March 2017

WHY SCIENCE MATTERS

> Public policy today is increasingly informed by science. Decisions related to issues such as climate change, the spread of infectious disease, energy, and innovation benefit from a sound understanding of the science behind them.[1]

Exhibit at the Canadian Science and Technology Museum, Ottawa

It's there – in the Giniigaaniimenaaning stained glass window in Centre Block,[2] in the rush with the puck down centre ice,[3] in the fabrics we wear to keep out the winter chill,[4] and in the rapid response protocols to natural disasters. Science contributes much to what we experience, and is essential for our future health, well-being, prosperity and growth.

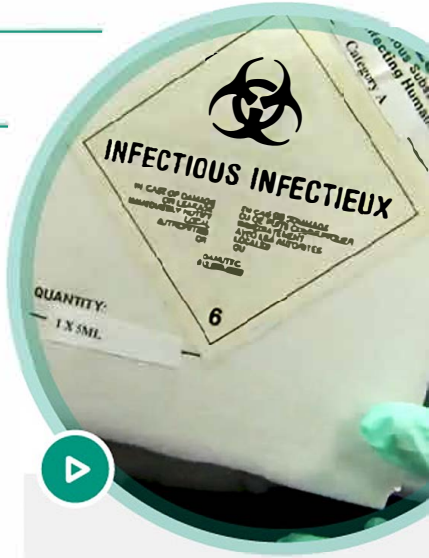
WHAT IS SCIENCE?

Science is a way of answering questions about our natural world. Using the scientific method, scientists seek to answer those questions by collecting data and evidence gathered through experimentation. Science generates knowledge, helps us solve problems and investigate issues. As Henri Poincaré said, "Science is built up of facts as a house is built up of stones – but an accumulation of facts is no more a science than a heap of stones is a house". It is through critical thinking and analysis that we can arrive at rational, reliable conclusions in order to move forward. Science strengthens Canada – even helping to define its borders - and advances those values Canadians hold dear.[5]

WHY SCIENCE MATTERS TO HEALTH CARE

Canadians are proud of their health care system and cite it as one of this country's defining characteristics.[6,7] Scientific research forms the backbone of that system.

In the past century, advances in nutrition, public health and medicine have helped raise the life expectancy in Canada from roughly 60 to more than 80 years today. The knowledge from basic science flows into medical advances. For example, the discovery of the structure of DNA led to such innovations as fertility treatments and new tools to study diseases and new ways to treat them.



Watch a video about the Level 4 Containment Lab in Winnipeg from Daily Planet on Discovery Channel Canada

Day to day, our health is protected by a wide range of regulations – from food labeling to industrial pollution controls, such as:

- Regulating the use of asbestos
- Regulating the safety of children's playpens
- Regulating the flammability of textiles and furniture fabrics
- Regulating the use of pest control products.

Before stepping outside, besides checking the weather, you can check the air quality index.[8] Data from air pollution monitoring stations across Canada are harnessed to enable citizens, particularly those at risk, to limit their exposure to air pollutants and breathe easier.[9]

When unfamiliar health threats arise, such as SARS, Ebola or Zika, researchers at the Public Health Agency of Canada's National Microbiology Laboratory in Winnipeg, work as part of the global effort to understand and contain the disease and develop ways to treat it. Their groundbreaking research led to the development of the first effective vaccine against Ebola.[10] [11]

WHY SCIENCE MATTERS TO OUR ENVIRONMENT

Concern for the environment consistently ranks high in national polls.[12] An appreciation of nature is an important part of Canadian life.

Our system of parks is the oldest in the world and our national parks, a symbol of our national identity.[13] [14] They are also designated areas of protected biodiversity – havens for species of animals and plants representing the historic richness of Canada's wildlife. For scientists they can be landscapes to study different species and their relationship with the environment.

Maintaining the health of our natural world is essential for our own health and well-being, both physical and economic. Science allows us to monitor the status of the environment and understand how best to protect it.

As climate change affects our coastal areas, communities need to adapt. Science helps us predict and visualize those changes. University of Prince Edward Island Climate Lab, in conjunction with Simon Fraser University's Spatial Interface Research Lab, has developed Coastal Impact Visualization Environment CLIVE – a tool to visualize the impact of storm surges and rising seas on the soft sandstone of Prince Edward Island. While the average annual estimate of coastline loss is about 28 cms a year, some storms have eroded 3 to 4.5 meters in one event.[15]

Learn about the impact of sea level rise on Prince Edward Island in this video

As marine traffic increases off BC coasts, developing ways to protect the creatures and plants demands research. A team from the University of Victoria is part of a country-wide partnership including industry, government and universities. Using an underwater glider, the researchers are studying the movement of whales in Clayoquot Sound to help decrease whale-ship collisions.[16]

When deciding the route of a pipeline, it is essential to consider the land the pipeline will traverse. Understanding the characteristics of the soil and rock helps to identify risks posed by landslides, flooding or even earthquakes that could damage the pipeline..[17]

NASA Visible Infrared Imaging Radiometer Suite (VIIRS) satellite image of forest fires near Fort McMurray, May 16, 2016

FIGHTING THE FORT MCMURRAY FOREST FIRE

On May 1, 2016, the largest wildfire to ever affect a populated area in Alberta began southwest of Fort McMurray. Within 2 days, the fire had swept into the city, forcing almost 90,000 people to flee as smoke and fire destroyed 2,400 buildings and homes. The wildfire eventually spread across 590,000 hectares in north Alberta.

Dr. Joshua Johnston is a Forest Fire Analyst with Natural Resources Canada's Great Lakes Forestry Centre in Sault Ste. Marie. Dr. Johnston helped battle the Ft. McMurray wildfire with science - not on the ground but on board a modified fixed-wing aircraft, 4,500 metres in the air. Using an infrared camera able to see through the thick smoke, Dr. Johnston could see the fire and observe its behaviour. While remote thermal sensing has been around since the Korean War, image processing has evolved dramatically in recent years. Dr. Johnston was able to map the flame front of the fire to track how fast the fire was moving and in what direction. The key is identifying the flame front in an infrared image – not just what area is hot, but that solid line that separates the fire from the forest. This helped fire fighters in Fort McMurray determine where the crews would best be deployed.

Natural hazards such as earthquakes can have far-reaching and devastating effects. Earthquakes occur in many parts of Canada, however two regions are particularly at risk– the West Coast and the Ottawa-Montreal-Quebec City corridor. Some of the largest earthquakes in the world have occurred off our West Coast. As researchers study ways to try to predict an earthquake, data is used to help understand the likelihood of an event, and how strong it might be. This information can inform building codes to ensure the buildings and infrastructure can withstand the seismological activity most likely to occur. New seismological data were used to update building codes in Canada in 2016.[18]

Scientists are harnessing traditional knowledge to explore how our environment is changing, and the impact on animal populations. (See box 3) Increasingly citizens are engaged in scientific research, helping to monitor everything from birds to bats, from insects to invasive species, cataloguing the biodiversity in their communities.[19]

WHY SCIENCE MATTERS FOR OUR NATURAL RESOURCES

We've come a long way from our beginnings as a nation of wood, fish and fur, but our natural resources still form a vital foundation for Canada. Scientific research helps keep those resources healthy and sustainable.

In 2015 natural resources were indirectly or directly responsible for 1.77 million jobs in Canada, and accounted for 17% of the GDP.[20] The energy sector contributed the largest portion.[21] However, energy use is also the source of over 80% of our greenhouse gas emissions. Science is a key to building a sustainable and economically strong future. Improving efficiency or replacing fossil fuels presents opportunities for new technologies and renewable resources. This is critical in remote communities in the North, far from any fuel source. There, clean energy projects in wind, smart grid and energy storage can make a difference to the quality of life, the economy and the environment. In Nunavik, Que., a wind turbine installed at the Raglan Mine has offset the use of 3.3 million liters of diesel fuel in its first 18 months of operation. Colville Lake, high in the Northwest Territories, has successfully tested batteries and solar panels that should allow the community to run entirely on the sun's energy during summer.[22]

Forests cover almost half of our country. They provide a rich habitat, with cultural, economic and recreational value, but also play a significant role in offsetting the global carbon burden.[23] The eastern spruce budworm is one of Canada's most damaging forest insect pests. In the 1970s and 1980s, budworm outbreaks affected 50 million hectares, destroying hundreds of millions of cubic metres of timber and severely damaging the economy in eastern Canada. But research out of Carleton University has helped discover a simple solution - to make the trees less palatable to the pest.
The researchers discovered a group of fungi in the Acadian Forest living in needles that can produce toxins against the budworm. Inoculating spruce seedlings in greenhouses with the fungi created trees with increased tolerance to the spruce budworm — enough to significantly reduce the impact of an infestation. 100 million trees have been inoculated so far, harnessing the natural world to protect an important resource.[24]

WHY SCIENCE MATTERS TO OUR ECONOMY

"As a driving force of the economy, science is a catalyst for innovation and the

DEFINING CANADA'S OFFSHORE BOUNDARIES

In late summer, 2016, the Canadian icebreaker CCGS Louis S. St-Laurent sailed out of Dartmouth, Nova Scotia, with an assortment of Canadian scientists on board. It was the start of a six-week expedition in the Arctic Ocean to map the seabed, using multi-beam sonar, underwater probes, and autonomous underwater vehicles. The mission - to collect data about the shape and composition of the seabed- information that will be used to help define the outer limits of Canada's continental shelf in the Arctic Ocean.

The scientists will create a map of the ocean floor using the high frequency sound of multi-beam sonar sweeping the ocean bottom. To determine exactly where the continental shelf actually ends, they will look for differences between continental crust and oceanic crust. Continental crust is thicker and denser than oceanic crust, and the rocks from the continent are different from those on the ocean floor. So, using seismic soundings, they can determine which rocks are which. (Seismic soundings are another way of taking measurements with sound waves, but using compressed air to generate the waves instead).

These data will be used to support Canada's submission for international recognition of an extended continental shelf. Such recognition is important not just for sovereignty, but also for rights over the natural resources of the seabed and subsoil of the continental shelf. Canada could add about two million square kilometres to its territory, about the size of three additional Prairie provinces, if its application for jurisdiction over the continental shelf under the Arctic Ocean is successful.

CARIBOU

Caribou are one of this country's largest mammals, found in almost every province and territory of Canada. As their habitat is eroded due to changing climate or human activity, some groups of caribou are particularly threatened. In order to develop effective management strategies, such as monitoring the status of the herds and conducting accurate surveys of the populations, researchers are seeking to understand more about the different groups and how different populations move and interact. In collaboration with Dene communities, University of Manitoba post-doctoral researcher Jean Polfus is studying the genetics of caribou in the Sahtú Region of the Northwest Territories.[32] [33] Enlisting the help of local community members, from hunters and elders to a twelve year old girl, Polfus collected caribou scat or poo for DNA analysis. The DNA helped identify and characterize the different groups of caribou. High school students and newly trained technicians in the communities worked alongside the researchers to isolate the DNA. But it was Dene traditional knowledge that helped advance the study in a unique way. By combining the traditional knowledge of caribou behaviour and the Dene language, which differentiates caribou well beyond conventional scientific classification, Polfus has been able to understand subtle genetic patterns in her data. This interdisciplinary collaborative research is helping to inform effective management practices in order to protect threatened herds.

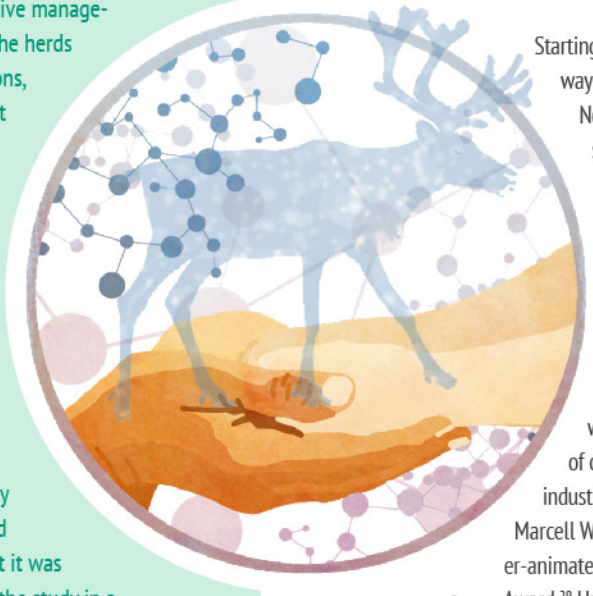


Image courtesy of **Jean Polfus**

creation of new goods and services. Governments around the world recognize the importance of science in developing an innovative, knowledge-based economy."[25]
The big success stories of Canadian creativity and innovation are well known and their impact on the economy can be felt in all of Canada's sectors from manufacturing to communications, and from high tech to the arts. Research leads to jobs, attracts economic capital, and stimulates trade benefits.

Investments in R&D have high rates of return—both social and economic. In 2011, RIM/Blackberry, the Waterloo-based high-tech company, spent $1.54-billion on research. That led directly or indirectly to the creation of more than 300 tech start-ups in the Waterloo area.

In the Vancouver/Lower Mainland area over 100 bio-pharmaceutical companies, 60 medical device developers and 30 bio-products companies have emerged. They collectively generate roughly $1 billion per year in revenues and employ, directly and indirectly, an estimated 14,000 skilled workers largely due to research coming out of UBC and SFU.[26]

The Toronto/GTA region is North America's largest combined life science and biomedical/biotechnology cluster. It is home to more than 1,000 biotechnology companies and institutes, representing more than 45,000 jobs.[27] The Ontario life sciences sector exports $5.7 billion in goods annually, representing 66% of Canadian life sciences exports. $1.1 billion of equity capital was raised by life sciences companies in Ontario in 2014.
The future for just this one specific sector of science is expected to keep growing. The OECD projects that all economic activity related to the life sciences will be worth some $1 trillion globally by 2030. (OECD)

Starting with Sir Alexander Graham Bell, Canada has led the way in telecommunications technology and fibre optics. Now we are at the forefront of new digital industries, such as video gaming and virtual reality software development. These and other 'creative arts', including music, film, design, and architecture rely on science and the latest technology to engage, entertain, enlighten, all while contributing to the 'creative economy'. When compared to the US and the UK, per capita, Canada has "the largest share of creative economy employment, the largest share of workers in creative occupations, and the largest share of creative workers embedded in non-creative industries."[28] Two NRC scientists, Nestor Burtnyk and Marcell Wein helped create what became the first computer-animated film to be nominated for a short subject Academy Award.[29] Hungry/LaFaim was just the beginning of a successful animation industry in Canada.[30]

In 2015, Queen's University physicist Dr. Arthur McDonald shared the Nobel Prize for Physics for his groundbreaking work at the Sudbury Neutrino Observatory. His work helped change our understanding of the fundamental sub-atomic particles known as neutrinos, and has forced researchers to revisit basic theories of particle physics.[31] Who knows what innovations might come from that discovery? It often takes decades to realize the impact of research. Lasers were called "a solution looking for a problem" when invented in 1960. Today, lasers are used in consumer electronics, medicine, industry, law enforcement, entertainment, and the military.

SCIENCE MATTERS TO CANADA'S FUTURE

As we celebrate Canada150, we can look to science to help us meet the many challenges ahead in the next 150 years, in areas such as environment, health, security, food, agriculture and energy. Science is a human endeavour, a quest for knowledge and a way to help create a healthy, sustainable, safe and strong country for all Canadians, now and in the future.

For footnotes, please visit the Science Notes website for more details.

ABOUT SCIENCE NOTES

Are prepared by the Science Media Centre of Canada (www.sciencemedia.ca) a non-profit, charitable organization. ScienceNotes aim to increase discussion on topical issues that have research based evidence at their core, by summarizing the current state of knowledge and policy landscape. Each issue is prepared and reviewed by a multi-disciplinary team and is published free of charge. This issue is made possible thanks to the Federal Science and Technology Directorate. For more information please write to us at: **info@sciencemedia.ca**

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