust network of credentialed organizations that can manufacture, test and certify N95 respirators and ship them directly to Canadian markets. The NRC was a leader in this vital initiative with health care organizations, academics, regulators, and manufacturers from across the country.



**THE BUILDING BLOCKS OF  
COVID-19 CONNECTIVITY**

With reliable telecommunications more important than ever, at the request of clients and industry partners, we resumed operations at our Canadian Photonics Fabrication Centre (CPFC) in mid-April. The CPFC is a global supplier of unique opto-electronic chips that transmit and receive high-speed digital signals over fibre optics. By continuing to produce these fundamental components, we helped telecommunications companies expand, maintain and repair their networks and services to meet demand during the pandemic. Strict health and safety protocols were put in place at the CPFC to protect on-site staff, in compliance with the Public Health Agency of Canada's guidelines for COVID-19.

**SUPPORTING THE COMMUNITY  
DURING THE CRISIS**

Our broad expertise positioned us uniquely to support businesses, universities and governments in their efforts against COVID-19 through our new Community Support Initiative. Whether they were manufacturing ventilators, mixing enzymes for test kits or verifying medical mask quality, we were proud to respond to over 600 requests for advice, expertise and technical support, and provide best in class advice and technical expertise to help them.

**DELIVERING PPE TO WHERE  
IT'S NEEDED MOST**

On March 27, we put the call out to our research centres and branches, asking them to identify surplus stock of unopened personal protective equipment (PPE) that could be sent to the frontlines in the fight against COVID-19. On April 3, we collected 10 pallets of urgently needed PPE, including N95 masks, nitrile gloves and hooded coveralls, the majority of which were from our Ottawa campus and shipped to The Ottawa Hospital.

**COVID-19 SUCCESS STORIES**

**MacKenzie Atlantic**

As an expert in precision manufacturing, design and metal fabrication, MacKenzie Atlantic was well positioned to answer the call for Canadian-made products to help in the fight against COVID-19. In only a few short weeks, the company expanded its operations to include the design and manufacture of face shields for health-care workers. NRC IRAP played a role in facilitating this journey, providing guidance on safety and effectiveness, as well as the process of applying for a Medical Device Establishment License (MDEL) — a necessary step for any company to sell or import any class of medical device in Canada. MacKenzie Atlantic received Health Canada approval and will be delivering on supply contracts for up to 1.5 million face shields to Canadian healthcare workers.



**Clēan Works**

In 2015, Clēan Works used NRC IRAP support to develop a device that combines ozone, ultraviolet light and hydrogen peroxide to kill 99.999 percent of viruses and bacteria on fruits and vegetables. Early in the COVID-19 response, it became clear the device could help sanitize N95 and other medical masks. An NRC IRAP project was rapidly developed to support the testing and development needed to repurpose the food-cleaning device into a Class 2 medical device. With NRC IRAP support, the firm received Health Canada authorization in less than one week. As of early May 2020, Clēan Works had more than 75 orders from regional hospitals.



Photo credit: The Perley and Rideau Veterans' Health Centre.









# MAKING A DIFFERENCE ON CLIMATE CHANGE



Climate change is one of the greatest challenges Canada and the world have ever faced. Last year, the NRC continued to take action on multiple fronts, using science and research to enable a cleaner, more sustainable future for Canadians — and positioning the country to achieve a net-zero emissions economy by 2050.

Helping Canada transition to a more sustainable economy is one of the core focus areas of our five-year integrated strategic plan, which sets out two key environmental goals for the NRC: contributing to a cleaner future by reducing Canada’s reliance on fossil fuels and supporting R&D that encourages sustainability and protects against threats to our environment. We will advance those goals by conducting science and research on:

## CLIMATE CHANGE MITIGATION



By supporting research on energy storage technology, clean fuels, and energy-efficient buildings and vehicles, we are helping reduce or prevent the emission of greenhouse gases that contribute to climate change.

## CLIMATE CHANGE ADAPTATION



The effects of climate change are being felt across the country, especially in Canada’s North. By advancing research on climate-resilient buildings and infrastructure, food security, and flood and erosion risk-management solutions, we are helping reduce the impacts of climate change.

## ENVIRONMENTAL MONITORING & PROTECTION



To create a greener and cleaner Canada, we are conducting environmental research on topics such as ocean health, nature-based shore protection, pollution prediction and detection, soil remediation, and freshwater and marine water remediation.

## CLEAN TECHNOLOGIES



We are working to design and support the development of innovative clean technologies that Canadian citizens and companies need to transition to a zero-carbon economy in a timely, impactful way.



## GROWING CLEANTECH ACROSS CANADA

One of NRC IRAP’s nine sector teams is dedicated specifically to clean technologies. It provides advice, connections and funding to innovative Canadian SMEs seeking to commercialize solutions for smart energy, emissions reductions, water and waste management, fuel cells, clean buildings and more.

### IN 2019–20, NRC IRAP SUPPORTED:



**142**  
cleantech  
firms



**171**  
cleantech  
projects



**\$28.4 M**  
in contribution  
agreements



# CLIMATE CHANGE MITIGATION

## LEADING-EDGE SCIENCE DRIVING THE LOW-CARBON ECONOMY

Fossil fuels are the world’s largest source of greenhouse gas emissions, making zero-emissions transportation fuels one of the greatest opportunities to mitigate the effects of climate change. Launched in 2019, our seven-year Materials for Clean Fuels Challenge Program — hosted by our Energy, Mining and Environment Research Centre — will create new materials to underpin the production of renewable fuels and enable a cleaner, more sustainable, low-carbon energy and petrochemical industry.

This program is focused on discovering and developing membranes, catalysts and other materials for use in early-stage exploratory technologies that will help reduce the cost of producing and storing clean hydrogen fuel. It also aims to scale up Canada’s ability to capture and convert carbon dioxide into renewable fuels and chemical feedstocks. Through it, we will collaborate with leaders in government, industry and academia around the world, including universities in Germany and the United Kingdom.



## Engaging with our stakeholders

In February, we attended the Globe 2020 Forum in Vancouver, where we connected with leaders from the public and private sectors in a roundtable discussion on our environmental research, clean technology initiatives and NRC IRAP investments in cleantech firms.

## Defining our strategy

We redefined our environmental research strategy in 2019. A workshop held in November brought together partners from within the federal government, academia, research organizations and industry. They helped us identify actions, outcomes and frameworks that will allow us to maximize our impact in reducing emissions and advancing innovative approaches to environmental sustainability — all key to achieving our goals related to climate change.







## Powering the future of transportation

Electric vehicles (and the batteries that power them) provide another path to a low-carbon future. Our Automotive and Surface Transportation Research Centre launched a new project last year with long-time collaborator TM4 — a manufacturer of electric vehicle motors and powertrain systems based in Boucherville, Quebec — to identify new ways of improving motor performance using soft magnetic composite (SMC) powder. Our modelling and simulation team worked with our powder forming team to investigate several state-of-the-art motor designs that take advantage of SMC. The three most promising were then selected for 3D electro-magnetic simulations.

This new project builds on seven years of joint innovation with TM4, including the design and engineering of the Sumo MD motor for electric buses (which uses SMC powder developed and optimized by Rio Tinto Metal Powders), which has now logged 950 million kilometres of operations. About 17,000 Sumo MD motors are slated for delivery to market in 2021, amounting to roughly \$100 million in sales for TM4. This motor also marks the first commercial success for SMC powder, helping to create an all-new product line for Rio Tinto.

**“TRIM is recognized internationally as the most reliable research tool for testing thermal runaways in lithium-ion cells. While it was created for the automotive industry, it has applications in other sectors as well, since thermal runaway can occur in any lithium-ion cell.”**

Kyle Handershot, Senior Regulatory Development Engineer, Transport Canada



## Bringing energy storage to the world

In May 2019, the NRC joined the World Bank Energy Storage Partnership, a new international initiative that aims to expand the deployment of energy storage technologies in developing countries with weak electricity grids. We're developing guidelines for the safe operation of energy storage projects and will use the opportunity to ensure lessons learned in Canada's early energy storage deployments — as well as innovative Canadian energy technologies — gain global exposure.

## Creating longer-lasting lithium-ion batteries

Researchers from our Nanotechnology Research Centre and the University of Alberta's Department of Physics have managed to double the charge storage capacity of a lithium-ion battery. By testing the batteries at elevated temperatures, they were able to slow diffusion in lithium aluminum electrodes and, for the first time, reversibly form new lithium-rich phases.

### Making batteries safer

For electric vehicles to be adopted widely, regulators and consumers need to know they are safe. In 2019, our Automotive and Surface Transportation and Energy, Mining and Environment Research Centres performed the world's first full-scale test of a thermal runaway initiation mechanism (TRIM) on a fully operational electric vehicle. TRIM tests the ability of a lithium cell to resist the cascading of a failure to other cells in a larger battery pack — a process called “thermal runaway” that can lead to overheating and explosions. Our TRIM test will be used to identify how packaging materials, cell spacing and thermal management strategies can be deployed to reduce battery failures.

### Giving end-of-life batteries a second chance

Lithium-ion batteries are not without their own environmental footprint. Last year, we began developing test standards and diagnostic tools for repurposing certain submodules of end-of-life batteries to avoid having them end up in landfills. (Recycling of these batteries is still quite limited, with most constituent materials, including environmentally hazardous ones, being thrown away.) We are also investigating direct anode regeneration and novel elemental separation techniques to facilitate the recycling of cathode materials — which will lead to more efficient and cost-effective methods for recycling lithium-ion batteries worldwide.



**Making Canadian industry more energy efficient**

Our Advanced Electronic and Photonics Research Centre is working on sensors that will make it easier to monitor and optimize the efficiency of manufacturing processes. Last year we successfully demonstrated a proof-of-concept for linear infrared detectors for machine-vision applications (imaging-based inspection and analysis) and are creating components

that will power Internet of Things sensors, which will help businesses of all kinds track power and fuel consumption, emissions and much more. A demonstration of power-autonomous distributed printed sensor arrays for smart buildings was also completed in collaboration with the Construction Research Centre.

In addition, last year the work of the Advanced Electronic and Photonics Research Centre related to the telecommunications industry was refocussed under our new High-throughput and Secure Networks Challenge Program. This includes the development of novel technologies, such as quantum dot multi-wavelength lasers, to help limit the growing demand for power in data centres and other facilities.

# CLIMATE CHANGE ADAPTATION

## FOR MORE CLIMATE-RESILIENT INFRASTRUCTURE

When most of Canada’s buildings, bridges, roads, wastewater systems and other public infrastructure were originally designed, extreme weather events caused by climate change, such as droughts, floods and wildfires, were far less common than they are today. Recent years have been the hottest on record. In 2019–20, we continued our work gathering the data needed to update Canada’s design codes, standards and guidelines as part of the Climate-Resilient Buildings and Core Public Infrastructure Initiative (CRBCPI), a \$42.5-million initiative funded by Infrastructure Canada that began in 2016.

We worked with more than 150 collaborators on a number of ongoing CRBCPI projects last year, including government departments at all levels (federal, provincial, municipal), national and international experts from engineering consulting firms, industry, non-profit organizations, academia and the climate science community. Together, we are creating a suite of evidence-based

guidance documents and decision-support tools to ensure climate resiliency is fully considered and integrated into the design of new buildings as well as in the rehabilitation of existing buildings and public infrastructure. For example, National Wildland Fire Urban Interface Guidelines are planned for completion in 2020, we are contributing to the new National Guidelines for Flood Resiliency

of Buildings to be published in 2021, and our research is informing updates to the Canadian Standards Association’s Canadian Highway Bridge Design Code.

In April 2019, we also provided municipalities, developers and other interested parties with direct, free access to the electronic editions of the National Building Code, the National Fire Code, the National Plumbing Code and the National Energy Code for Buildings through the NRC website. Making these codes free in an electronic format has increased their distribution across Canada dramatically: we received 110,000 electronic requests in 2019–20, compared to just 18,500 electronic and paper requests combined the year prior. The review process is currently underway for updates to the next editions of the National Model Code documents.

**“Together, Infrastructure Canada and the National Research Council are working to integrate climate resilience into building and infrastructure design through future climate data, guidance, standards and codes. Ultimately, the Climate-Resilient Buildings and Core Public Infrastructure Initiative will contribute to an infrastructure landscape that can keep Canadian communities safer from extreme weather and the effects of climate change.”**

Kelly Gillis, Deputy Minister,  
Infrastructure Canada









### Safer ice roads in Canada's North

Many Northern and First Nations communities, as well as mining, logging and oil and gas companies, rely on winter roads to access necessities and receive shipments of goods. Last year, the Ocean, Coastal and River Engineering Research Centre continued to work with Transport Canada, the Royal Military College and Crown-Indigenous Relations and Northern Affairs Canada to find ways to reinforce these roads, especially those that run over floating ice cover and have been unable to reach safe ice thickness in recent years due to changing environmental conditions. This research aims to increase the predictability of ice roads' load-bearing capacity and ability to sustain vehicle weight so that, even with thinner ice underneath, they will still be safe to cross.

The expansion of our Arctic research program last year to include new collaborators and pilot test locations will further support Canada's sustainable

development in the North, while improving the quality of life for Northerners through more reliable infrastructure.

### Making railways more resilient to changing temperatures

Railways are a critical part of Canada's infrastructure for freight and passenger transportation. Under the CRBCPI, last year researchers from our Construction Research Centre and Automotive and Surface Transportation Research Centre designed and installed a structural and geotechnical monitoring system on a section of live track at our VIA Rail test site in Ontario. The system measures track temperature, rail strain and track/foundation deformation caused by heat waves, freeze-thaw cycles and other climate effects. The data will help improve future railway installations in permafrost-rich regions where more frequent freeze-thaw cycles are a serious concern, as they can shift the foundation under the tracks and potentially make rail operations unsafe.



Dr. Keith Chaulk

### Plastics that are better for the environment

Through our Advanced Manufacturing Program, we are working closely with Canadian industry to develop innovative bio-based plastics and adapt manufacturing processes to use these new materials. The new formulations offer performance that is equivalent to traditional plastic products — but because the polyesters are produced naturally by fermentation they are fully biodegradable, making them ideal for the manufacture of compostable product packaging.

### Planting the seeds for drought-resistant wheat

Researchers in our Aquatic and Crop Resource Development Research Centre continued their efforts to ensure Canadian wheat can withstand drought and other stresses that come with climate change. Our work in this area has included contributing to the wheat genome sequencing effort and identifying the genes for a wax coating that will help retain water and awns for better yields in drought conditions. It also includes ongoing efforts to promote sustained photosynthesis in hot-dry conditions and discover deeper roots that can reach water beneath the surface.

On February 13, 2020, we appointed Dr. Keith Chaulk as Director of the Arctic and Northern Challenge Program. Dr. Chaulk, who is Labrador Inuit, brings a personal understanding of Indigenous issues along with a deep background in the resource industry that will help us further expand our Arctic research program.

Climate change is radically changing the environments of Indigenous communities in Canada's North. Dr. Chaulk advocates for a "top-down approach" when it comes to Northern issues: projects are led by people in the North (the "top" of the world) who have experienced the issues firsthand.





# ENVIRONMENTAL MONITORING & PROTECTION

## CLEANING UP CANADA'S WATERWAYS

Science and research play an important role in keeping our country's landscape clean and safe. Last year, we continued to advance projects that will help prevent or limit the impact on the environment when industrial pollutants and chemicals are released into lakes and rivers.

When sulphuric acid leaches heavy metals out of crushed rock and tailings at mining operations, nearby waterways can become contaminated, causing significant ecological damage today and over the long-term. Last year, our Environmental Advances in Mining program continued its work to better understand the leaching process and how it can be prevented. Following the signing of a December 2019 research services agreement with Quebec's Nouveau Monde Graphite, we began work simulating non- or low-acidic tailings to identify ways of minimizing how air gets into waste rock, which can lead to the formation of sulphuric acid. Preliminary results were presented during Quebec's environmental public hearings in winter 2020.

To advance our work in oil spill detection, last year researchers from our Energy, Mining and Environment Research Centre completed testing of technology that uses underwater pulsed lasers and ultrasonic transducers to track and map, in real time, complex oil spills that occur under ice-covered water. The technology can be implemented in a remote operated vehicle, helping to keep people safe during dangerous emergency response scenarios. Test results were highly promising and we are now moving to validate and deploy the technology in real-world conditions.

Researchers from the Ocean, Coastal and River Engineering Research Centre developed and tested new oil recovery boom designs that outperform conventional technologies for oil spill cleanup when water

flow speeds are high. And to support pollution remediation throughout the Great Lakes watershed, we collaborated with U.S. researchers to characterize pollutant loads, predict their movement through the watershed and guide water quality management decision-making.

In addition, we launched a new three-year project in 2019–20 to detect leaking oil in long-haul pipelines. With funding from Natural Resources Canada, researchers from our Security and Disruptive Technologies Research Centre are developing a distributed sensing system based on optical fibre Bragg grating (FBG) technology. When exposed to oil, the thousands of FBG sensors spaced equally along a length of optical fibre create changes in the fibre strain, which can be detected using techniques developed to monitor the health of telecommunications networks. This allows for a leak to be precisely located so a response can be initiated before serious contamination of soil and ground water occurs.

## Using nanotechnology to preserve one of our most precious commodities

New technology developed in 2019–20 by our Nanotechnology Research Centre could reduce how much freshwater is used by Alberta's oil sands operations. A lot of water is needed to soften and extract bitumen from the sand so it can be sent through a pipeline to an oil refinery. Working like giant sieves, membranes can help remove pollutants from the oil-produced water to extend the life of a water supply. NRC researchers, in partnership with the IBM Almaden Research Center, the IBM Alberta Centre for Advanced Studies and the University of Alberta, have found a way to make those membranes more efficient, coating them with a unique polymeric nanoparticle that clings strongly to the membrane surface and blocks polluting substances.

This collaborative research is expected to have a significant impact on water management in the oil sands, with the membranes expected to reduce freshwater usage by up to 15 percent.





### **Canadian clean water technology goes global**

Before they can begin to deliver environmental benefits, clean technologies have to get out of R&D and into the marketplace. The NRC IRAP Fast Pilot in Foreign Markets (FPFM), which helps speed up that process, was significantly expanded for 2019–20.

Through FPFM, NRC IRAP provides small and mid-sized companies up to \$300,000 in funding to install pilot/demonstration cleantech projects at potential customer sites in other countries. Last year, FPFM supported 16 projects in six countries, doubling the total from 2018–19, including

four in China and eight in the United States. Two FPFM-funded demonstration projects in the U.S. involving Vancouver's Axine Water Technologies went into full commercial deployment last year.

In June 2019, NRC IRAP signed a memorandum of understanding with the Government of British Columbia to develop a program based on FPFM specifically for SMEs in that province. Through the BC Fast Pilot Program, NRC IRAP will provide funding to cover salary and contractor costs, while Innovate BC will cover materials, travel and capital costs for pre-commercial cleantech demonstration projects.

**"The Fast Pilot program has been instrumental in accelerating commercialization of Axine's first-generation wastewater treatment solution into the pharmaceutical market. It's a great program and a natural complement to NRC IRAP's core programs that are helping Canada's leading cleantech companies achieve scale faster."**

Jonathan Rhone, CEO,  
Axine Water Technologies

## CLEAN TECHNOLOGIES

### Ultrasonic sensors for safer mines

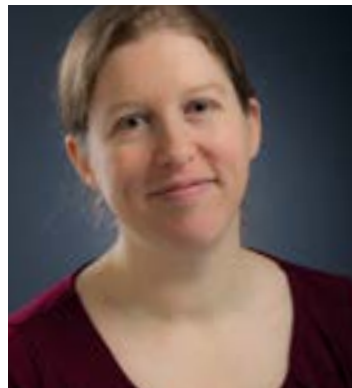
Millions of rock bolts are installed every year to stabilize mine tunnels across Canada. Because seismic activity and blasting affect the bolts' load-bearing capacity, their condition needs to be monitored regularly to keep miners safe. To simplify that process, we developed a rock bolt sensor that uses ultrasonic technology to track bolt stress, deformation and other factors. Rather than pulling out each bolt to visually check its condition, operators simply tap its RFID tag — or monitor them remotely over Wi-Fi or LTE. Now that the technology has been tested in a real mine, last year our Energy, Mining and Environment Research Centre began exploring ways to integrate the sensors' real-time data with seismic monitoring and other mining systems.

### Slowing the melt

Can engines powered by liquified natural gas (LNG) help reduce ice-melting black carbon emissions from ferries and other ships? A team from our Metrology Research Centre, in collaboration with the University of British Columbia and the University of California Riverside found the answer is a resounding yes. Tests conducted last year on a commercial ferry showed LNG decreased black carbon emissions by 97 percent compared to diesel fuel, and cut other particulate matter emissions by 92 percent. Black carbon is a fine particulate matter formed by the incomplete combustion of fuels. When it falls to the ground, it darkens snow and ice surfaces, causing more sun rays to be absorbed and greatly accelerating the melting of Arctic snow and ice.

### Detecting methane with drones and lasers

Because methane has 20 times the warming potential of carbon dioxide, it is important to detect and reduce emissions of this greenhouse gas from Canada's oil and gas sector. In 2019–20, researchers from our Security and Disruptive Technologies Research Centre field-tested a drone-mounted, battery-powered mid-infrared laser spectrometer, which has the potential to provide highly detailed, remote insights into methane emissions from pipelines and tailing ponds. The NRC has been developing laser-based quantum sensors to detect methane since 2014, with our novel mid-infrared laser technology providing a methane sensitivity 100 times greater than conventional lasers.



**"It was very exciting to see how our measurements have a direct application helping a Canadian company assess and improve their environmental performance."**

Dr. Stéphanie Gagné,  
lead NRC researcher on  
black carbon emissions  
from ships

### Leading the way in sustainable bioplastics

Canada's forestry and agriculture industries are an excellent source of raw materials for sustainable bioplastics and biofuels. In 2019–20, we prepared prototypes and technical datasheets to support paper producer Domtar's commercialization of various lignin-thermoplastic products. We've been working with Domtar for several years to convert lignin, a by-product of chemical pulp mills, into pellets that can be used as a substitute for petroleum-based plastics in a broad range of industrial products.

### From the stars to our home

A recent collaboration on astrophotonics between our Herzberg Astronomy and Astrophysics Research Centre and Advanced Electronics and Photonics Research Centres has yielded a new molecular detection technique with applications beyond astronomy. Originally intended for planetary exploration, this technique will also allow for greenhouse gas detection and environmental monitoring here on Earth — a perfect example of the new discoveries that can be made when we bring together our capabilities across many different fields of science and engineering.





← DIESEL  
OIL

← HUILE  
DIESEL



# THE NRC'S COMMITMENT TO SUSTAINABILITY



The NRC adheres to the goals and principles of the Federal Sustainable Development Strategy (FSDS), taking action across our organization to make a “low-carbon government” a reality.

## HELPING CANADA MEET ITS SUSTAINABILITY GOALS

In alignment with the FSDS, our 2019–20 Departmental Plan integrated environmental performance considerations into all decision-making processes for property management and procurement as part of our commitment to help the Government of Canada reach its low-carbon goals. For example, we required all

procurement personnel to complete the Public Service Green Procurement Course, ensured only cleaning products and equipment with minimal environmental impact could be used in our facilities, and contributed to government emissions reductions through improved energy management.

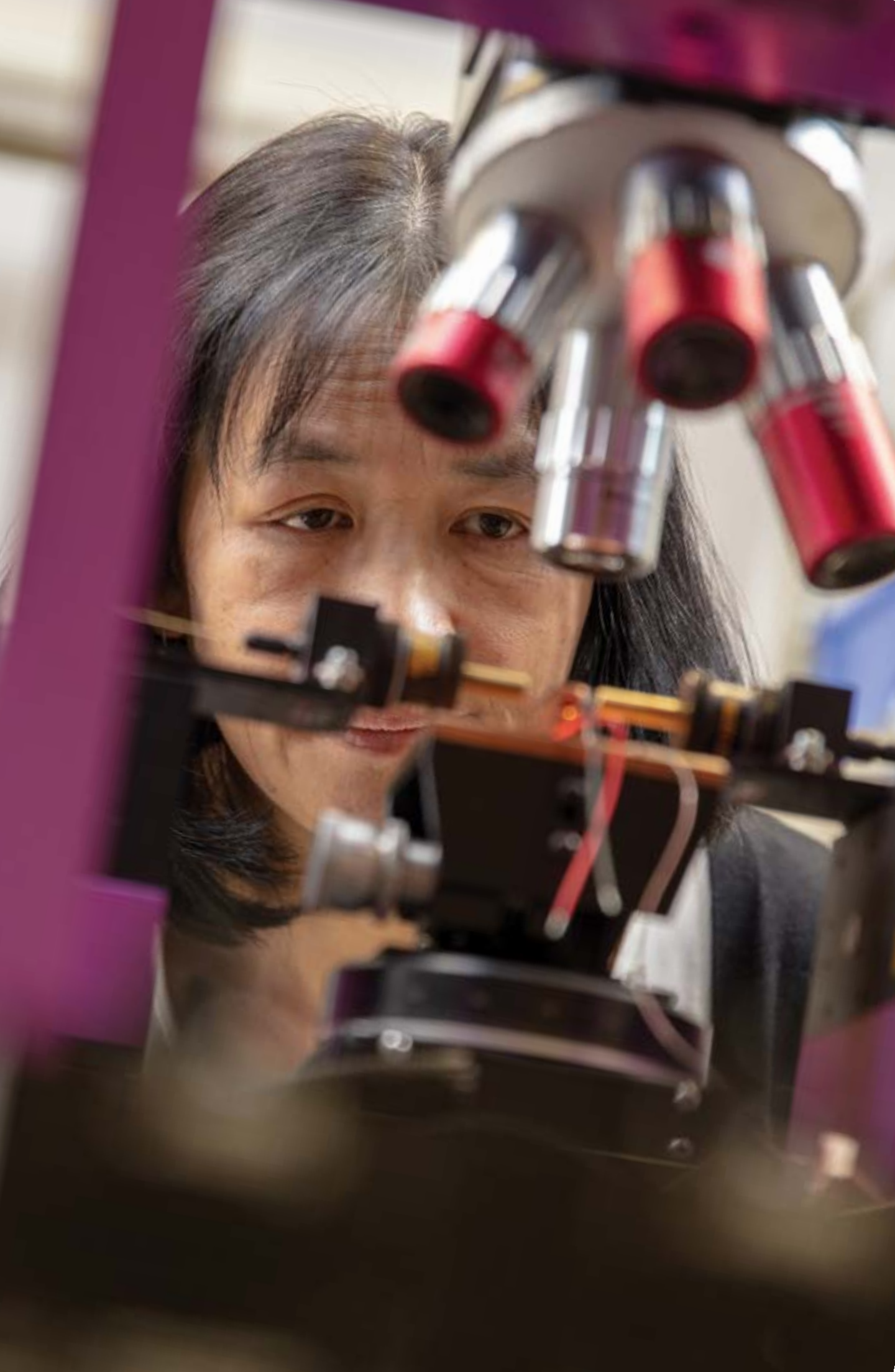
Last year, we began working on the first Departmental Sustainable Development Strategy of our own, separate from those of other agencies in the Innovation, Science and Economic Development (ISED) portfolio. Our broader, more comprehensive three-year strategy will be tabled in September 2020.

## ENERGY SAVINGS AT OUR RESEARCH CENTRES

In 2019–20, the NRC was proud to be among the few science-based departments in Canada to have already met the target of reducing carbon emissions of government buildings by 40 percent (compared to 2005 levels). This was a significant achievement given the complexity and 24/7 operations of most of our laboratory facilities — and a signal that our commitment to completing energy retrofit projects and integrating energy-efficient technologies into our buildings is paying off.

A key contributor was our Aerospace Research Centre, which cut electrical costs by \$1 million and helped reduce the NRC's overall emissions by 10 percent last year by becoming a Class A customer under Ontario's Independent Electrical System Operator, offsetting grid consumption with natural gas co-generation and shutting down non-critical building systems during peak times.





# AWARDS AND HONOURS



Several NRC researchers and scientists were recognized throughout the year for the excellence of their work and career-long contributions to their respective fields.

## INDIVIDUAL AWARDS AND RECOGNITIONS

**Dr. Kathleen Brière** – ISED Deputy Minister’s Award of Merit, Leadership in Innovation

**Dr. Pavel Cheben** – Public Service Award of Excellence, Government of Canada

**Dr. Pavel Cheben** – Fellow, American Physical Society

**Dr. Anant Grewal** – Associate Fellow, American Institute of Aeronautics and Astronautics

**Dr. David Lockwood** – Gordon E. Moore Medal, Electrochemical Society

**Dr. Marek Malac** – President, Microscopical Society of Canada

**David MgBoron** – ISED Deputy Minister’s Award of Merit, Leadership in Innovation

**Dr. Ralph Paroli** – Award of Merit, American Society for Testing Materials

**Dr. Prakash Patnaik** – Excellence Award, NATO Science & Technology Organization Panel

**Philip Rizcallah** – Award of Merit, Canadian Standards Association

**Dr. Mohamad Sabsabi** – Award presented at first International Summit on Laser-induced Breakdown Spectroscopy

**Jeff Stockhausen** – ISED Deputy Minister’s Award of Merit, Regional Operations Excellence

**Dr. Joseph Su** – Foundation Medal, Fire Protection Research Foundation

**Dr. Zoubir Lounis** – Ernest E. Howard Award, American Society of Civil Engineers

**Dr. Alanna Wall** – Young Contributor Award, NATO Applied Vehicle Technology Panel

**Dr. Priti Wanjara** – G. MacDonald Young Award, American Society for Materials Canada Council

**Dr. Priti Wanjara** – Fellowship Award, Canadian Welding Bureau

**Dr. Dan-Xia Xu** – Fellow, Royal Society of Canada

## NRC OVERALL AWARDS

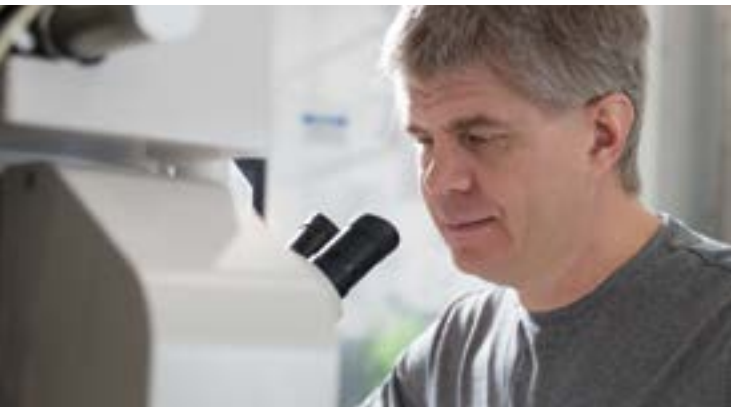
Provincial Employer Support Award, Canadian Forces Liaison Council



Dr. Kathleen Brière



Dr. Mohamad Sabsabi



Dr. Dan-Xia Xu (opposite page) and Dr. Marek Malac (above)



# NRC LEADERSHIP



## SENIOR EXECUTIVE COMMITTEE (composition as of May 1, 2020)



**Iain Stewart**  
President



**Maria Aubrey**  
Vice-President, Business  
and Professional Services



**Michel Dumoulin**  
Vice-President,  
Engineering



**Roman Szumski**  
Vice-President,  
Life Sciences



**Emily Harrison**  
Vice-President,  
Human Resources



**Geneviève Tanguay**  
Vice-President,  
Emerging Technologies



**David Lisk**  
Vice-President,  
Industrial Research  
Assistance Program



**Roger Scott-Douglas**  
Secretary General  
(outgoing)



**Serge Bijimine**  
Secretary General  
(incoming)



**François Cordeau**  
Vice-President,  
Transportation and  
Manufacturing



**Dale MacMillan**  
Vice-President, Corporate  
Services and  
Chief Financial Officer



**Dan Wayner**  
Departmental  
Science Advisor and  
Chief Science Advisor



**Carolyn Watters**  
Chief Digital  
Research Officer

**COUNCIL MEMBERS** (composition as of May 1, 2020)



**Douglas W. Muzyka**  
Chair of the NRC Council,  
Former Senior Vice-President  
and Chief Science  
and Technology Officer,  
E.I. DuPont de  
Nemours and Company,  
Indian River, Nova Scotia



**Iain Stewart**  
President, National  
Research Council Canada,  
Ottawa, Ontario



**Susan Blum**  
Associate Vice-President,  
Research and Innovation,  
Saskatchewan Polytechnic,  
Saskatoon, Saskatchewan



**Ray Hoemsen**  
Former Executive Director,  
Research Partnerships &  
Innovation, Red River College,  
Winnipeg, Manitoba



**Neil Bose**  
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Memorial University, St. John's,  
Newfoundland and Labrador



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Vice-Chancellor,  
Ryerson University,  
Toronto, Ontario



**Steven Murphy**  
President and  
Vice Chancellor,  
Ontario Tech University,  
Oshawa, Ontario



**Carolyn Cross**  
Founder, Chairman and  
Chief Executive Officer,  
Ondine Biomedical Inc.,  
Vancouver, British Columbia



**Karen Bakker**  
Professor and Canada  
Research Chair,  
University of British Columbia,  
Vancouver, British Columbia



**Norma Beauchamp**  
Former President and  
Chief Executive Officer,  
Cystic Fibrosis Canada,  
Toronto, Ontario



**Pierre Rivard**  
Executive Chairman  
and Co-Founder,  
TUGLIQ Energy Corp.,  
Toronto, Ontario



**Aled Edwards**  
Founder and Chief Executive  
Officer, Structural  
Genomics Consortium,  
Toronto, Ontario

