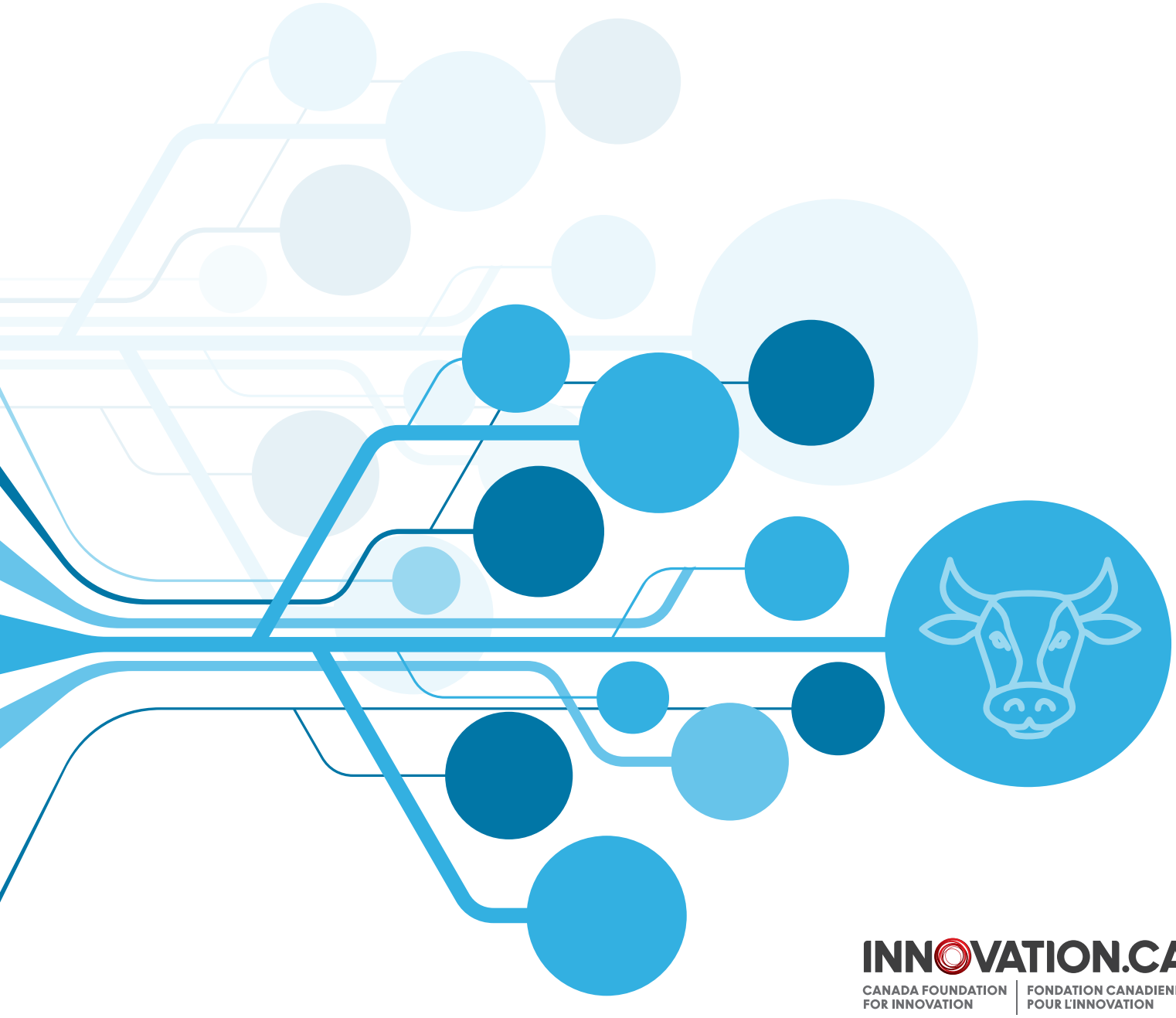
# MAPPING INVESTMENTS TO IMPACTS: **AGRICULTURAL RESEARCH**
## Dairy farming

April 2018



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## ACKNOWLEDGEMENTS

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The CFI would also like to thank Frédéric Bertrand and members of our Advisory Committee, composed of representatives from 20 organizations including universities, federal and provincial government departments and agricultural associations, for their time, expertise and advice in the development of this project.

## METHODOLOGY

Using a data collection framework, administrative documentation and performance data on selected projects were reviewed, including project proposals, budgets, financial, progress and final reports as well as bibliometric analysis of publications authored by project leaders. Findings from interviews and the document review are integrated to assist in the interpretation of findings and to guide the logical flow from CFI funding to research evidence leading to possible outcomes with social, economic and environmental benefits. A subset of projects within each area of study were selected for detailed analysis through the above methods. This selection was made using multiple criteria to maximize the collection of evidence on impact pathways while confining the scope of the study.

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# KEY FINDINGS: Pathways from dairy farming research to impacts

**Resource sharing between researchers enables collaborations across disciplines and industry.**

- Strong linkages between universities and industry stakeholders enable the development of industry-relevant research expertise and infrastructure as well as resource sharing through collaborative projects.
- Shared access to leading-edge infrastructure facilitates opportunities for multidisciplinary research.

**Trainees create and strengthen linkages between academia and industry in the dairy sector.**

- Trainees act as vectors of knowledge transfer through their training with leading-edge technology and their employment in the dairy industry.
- Trainees use evidence-based practices in academia to address challenges faced by the industry.

**Producers, manufacturers and consumers of dairy products benefit from research evidence created through the research infrastructure.**

- Research evidence contributes to the establishment of policies and guidelines to help ensure that Canadian dairy industry standards remain high and competitive.
- Research evidence provides dairy processors with innovative technologies to maximize productivity and improve the quality of dairy products while controlling costs and limiting negative environmental impacts.

# DAIRY FARMING

Investments in dairy research infrastructure from the Canada Foundation for Innovation (CFI) range from creating multidisciplinary research centres, to more efficient milk processing methods, to the development of sustainability technologies and better animal welfare practices.

## BACKGROUND

The dairy industry is one of the largest food industries in Canada and is an important contributor to the country's economy. It ranks third (based on farm cash receipts) in the Canadian agriculture sector following grains/oilseeds and red meats.

In 2015, the industry contributed $19.9 billion to the Canadian gross domestic product (GDP) and created or maintained 221,000 jobs (**Figure 1**). These socioeconomic impacts are almost equally distributed between the production and processing sectors (**Figure 2**). Operating under a supply management system, exports of dairy products totalled $210.7 million in 2015.

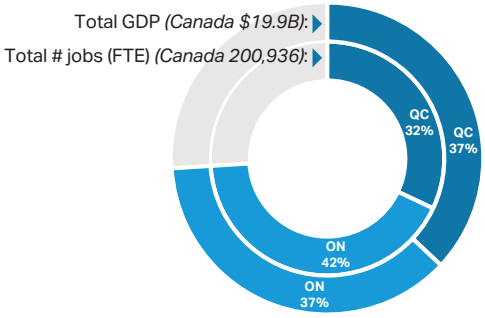
The production of milk and dairy products is especially important to regional socioeconomic development in the provinces of Quebec and Ontario. With the highest volume of milk and the greatest number of farms involved in milk production, Quebec is the largest milk producing province. Ontario is the second largest milk producer, but is the largest dairy processing province with nearly half of Canada's jobs and GDP in the sector (**Figure 2**). The dairy industry is also vital for many Western and Atlantic rural communities.

This report studies the impact of CFI investments across the spectrum of dairy research, from leveraged funding obtained by project leaders and collaborations enabled through infrastructure to the impact of training Highly Qualified Personnel (HQP). The report also touches on the important pathways for knowledge transfer and the benefits of research evidence in terms of social, economic and environmental value to Canada.

## CFI INVESTMENTS

The CFI makes financial contributions to Canada's universities, colleges, research hospitals and non-profit research organizations to increase their capability to carry out high-quality research. The CFI has invested in cutting-edge labs, facilities and equipment for 18 dairy research projects at seven universities between 1998 and 2015, totaling $11.3 million (**Figure 3**).

**Figure 1:** The Canadian dairy industry



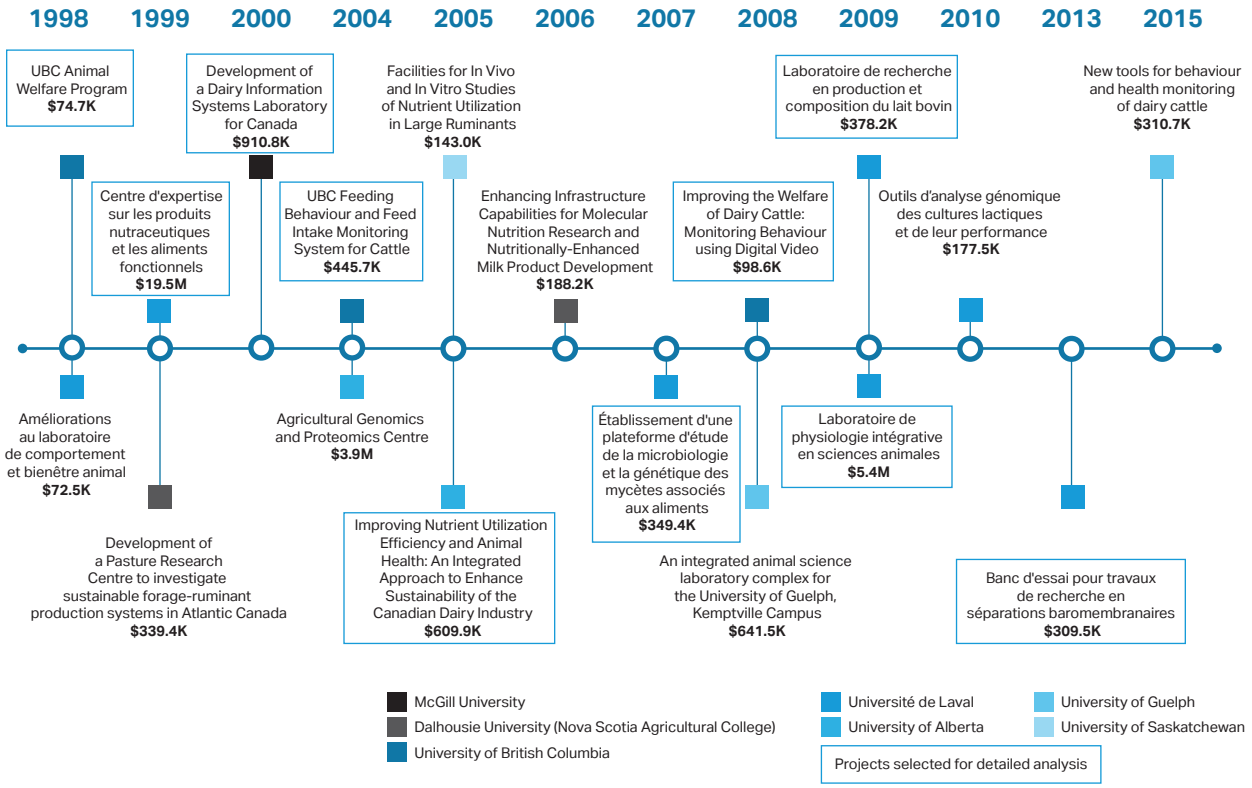

**Sources**: EcoRessources (2016) Update on the economic impact of the Canadian dairy industry in 2015, Prepared for Dairy Farmers of Canada

Statistics Canada/Canadian Dairy Information Centre (CDIC).

**Figure 2:** The Canadian dairy industry by sector (2015)

| Production sector | Quebec | Ontario | Total Canada |
|---|---|---|---|
| Total Milk production (hectolitres): | 37% | 33% | 81.8M |
| # of dairy heifers: | 34% | 37% | 447,800 |
| # of dairy cows: | 36% | 33% | 959,100 |
| #farms with dairy shipments: | 49% | 33% | 11,280 |
| # jobs (full-time equivalent): | 43% | 33% | 115,793 |
| GPD: | 37% | 33% | $8.7M |
| **Processing sector** | | | |
| # processing plants: | 41% | 30% | 484 |
| # jobs (full-time equivalent): | 31% | 42% | 105,143 |
| GPD: | 27% | 49% | $11.2B |

**Figure 3:** Timeline of CFI projects in dairy farming




**Note**: CFI administrative data as of April 15, 2016. Dollar amounts reflect the total project cost of which only 40 percent is the CFI contribution. Amounts for some projects are based on interim financial reports and are therefore provisional.

CFI investments have enabled researchers to acquire state-of-the-art research equipment promoting world-class research. Investments in each of the 18 dairy research projects range from $60 thousand to $6 million. The largest amount of funding to an institution went to Université Laval, accounting for seven projects and $8.74 million. This funding aided in the creation in 1999 of the Institute of Nutrition and Functional Foods (INAF) formerly the Centre d'expertise sur les produits nutraceutiques et les aliments fonctionnels.

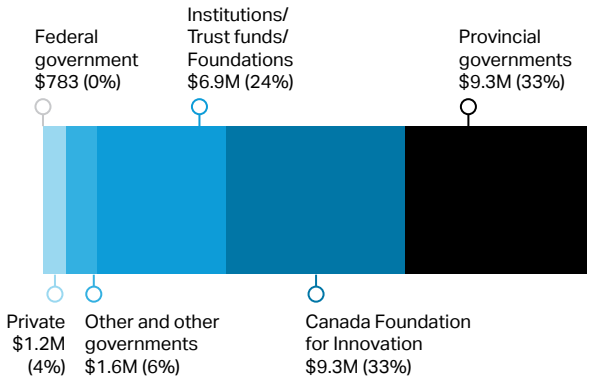
A second large infrastructure investment of $2.2 million was made at Laval in 2009 to create the Laboratory of Integrated Animal Physiology.

Other investments range from $60,000 at the University of Saskatchewan for a project related to nutrient use and the effect of nutrients on the metabolism of ruminants, to $1.51 million at the University of Alberta toward the construction of the Agricultural Genomics and Proteomics Unit and an animal health and efficiency project. The variety in focus of these dairy projects has resulted in the

acquisition of diverse types of infrastructure. While some of the research is based in labs and requires specific equipment for studying microorganisms and genetic materials, for example cell culture systems and bioinformatics technological platforms, others research involves dairy farming on a larger scale, and uses imaging and video software along with large-scale farm equipment to monitor the behavior of ruminants. This breadth of infrastructure continues to be used to advance these areas of dairy farming research.

From the 18 dairy research infrastructure projects funded by the CFI, a subset of 10 projects at four universities were selected for detailed analysis of their pathways to impacts. The remainder of this report focuses on these 10 projects which are identified in **Figure 3**. These projects were selected using multiple criteria with a view toward maximizing the collection of evidence on impact pathways while confining the in-depth analysis at the project level and managing the scope of this report. Considerations were made to the materiality of the CFI funding, balance between infrastructure types, research outcomes and targeted impacts.

**Figure 4:** Matching funds for CFI investments in 10 selected dairy farming projects




**Note**: CFI administrative data as of April 15, 2016. Amounts for some projects are based on interim financial reports and are therefore provisional.

## Infrastructure supported by the CFI includes:

**Research equipment:**

- Cameras, digital video equipment
- Nutrient infusion system
- Advanced ventilation
- Milk skimmer
- Baro-membrane filtration system
- High-speed vocalization analysis equipment
- Advanced computers and software

**Construction:**

- Redevelopment of laboratories and buildings
- Institute of Nutrition and Functional Foods
- Laboratory of Integrated Animal Physiology
- Interactive training room

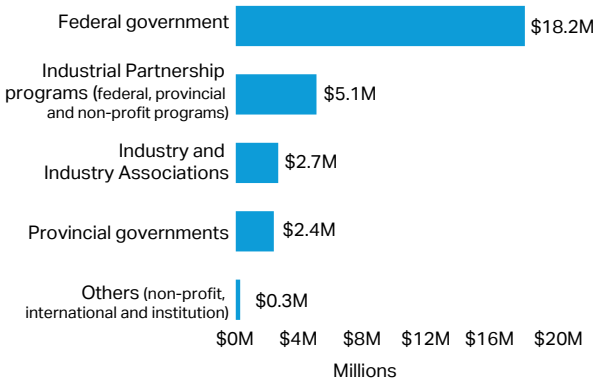
## MATCHING FUNDS

CFI contributes up to 40 percent of a project's research infrastructure costs. Matching funds are often provided by provincial governments in combination with the host institution or industry partners. As shown in **Figure 4**, the projects have diverse combinations of funding sources.

## RESEARCH FUNDS

The availability of CFI infrastructure has enabled Canadian researchers working in dairy to secure additional funding to advance their research and support trainees. Sources of funding are varied and come from federal and provincial governments, non-profit organizations, industry and academia, as shown in **Figure 5**.

**Figure 5:** Research funds obtained by project leaders since initial CFI award for 10 selected dairy farming projects




**Note**: Awards and amounts included were reported and validated by project leaders and only include funds obtained since year of initial CFI award. Awards and amounts may not be unique counts due to the co-applicant status of the project leaders.

Project leaders have been able to secure research funding from Canadian agencies such as the Natural Sciences and Engineering Research Council (NSERC) and Genome Canada, as well as government departments, for example Agriculture and Agri-Food Canada and the ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ). Since dairy is an important sector in the Canadian economy, researchers have been able to acquire funding and partnerships with a number of industry associations, and private companies such as the Dairy Farmers of Canada, Novalait, Westgen, Alberta Milk, Diamond V and the Alberta Livestock and Meat Agency.

## NETWORKS, COLLABORATIONS AND LINKAGES

In the 10 projects examined for this report, there are highly interconnected networks between dairy researchers and the dairy sector. Industry and government actors strengthen these networks and collaborations through the governance of institutions, financial contributions to research projects funding and co-generating research results. In some cases, through collaborations, industry partners have adopted and implemented innovative solutions developed with the CFI-funded infrastructure. The availability of multidisciplinary infrastructure and research buildings encourages collaborations between different areas of dairy research. This allows for further impact through academic and research partnerships extending beyond Canada to an international level.

"We have a significant and ongoing relationship with industry partners and many of our research programs are funded collaboratively with the dairy industry. Our research infrastructure also allows us to have academic partnerships beyond North America and throughout the world. "

Daniel Weary,
The University of British Columbia

Infrastructure projects were developed to align with current and emerging industry needs. For example, at Université Laval, the STELA Dairy Science and Technology Research Centre is INAF's knowledge transfer unit focusing on milk and milk products. The governance of the STELA Research Centre at INAF includes an advisory board composed of representatives from private industry and government at the regional and national levels, including Agriculture and Agri-Food Canada, Agropur Cooperative, Novalait and the Canadian Dairy Commission. Laval also participates in national and international collaboration networks including EmbryoGENE, a Canadian-based network dedicated to the understanding of the genome and embryo environment of livestock.

## Select list of project collaborators:

### INDUSTRY & INDUSTRY ASSOCIATIONS

- Agropur Dairy Cooperative
- Dairy Farmers of Canada
- L'Alliance Boviteq (LAB) Inc. / SEMEX
- Valacta
- Danone
- B.C. Milk Producers Association
- Pfizer Animal Health
- Novus International Inc.
- Merck Animal Health Canada – Intervet Canada

### ACADEMIA

(In addition to academics of funded institutions collaborating on CFI-funded infrastructure)

- Centre de recherche en sciences animales de Deschambault (CRSAD)

### GOVERNMENT

- Agriculture and Agri-Food Canada
- Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ)

## ATTRACTION AND TRAINING

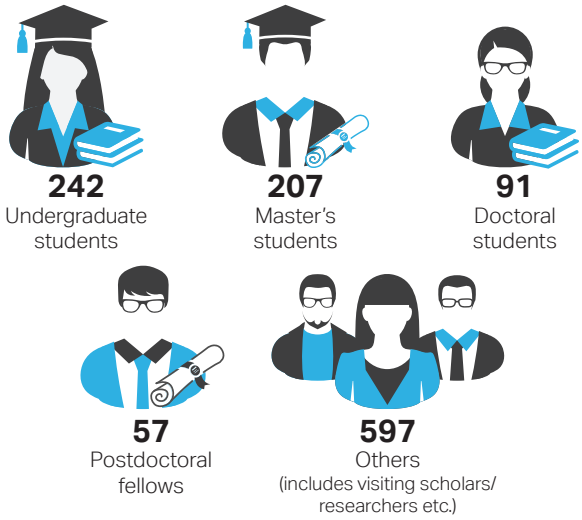
The strong alignment of research projects with industry needs creates an ideal training environment and contributes to the knowledge and skill development of the next generation of researchers. Many of these highly qualified personnel go on to secure employment in academia or industry. Training on leading-edge infrastructure they act as knowledge transfer and innovation vectors in the dairy industry.

The combination of industry-related research themes and the opportunity to train with cutting-edge equipment, attracts students. Steve Labrie's, PhD, CFI-funded food mycology laboratory allows students to do genomics-based identification and characterization experiments of fungal microflora in milk. According to Labrie, his laboratory was the first research group to have demonstrated the importance of the whole cheese fungal microflora ecosystem as well as having applied metatranscriptomics tools to cheese flora. Most of Labrie's former students are now working in cheese-making and yogurt companies, dairy farms or in science-based organizations. For example, Iraz Alper-Bourdichon, who completed her PhD with Labrie, was the Dairy Science and Technology Project Manager at France's Centre National Interprofessionnel de l'Economie Laitière – CNIEL, the umbrella organization for the dairy industry in France. She recently obtained another management position as Bioprocess Development Team Manager at DuPont Nutrition and Health.

"Almost 100 percent of my students find research-related jobs. My students obtain a research position rapidly because we are five years ahead with our technologies on what they do in the industry. We feed all the technology of the future of the dairy sector."

Marc-André Sirard, Université Laval

## CFI infrastructure has helped train Highly Qualified Personnel (HQP)[1] including:




Students trained with CFI infrastructure also continue into academia. After training with equipment from the UBC Animal Welfare Program and completing his doctoral studies with Marina von Keyserlingk, PhD; Trevor DeVries has held an Associate Professor position at the University of Guelph since 2007. In 2016, he became the holder of the Canada Research Chair in Dairy Cattle Behaviour and Welfare at the University of Guelph. At the University of Alberta, after completing his doctoral studies with Masahito Oba, PhD, in 2009, Greg Penner, PhD, joined the Department of Animal and Poultry Science at the University of Saskatchewan where he is an Associate Professor and holds the Centennial Enhancement Chair in Nutritional Physiology. Penner's research program covers forage utilization, ruminant nutrition and regulation of gut function in cattle and he has trained more than 10 graduate students and postdoctoral fellows.

Students trained by Marc-André Sirard, PhD, at Université Laval using bioinformatics, genomics, epigenetics and confocal platforms now occupy leadership positions in industry. The trajectories of Sirard's students are highly diverse. They work in laboratories that research topics such as bovine embryology and nutrition or the epigenomics of human embryonic stem cells or cancer. Others have found employment in human in vitro fertilization clinics. Some working in other areas of application of genomic tools, such as developing ecotoxicogenomics tools in science-based federal departments. For example, Patrick Blondin is now Boviteq's Director of Embryo Operations and Semex's Director of Research & Development.

## KNOWLEDGE TRANSFER

Research conducted by CFI-funded project leaders in dairy has advanced knowledge in a number of areas including process efficiency, reproductive health and genetics of livestock, food product health and safety, and animal welfare. The variety of these research areas has created many pathways for information dissemination and knowledge transfer within and beyond academia to consumers, producers and industry.

Project leaders conducting research on CFI-funded infrastructure are among the top-ranked researchers in agriculture in terms of scientific output. Combined these eight project leaders published 679 papers with a total of 6,667 citations. In terms of scientific impact, five are above the world average as ranked by the averaged normalized citation impact.[2]

Beyond disseminating research results through scientific publications, researchers also work to communicate the findings to broader audiences. Labrie used his research to help inform policy makers and Canadians about food safety and healthy alternatives. He contributed to the

1 Highly qualified personnel (HQP) include technicians, research associates, undergraduate students, graduate students and postdoctoral fellows. Numbers as reported by project leaders for 10 selected dairy farming projects.

2 Bibliometric analysis conducted by the CFI from Web of Science InCite over the time period of 2008-2014. Publications and citations may not be unique counts due to co-authorship of publications between project leaders.

publication of expert reports and a book on sodium reduction in cheese for the International Dairy Federation and was invited to join a symposium of experts organized by Health Canada on the reduction of sodium in food. Labrie's research group was also invited by Genome Canada to talk to Parliamentarians on the potential of genomics for the cheese sector and how it can be used in the food sector beyond the conception of genetically modified organisms.

Research projects lead by Kevin Wade, PhD, created links between academia, industry and farmers. Large-scale data mining by Valacta (an industry partner), the Canadian Dairy Network in Guelph and other research centres led to the development of an interactive data visualization software. The software uses algorithms developed in the laboratory to provide data needed by dairy farmers to monitor and act on key parameters on the farm that in turn will beneficially impact their yield and profitability. Valacta, convinced by the potential benefits of the software, finalized and packaged it for use in the company's monitoring and advisory services.

## BENEFITS TO CANADA

CFI investments in dairy infrastructure have resulted in social benefits through improved animal welfare practices and food health and safety, economic benefits through improved efficiency in milk and cheese processing as well as new feed research, and environmental benefits through the development of sustainable practices.

In collaboration with Alberta Milk, Oba initiated a series of research projects to evaluate different types of distiller grains as a feed source for the dairy industry. Distiller grains are a cereal by-product generated during the distillation process for the production of ethanol from common grains such as wheat, barley or corn. His research and data is used by nutritionists working for feed companies in the formulation of dairy-cow diets for their customers. Oba found that distiller grains, when used as an alternative protein source in the diet, can improve milk production. The inclusion of wheat distiller grains in the diet of dairy cows in place of forage would benefit the industry by lowering the cost of feed and making the industry more environmentally sustainable.

The research team at UBC has played a key role in providing the scientific evidence required to update the Code of Practice for the Care and Handling of Dairy Cattle published in 2009. This manual cites animal welfare research undertaken using the infrastructure purchased with CFI funds. Also, according to researchers, their research influenced animal welfare policy documents and animal care standards published by the World Animal Health Organization and by the U.S. National Dairy Farmers Assuring Responsible Management (FARM) Program. Furthermore, UBC also developed the C.O.W.S. program®, a joint collaboration between the UBC Animal Welfare Program and Novus International. It evaluates daily activities of individual dairy farm herds to benchmark several cow comfort measures, facility design and management measures. The program provides producers with the information to help them ensure the comfort and well-being of their cows.

The research conducted by Yvan Chouinard, PhD, will have a direct impact on the feeding management of dairy herds, and on the profitability of companies, as his team will provide producers with new knowledge to predict the effectiveness of the digestive process and thus the nutritional value of rations. There is great potential in the use of milk fatty acids as a non-invasive diagnostic tool to evaluate rumen function and to adjust diets. The results of the fatty acids analysis made with chromatography using the CFI-funded equipment were used to validate low-cost infrared analytical techniques used in by companies such as Valacta. Today, Valacta can offer new diagnostic services based on the milk's fatty acid profile, including estimating methane emissions. This non-invasive testing can increase dairy cow health and production as well as reduce greenhouse gas emissions, while at the same time maintaining a cost-effective feed diet.

Research projects at the food mycology laboratory contributed to the development of new applications for surface-ripened cheeses that increased the competitiveness of Canadian dairy processing companies in the national and international markets. For example, Labrie worked with Agropur Coopérative to apply genomic tools to better control production, by limiting losses and producing high-quality cheeses with a longer shelf life. Agropur's ability to monitor and control the cheese typicity using genomics tools has allowed them to triple their capacity for Oka cheese, creating economic benefits.

Yves Pouliot, PhD, has been conducting pilot-scale studies on customizable membrane separation systems. These systems are used for filtration processing in milk. His team is currently developing a simulation software to test different dairy processing scenarios in relation to economic data (cost of raw materials and resources) as well as to environmental data. This tool will help dairy processors to select the most energy-efficient option. As the dairy industry uses a lot of water and energy in the processing of milk products, improving eco-efficiency through the analysis of membrane systems not only minimizes costs, but also reduces the impact on the environment.

Sirard's research team used the CFI infrastructure to develop a new in vitro maturation protocol for bovine oocytes that has enabled their industry partner, Alliance Boviteq, to increase the number of heifers per year per animal in order to optimize lactation cycles. This production system, resulting in more female embryos of the best cows in Quebec and Canada, enables the production of better quality bovine ova than those of American or European groups. This project increases and reinforces the competitiveness of the Canadian industry in the export of dairy cow genetics, creating economic value. In terms of social impacts, Sirard's research group on bovine reproduction research contributes to a better understanding of human infertility. In fact, a large proportion of their research and dissemination activities are on human reproduction.

The research leading to increases in pregnancy rates in dairy cows also serves as the basis for similar studies in humans and will assist personalized medicine in human infertility treatments.

## CONCLUSION

CFI investments in dairy research infrastructure have yielded important research achievements and benefits in Canadian and international agricultural practices. CFI project leaders leverage funding support from a wide range of organizations and sectors to advance research in the dairy sector including improved and innovative management, production and processing practices, with consideration towards animal welfare, efficiency and environmental sustainability. The research infrastructure has contributed to the training of HQP including undergraduates, master's, and doctoral students as well as postdoctoral fellows. The enhanced capacity of skilled personnel through training has led to employment in academia and industry. The research centres constructed with CFI funding have welcomed international researchers and have created relationships with the dairy industry within and beyond Canada. The research evidence produced has led to new animal welfare policies and practices, informed industry on new, efficient and cost-effective processes, and the development of new technologies and databases to monitor and manage Canadian dairy livestock. These achievements ensure that the dairy sector maintains its position as one of Canada's most important food industries.