2016-2017 ANNUAL REPORT

Growing *Discoveries*

Mobilizing Emerging Technologies for Smarter Agriculture

GIFS | GLOBAL INSTITUTE FOR FOOD SECURITY

Growing science for life

Nutrien - a Founding Partner

VISION

Ingenious science that delivers sustainable food security for the world.

MISSION

To help feed the world through transformative innovations in agriculture and food production that will benefit Saskatchewan's economic, social and environmental well-being and which will empower developing countries to achieve local food security.

FOUNDING PARTNERS

With initial commitments of up to $35 million from Nutrien and $15 million from the Government of Saskatchewan over seven years, and the support of world-class facilities and centres at the University of Saskatchewan, GIFS will apply Saskatchewan's unique resources, innovation and expertise to address the increasing global demand for safe, reliable food.

Nutrien™ Feeding the Future™

Government of Saskatchewan

University of Saskatchewan

BY 2050 9.6 BILLION

By 2050, world population will be 9.6 billion. To feed this population, developed nations need to produce about 70% more food. Developing nations need to double or triple their food production. Saskatchewan is well positioned to lead the way in increasing agricultural productivity. We are creating new technologies to achieve these goals, which provide commercial benefits as well. These technologies will be transferred to developing nations.

Join us as we help feed the world, one innovation at a time.

2016-2017 MAJOR HIGHLIGHTS

JUNE 2016

- GIFS International Scientific Advisory Panel Inaugural Meeting is held in Saskatoon.
- The GIFS Emerging Technologies for Global Food Security Conference, held in Saskatoon, attracts over 340 delegates and 47 speakers from 25 countries.

AUGUST 2016

- GIFS hosts the First Annual P²IRC Symposium, and the Inaugural meeting of the P²IRC International Scientific Advisory Committee is held.

SEPTEMBER 2016

- Dr. Leon Kochian officially joins GIFS as Associate Director and lead of the Root-Soil-Microbial Interactions Research Pillar.

JANUARY 2017

- GIFS moves into 5,000 square feet of newly renovated office and state-of-the-art wet-lab space in the National Research Council building.

APRIL 2017

- Mr. Dave Schneider joins GIFS as Digital Agriculture Research Pillar lead.

JUNE 2017

- The 2nd Annual P²IRC Symposium is held in Saskatoon.
- The Dr. Donald Baxter Scholarships for Global Food Security is established with a $1 million endowment from Dr. Patrick Man Pan Yuen.

NOVEMBER 2017

- GIFS receives $1.35 million from Western Economic Diversification Canada for its Omics and Precision Agriculture Laboratory (OPAL).

Photo (left): Petterik Wiggers (Panos)

Cover Photo: Mikolaj Cieslak*, Sally Vail**, Raju Soolanayakanahally**, and Przemyslaw Prusinkiewicz*

* Biological Modelling and Visualization Laboratory, University of Calgary

** Agriculture and Agri-Food Canada

Message from the Chair

Dr. Lorne Hepworth,
BOARD CHAIR
Global Institute for Food Security

The unique spirit of partnership and shared interest in addressing global food security continues to be exemplified at GIFS. On behalf of the Board of Directors, I am pleased to see the progress GIFS is making in executing the mandate our initial stakeholders envisioned. Together with our partners, we truly are growing discoveries that will help feed the world as global population grows.

The GIFS Board say goodbye this year to Alanna Koch, Former Deputy Minister to the Premier of Saskatchewan. We extend a heartfelt thanks to Alanna for her years of service to the Board. Alanna's position was filled by Rick Burton, Deputy Minister, Saskatchewan Ministry of Agriculture. We also welcomed a highly accomplished and respected board member in Leslie Prosser, Q.C. Leslie is former managing partner of Robertson Stromberg LLP and a senior member of the corporate/commercial group in Saskatoon. Leslie is serving as Corporate Secretary to the Board.

This year was one of continued growth at GIFS. As of the end of the 2017 fiscal year, 35 staff and students were working in newly designed, state-of-the-art laboratory space at GIFS. Rounding out our senior research team, Mr. Dave Schneider, a world authority in computational biology and big data analytics, was hired to lead our work in Digital and Computational Agriculture.

Including the Plant Phenotyping and Imaging Research Centre (P^2IRC) managed by GIFS, as of end of fiscal year there were 53 researchers, scientists and students working on projects that have the potential to provide environmental benefits to the world, and economic benefits to Saskatchewan and Western Canada farmers as well as to farmers in the developing world. By fall this year, that number increased to 114 including graduate students.

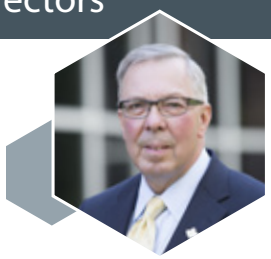
The second annual P^2IRC Symposium held in June, brought together nearly 300 researchers from six countries to discuss challenges in digital plant phenotyping and potential solutions, and the need to establish common data standards to foster international collaboration among researchers. At the Symposium, I learned of one initiative where a group of P^2IRC principle investigators held a research "boot camp." About 50 students, half studying agriculture, and half in the computer sciences, were divided into multi-disciplinary groups and given a research problem to solve together. I was so impressed by the enthusiasm and passion with which our researchers and students are working to learn from each other in order to strengthen their own research, and to collaborate to achieve our ultimate goal of enhancing food security globally.

GIFS is also supporting important work on increasing pulse crops in Ethiopia, and our role in helping to accelerate the availability of a high-quality reference genome sequence for wheat will help breeders develop wheat varieties that adapt to changing environmental conditions and improve wheat yield.

We look forward to the coming year with excitement and anticipation. A number of world-class universities, government agencies, industry and philanthropic organizations have expressed interest in collaborating and partnering with GIFS, and we look forward to formalizing these relationships. In addition, GIFS' 2018 Emerging Technologies for Global Food Security conference in June will feature over 50 presentations and panel discussions with renowned scientists and researchers from all over the world.

On behalf of the entire board, thank you to all the staff, researchers, scientists and students who are working hard to grow discoveries that will help us achieve our vision of ingenious science that delivers sustainable food security to the world. I would also like to thank the members of our International Scientific Advisory Panel; how fortunate we are to have such highly acclaimed individuals helping to provide us with the best in scientific advice. Finally, thank you to our founding partners, for their vision in creating GIFS and ongoing investment in GIFS' mandate.

Our Directors



Lorne Hepworth
BOARD CHAIR
Global Institute for Food Security

Michael Atkinson
PROFESSOR
Johnson-Shoyama Graduate School of Public Policy, University of Saskatchewan

Alanna Koch
DEPUTY MINISTER
Deputy Minister to the Premier, Government of Saskatchewan (Until Fall 2017)

Rick Burton
DEPUTY MINISTER
Saskatchewan Ministry of Agriculture (Beginning October 2017)

Message from the Executive Director & CEO

In the past 12 months, GIFS has undergone steady growth; in fact, we have almost doubled our staff since the last report. In addition, the activities of the Plant Phenotyping and Imaging Centre (P^2IRC), managed by GIFS, has expanded to include 114 researchers. Such rapid growth, although planned, is not without its challenges be they related to facilities, personnel and operational management. As you will discover in reading this report, we are meeting those challenges head-on and we remain focused and in pursuit of excellent science and efficient translation.

This has been a year of considerable scientific success, with major achievements in wheat genomics by Andrew Sharpe and Curtis Pozniak. Bread-making wheat is a complicated species and has posed real technical difficulties in assembling a full reference genome, which could be used widely by breeders. Drs. Sharpe and Pozniak have pioneered novel bioinformatic approaches, which have simplified the genomic assembly. Dr. Ian Stavness, a Professor in Computer Sciences and a principal investigator in P^2IRC, has applied the science of artificial intelligence to plant breeding. In a breakthrough publication, Dr. Stavness has shown how we can "train" software to recognize key features and traits in a growing plant. As predicted in last year's report, we have now established a major research effort in roots, soils and rhizosphere led by Dr. Leon Kochian, Canada Excellence Research Chair in Food Systems and Security, which is collaborating with an international network of leading researchers in root biology and function, "shining a light" on the hidden half of crop plants.

To support this immense growth, we opened a new suite of laboratories and offices which are fully equipped, occupied and functioning. Our biggest challenge as we continue to expand our research will be to match our laboratory activities to the expansion of greenhouse and environmental chamber space. GIFS is working closely with the University and other stakeholders to meet these needs.

Our affiliate researchers all continue to deliver excellent science and translation of their results, often in developing countries. In this year's report, we are highlighting the work of GIFS' affiliates working on an IDRC project under the Canadian Food Security Research Fund (CFSRF). This project in Ethiopia, led by Dr. Carol Henry, has been exemplary in the empowerment of rural communities in food and nutrition. Based on using chick peas as an inter-seasonal crop, the program has increased protein and micronutrient availability to families living at subsistence level, while building local skills and capacity to sustain its function, without the need for ongoing external inputs. GIFS is proud to be associated with such a successful program.

GIFS continues to show leadership in areas that will enhance agriculture and food production in Saskatchewan and western Canada. We have played a significant role in the preparation of a proposal, Protein Industries Canada (PIC), for the Federal Government's Superclusters initiative. At the time of writing, we have just heard that the PIC proposal was successful and that the Federal Government will invest up to $153 million in the venture. GIFS hopes to play a pivotal role in making this exciting initiative a great success for Canada!

Maurice Moloney,
EXECUTIVE DIRECTOR & CEO
Global Institute for Food Security

Dallas Howe
CHIEF EXECUTIVE OFFICER
DSTC LTD

Dr. Lutz Goedde
PARTNER
McKinsey & Company

Stephen Visscher
DEPUTY CHIEF EXECUTIVE
Biotechnology and Biological Sciences Research Council

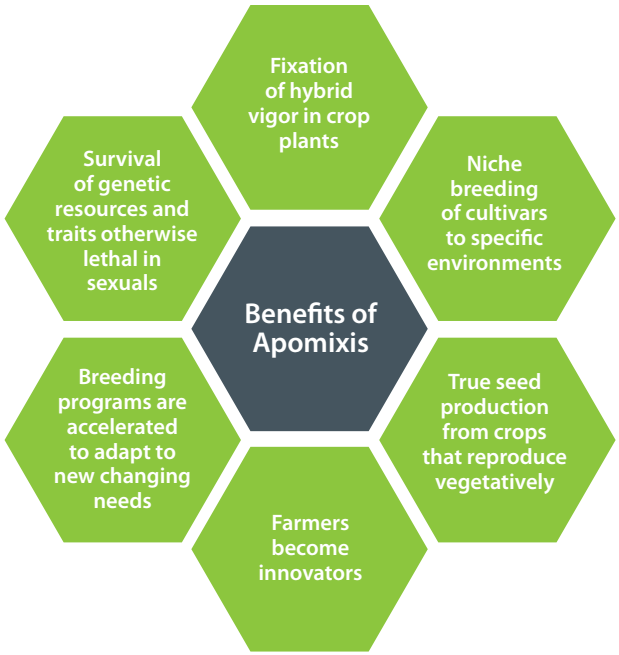
Leslie Prosser, Q.C.
CORPORATE SECRETARY TO THE BOARD

Seed and Developmental Biology

To feed a future world population of over 9.6 billion people, we need seeds that will help farmers increase their crop yields and reduce risk from pests, diseases and weather.

Dr. Tim Sharbel and his team are working to understand and harness the transformative potential of apomixis in food crops. Apomixis is a naturally occurring form of plant reproduction where a flowering plant produces seeds without sexual "crossing" with another plant. This trait is largely absent from agricultural crops, but is found in many wild species.

If successful, plant breeders could develop new varieties of crops, with "smarter" seeds that could respond to specific environments, germinate more efficiently, and provide increased yields.



The Research

Dr. Sharbel's lab is organized into three major themes:

1. Exploiting biodiversity to identify genetic factors controlling apomixis in plants;
2. Understanding apomixis: determining the mechanisms by which apomixis is controlled; and
3. Applying apomixis to key crop plants.

Projects underway in Dr. Sharbel's lab are focusing initially on the genus *Boechera*, a wild North American relative of *Arabidopsis*. The team is also studying *Hypericum perforatum* (St. John's Wort), the *Ranunculus auricomus* complex, *Poa pratensis* (Kentucky Bluegrass) and the forage grass *Eragrostis*. Each of these species displays sexual and apomictic reproduction.

The seed research program undertakes: (1) studies of population-level variability in reproduction, and (2) targeted 'omics' studies to identify candidate apomictic factors. Ultimately, candidate apomictic genes will be introduced and expressed in agriculturally-relevant crops to test their ability to induce asexual reproduction and propagation of beneficial seed traits over generations.

Dr. Sharbel has been working on understanding apomixis in the genus *Boechera* for 20 years. The ongoing experiments at GIFS are focussed on understanding two candidate apomixis genes which have been previously identified (APOLLO and UPGRADE2), in addition to generating new data (e.g. proteomics, regulatory factors, degradome, etc.) in order to comprehensively understand the switch from sexual to apomictic seed production. Furthermore, various constructs of the APOLLO gene have been introduced into maize and *Brassica oleracea* in a proof-of-concept experiment to understand the action of this gene in crops. The first generation of transformants is growing and will be analysed for seed production in the coming months.

Much like the work of Sharbel's team in *Boechera*, the researchers have identified a number of "gene fragments" in the apomixis genomic region of St. John's Wort. The outcomes of this work are to identify post-transcriptional regulatory networks associated with the switch from sexual to apomictic seed formation. This will result in a list of additional candidate genes whose genetic makeup can be modified in crops.

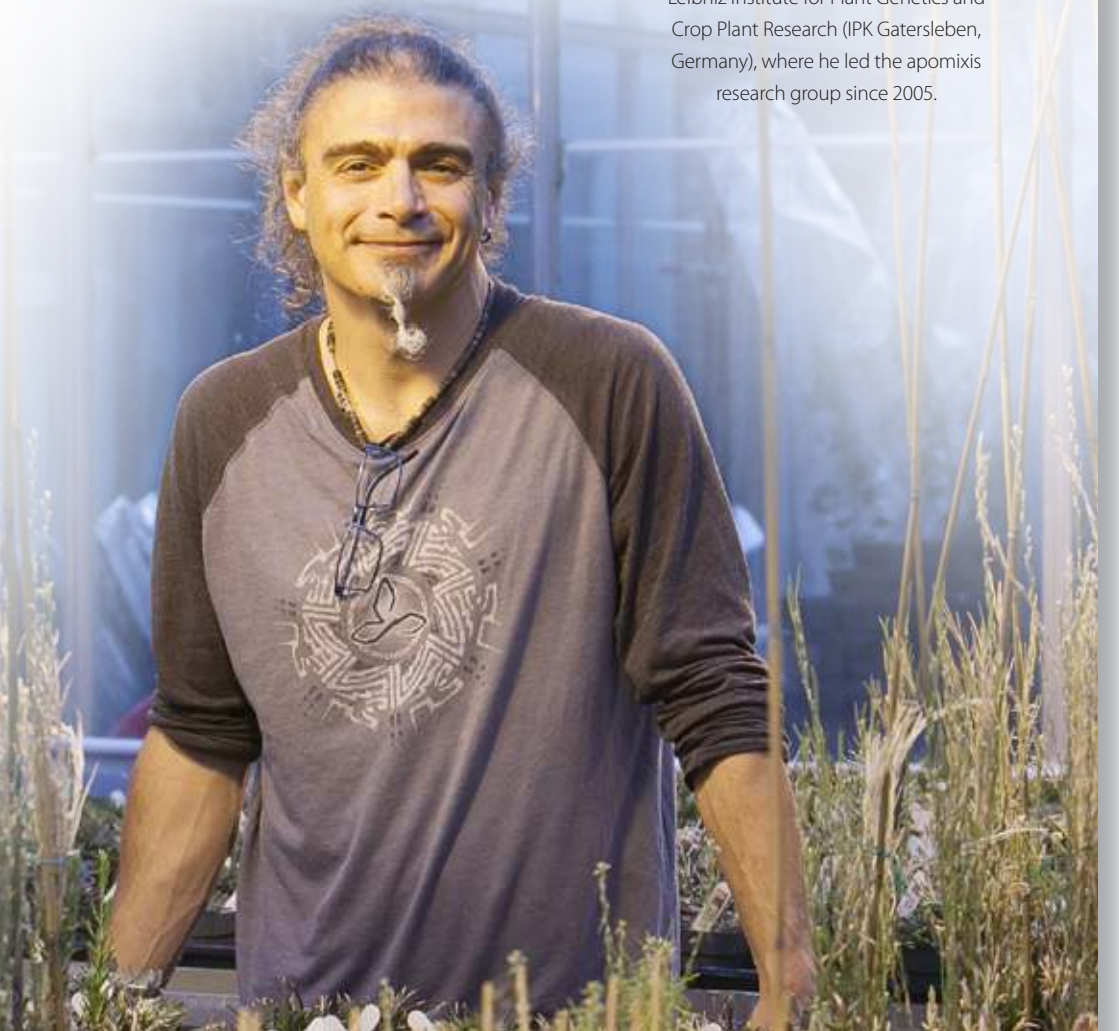
Poa pratensis (Kentucky Bluegrass) is an apomictic grass species that exists in the temperate zones of the northern hemisphere. One of the most common grass species in the world, and adapted to many conditions, it is also one of the most commercially exploited grasses in the world. Sharbel's team has characterized the genetics behind apomixis in over 200 genotypes of *P. pratensis* and closely related species, and is using this information to conduct more targeted experiments to identify new candidate apomixis genes.

A collaboration with partners like Dr. Kirsten Betts from the University of Saskatchewan, is gathering data on reproductive biology and genome variation in lentils and chick peas. As fertilization occurs in the closed flower in these species, hybrid breeding has not yet been exploited. The team is conducting analyses which focus on generating new breeding opportunities, for example fixing hybrid vigor, to improve these crops.

Dr. Tim Sharbel,

GIFS Enhancement Chair in Seed Biology

Dr. Sharbel is an internationally acclaimed expert in apomixis. He came to GIFS in fall 2015 from the Leibniz Institute for Plant Genetics and Crop Plant Research (IPK Gatersleben, Germany), where he led the apomixis research group since 2005.



Martin Mau,

Postdoctoral Fellow in Seed and Developmental Biology

Martin Mau, Postdoctoral Fellow in Seed and Developmental Biology came to GIFS from Germany, and is leading a research team to conduct functional studies of apomixis candidate genes using cutting-edge gene editing technologies and establishing high-throughput pollen phenotyping and genotyping methods. His team is also performing large-scale intergeneric crosses to investigate the nature of apomixis transfer into sexual populations. Ultimately, he aims to identify all contributing genetic factors to apomictic reproduction using a comprehensive backcrossing strategy in combination with next generation sequencing technologies.

"Apomixis is *the* disruptive breeding technology which in the future will enable price - and cost-efficient breeding on the one hand, but will also allow us to re-focus world-wide on locally adapted crops in niche breeding projects."

- Martin Mau

Root-Soil Microbial Interactions

Roots that respond well to drought, salinity, acidity and climate change will be more efficient at transporting nutrients to plants -- plant yields will improve, marginal soils can be utilized, and CO2 can be sequestered.

Because roots are hidden in the soil, very little is known about root traits, and even less is known about the root microbiome, the microbial ecosystem that resides both in the root and the soil closely associated with the root surface. Under Dr. Leon Kochian, GIFS is working to find more efficient ways to study and image roots and the soil that surrounds them, so they can contribute to improving crops and developing new crop varieties that are more resilient and adaptable to marginal soils.

Dr. Kochian's team currently includes 10 researchers from various parts of the world, and collaborates with Mr. Dave Schneider, a world authority in computational biology and big data analytics, and Dr. Brian Ham, an expert in the new field of long-distance RNA signaling.

The Research

High Throughput Root Phenomics Platforms

Dr. Kochian's team is developing technologies and techniques for high throughput phenotyping of root development, architecture and physiological function. This will serve as a framework for integrating these digital root phenotypes into crop breeding pipelines.

Targeted Breeding of Superior Root Traits

This will lead to applying root phenotyping data sets to facilitate targeted plant breeding for root traits at a speed and scope far beyond current breeding practice, generating new crop varieties capable of thriving in marginal soil conditions.

Improved Crop Varieties in the Developing and Developing Words

The goal of this work is to develop improved crop varieties with higher yields in the face of abiotic and biotic stresses, and to examine societal and economic issues limiting the acceptance of new technologies by farmers, regulators and society in general.

The Root Microbiome – A New Frontier for Agricultural Research

Dr. Kochian's team is studying the signaling and regulatory processes that help shape the composition and function of the root microbiome. This will increase understanding of the roles that microbes living on and in the root play in acquiring nutrients like phosphorous and water, enhancing root growth, and protecting roots against soil-borne diseases.

Crop Adaptation to Marginal Soils

This research will help to identify the physiological processes and associated genes that crop plants employ to flourish in soil extremes. This will help in the development of crop varieties that are resilient to climate change and that acquire and use water and fertilizer more efficiently and sustainably.

Projects Underway:

- **Improve crop performance on low phosphorus (P) soil:** Phosphorus is essential for plant growth. Having identified genes that improve tolerance to low P soil, the team is conducting research to enable plant breeders to screen for genes that enable plants to better tolerate low P soil, and use them to improve their performance in this soil. This project is a collaboration with Embrapa Maize and Sorghum in Brazil.
- **Improve crop tolerance to salt and drought via the root microbiome:** In collaboration with U of S Professor Sue Kaminskyj, the team is working to validate if colonizing tomato roots with the fungus Trichoderma results in changes in root architecture that will improve plant performance under drought and saline conditions.
- **Predict root architecture non-invasively in the field:** The team is developing tools to help plant breeders identify crop varieties that have larger root systems that enable plants to acquire fertilizer and water more effectively.

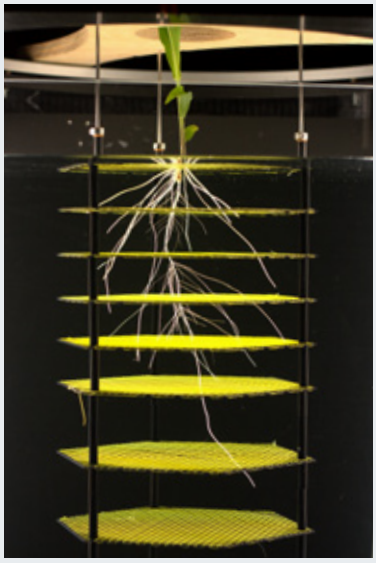
Canada Excellence Research Chairs
Chaire d'excellence en recherche du Canada

Dr. Leon Kochian,

Associate Director, GIFS Root-Soil-Microbial Interactions Research Pillar Lead, and Canada Excellence Research Chair (CERC) in Food Systems and Security, University of Saskatchewan

Dr. Leon Kochian joined GIFS as Associate Director and lead on the GIFS Root-Soil-Microbial Interactions in September 2016. Dr. Kochian came to GIFS from Cornell University, where he was the Director of the USDA Agricultural Research Services Robert W. Holley Center for Agriculture and Health, and a Professor in the Departments of Plant Biology and Soil and Crop Sciences.

As Canada Excellence Research Chair (CERC) in Food Systems and Security at the U of S, Dr. Kochian is bringing together biologists, computer scientists, bioinformaticians, engineers and social scientists to address food security challenges by focusing on the plant root system to: improve crop production, quality and safety; promote environmentally sustainable agricultural practices; and address societal and economic barriers that limit impact of new agricultural technologies.



This is a 14 day-old maize plant grown in low phosphorus hydroponic soil-free media.

"It's exciting to be working with a team that is working on research focussed on roots – this is a new area of research for me, and one that is so important to the overall ability of plants to use water efficiently."

- Li Liu

Li Liu,

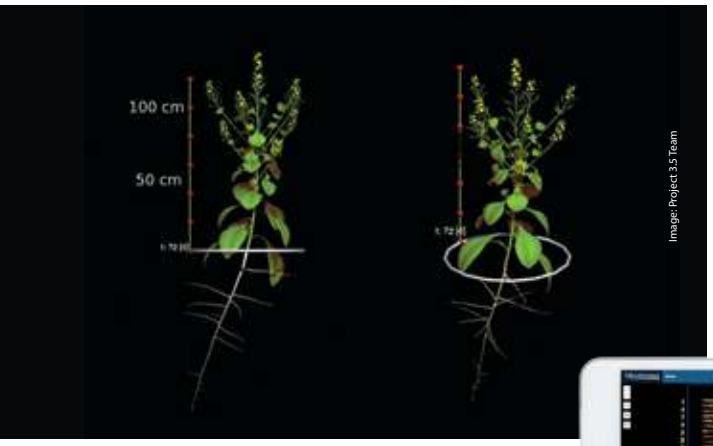
Postdoctoral Fellow in Root-Soil-Microbial Interactions

Postdoctoral Fellow Li Liu is working in collaboration with researchers from the National Research Council to understand how the TOR protein, a unique signaling molecule that is involved in how plants, animals and humans respond to the environment, functions to improve wheat drought tolerance and water use efficiency. This research should lead to the development of more drought tolerant crops.

Digital and Computational Agriculture

From plant breeding and soil science to automated on-farm practices, information technology will play a large role in achieving GIFS' mandate to address global food security challenges. Technologies like genomics, phenomics, bioinformatics, global positioning systems and high-precision satellite imaging will provide plant breeders and farmers with the information they need to grow crops more efficiently and economically, particularly as we adjust to a changing climate.

GIFS is taking a systems approach to complex agricultural problems, and linking labs and field data to powerful analytics. The result will be more accurate forecasting and prediction, identification of hidden trends, and the discovery of creative solutions that can be applied by scientists, breeders, and farmers.



A 3D L-system-based model of canola development.

Image Source: Mikolaj Cieslak, Sally Vail**, Raju Soolanayakanahally**, and Przemyslaw Prusinkiewicz**

** Biological Modelling and Visualization Laboratory, University of Calgary*

*** Agriculture and Agri-Food Canada*

Spatial and genetic variability (NDVI shown) of durum wheat in early season ground cover.

Impact on Laboratory Research

The influx of new technologies and high-volume data are revolutionizing how laboratories investigate complex biological processes such as the development of seeds and roots, drought resistance, root-shoot signalling, and plant-microbiome interactions. These data-driven studies rely on the close integration of experimental design, data acquisition, computational and statistical analyses, and visualization.

As a result, there are close linkages in many projects underway in the Seed and Developmental Biology and Root-Soil-Microbial Interactions research pillars, including work being done as part of the CERC in Food Systems and Security. These linkages are making it possible to more efficiently tackle mission-critical problems where solutions transcend traditional disciplinary boundaries.

Progress at Plant Phenotyping and Imaging Research Centre (P^2IRC)

P^2IRC was established in 2016 through a $37.2 million Canada First Excellence Research Fund awarded to the U of S to develop a centre, managed by GIFS, dedicated to Designing Crops for Global Food Security. P^2IRC research will transform crop breeding and provide innovative solutions to national and global food security.

Over 20 research projects are currently underway at P^2IRC in the following areas:

- **Phenometrics:** Leveraging the power of precision digital phenotyping and genomics for crop breeding
- **Image Acquisition Technologies:** Using advanced imaging techniques to understand crop characteristics
- **Computational Informatics of Crop Phenotype Data:** Understanding how digital data can revolutionize plant breeding
- **Societal and Developing World Impact:** Exploring the global gaps in policy, regulatory, production and marketing systems




P^2IRC Plant Phenotyping and Imaging Research Centre

Mr. Dave Schneider,
GIFS Digital and Computational Agriculture Research Pillar Lead

Mr. Dave Schneider joined GIFS in April 2017 and is a professor in the School of Environment and Sustainability. Prior to joining GIFS, he was a professor in the Department of Plant Pathology at Cornell University in Ithaca, New York, and a computational biologist for the Agricultural Research Service at the United States Department of Agriculture.

"The widespread availability of large volumes of high resolution data related to crop production is driving radical changes in the way we look at food security. At GIFS we're focusing on developing a unique synthesis of previously disparate fields including computer science, engineering, and plant biology that will enable us to transform raw data into novel insights that will impact producers and consumers."

- Dave Schneider

Social License and Developing World Impact

Photo: Petterik Wiggers/Panos

As new technologies are developed at GIFS they will be shared with plant breeders and farmers. GIFS is working to address gaps in policy, the regulatory environment, research, distribution and marketing systems so as not to hinder the approval, acceptance, and widespread adoption of technology.

Projects Underway

In addition to recruiting a Research Chair in Innovation, Big Data and Productivity, the following initiatives have been completed or are underway:

Global research excellence:

- In collaboration with Global Open Data for Agriculture and Nutrition, Jeremy de Beer presented a paper at a global summit of leaders in New York, at major academic and civil society conferences in Europe and at several grassroots stakeholder workshops in Africa (including an FAO-sponsored event in South Africa). The work was also presented at a focus group with First Nations people in Saskatoon.
- Drs. Smyth and Phillips are engaged in the New Plant Breeding Project, a multi-year project which includes a global panel of 700 experts. Five surveys have been undertaken, with two publications pending.

Mobilizing knowledge:

- Numerous presentations were given to industry organizations including Monsanto and governments including the Environmental Protection Agency (USA) and the Canadian Food Inspection Agency.
- A presentation was provided to the Inter-American Institute for Cooperation on Agriculture in the lead up to participation in The Eighth meeting of the Conference of the Parties serving as the Meeting of the Parties to the Cartagena Protocol on Biosafety (COP MOP 8).
- Drs. Phillips and Smyth co-edited a book on coexistence between genetic modification, conventional and organic foods (in collaboration with Nicholas Kalaitzandonakes, University of Missouri, and Justus Wesseler, Technical University of Munich). They also authored a book with William Kerr of the University of Saskatchewan on the regulation and trade of products of biotechnology.
- A submission providing science-based insights into the regulation of innovation and the importance of not over regulating new technologies was made to the Convention on Biological Diversity for their 'Submission of Information on Synthetic Biology'.

Contributing to national and regional strategic priorities:

- Dr. Phillips was a member of the team writing the Protein Industries Canada supercluster proposal, contributing to both the economic impact and governance model sections.
- Drs. Phillips and Smyth participated in Genome Canada and CAPI strategic planning events regarding the future of investment in agriculture.

Dr. Peter Phillips

Dr. Peter Phillips is an international political economist, Professor of Public Policy and Graduate Chair at the Johnson-Shoyama Graduate School of Public Policy. His research concentrates on issues related to governing transformative innovation.

Dr. Stuart Smyth

Dr. Stuart Smyth is an Assistant Professor in the Department of Agriculture and Resource Economics at the University of Saskatchewan, where he holds the Industry Research Chair in Agri-Food Innovation. His research focuses on sustainability, agriculture, innovation and food.

ISAC Members

International Scientific Advisory Panel

The Inaugural meeting of the GIFS International Scientific Advisory Panel (ISAP) established to provide GIFS with independent expert science was held in June 2016. The panel is made up of internationally recognized scientists in areas of expertise that align with GIFS' research themes.

John Pickett, CBE, DSc, FRS – ISAP Chair

Julia Bailey-Serres, PhD

Professor of Genetics, Department of Botany and Plant Cell Biology, University of California, Riverside

Richard 'Dick' Flavell, PhD, DSc, CBE, FRS

Margaret Gadsby, MSc, PAg

Bill Lucas, PhD, DSc

Distinguished Professor and Chair, Department of Plant Biology, University of California, Davis

Kiran Sharma, PhD

CEO and Theme Leader for the Agribusiness and Innovation Platform, and Principal Scientist- Cell Biology at ICRISAT.

Joerg Bohlman, PhD

Professor and Distinguished University Scholar, Michael Smith Laboratories, University of British Columbia.

Gijs van Rooijen, PhD

Chief Scientific Officer, Genome Alberta

Wheat Genome & Other Funded Research

GIFS is contributing to Generating Multiple High-Quality Reference Genomes for Wheat

With more than 35% of the global human population consuming wheat as a staple food, as global population grows, so too will our dependence on wheat. In fact, wheat productivity will need to increase by 1.6% per year to meet the future demands of a projected world population of 9.6 billion by 2050.

With limited new land, and climate change resulting in drought in some parts of the world, the only way to ensure wheat continues to be a reliable source of nutrition will be to improve the traits, or characteristics, of wheat so that it can adapt to changing environmental conditions. This can be accelerated with the availability of a high-quality reference genome sequence that can provide plant breeders with the detailed genomic information, or a blueprint, they can use to identify the most useful genes in adapting wheat to various conditions, to deal with stress from drought and pests, and ultimately, to improve wheat yield.

GIFS Director of Genomics and Bioinformatics Andrew Sharpe is part of an international team of researchers working to produce whole genome assemblies of multiple cultivated bread wheat varieties from all over the world.

Sharpe is a member of a public-private collaborative project being coordinated by the 10+ Genome Project being led by Curtis Pozniak, a Professor and Wheat Breeder at the University of Saskatchewan's Crop Development Centre. Project participants include Nils Stein of IPK Gatersleben in Germany, Jesse Poland of Kansas State University, Illumina, Inc., NRGene, a leading genomic big data company in Israel, and the United States and the Tel Aviv University in Israel. The project is using a proprietary genome assembly software developed by NRGene. Sequencing and assembly of two Canadian wheat cultivars (CDC Landmark and CDC Stanley) have already been completed and data is publicly available to support wheat research globally.

Funding for the Canadian portion of the project is being provided by Genome Canada, Genome Prairie, Saskatchewan Ministry of Agriculture, the Saskatchewan and Alberta Wheat Development Commissions, the Western Grains Research Foundation through the Canadian Triticum Applied Genomics (CTAG2) project, the Canada First Research Excellence Fund and GIFS.

Andrew Sharpe

Curtis Pozniak

10+ Genome Project:

www.10wheatgenomes.com
NRGene: www.nrgene.com
CDC Landmark and CDC Stanley:
http://webblast.ipk-gatersleben.de/wheat_ten_genomes/

Other Funded Research

Therapeutic Food Products for Malnutrition and Emergency Response

Principal Investigator:
Dr. Michael Nickerson – Associate Professor, Ministry of Agriculture Strategic Research Chair, U of S

To aid in the treatment of moderate to acute malnutrition in high-risk communities, the goal of this research is to develop innovative therapeutic food products using pulse and cereal flours/concentrates and other bioactive and raw materials grown in Saskatchewan and Ethiopia including barley, peas, lentils and chickpeas.

Use of Biofortified Lentils to Remediate Iron Deficiency and Arsenic Poisoning

Principal Investigator:
Dr. Albert Vandenberg – Professor and NSERC Industrial Research Chair, U of S

This project is an international collaboration that is exploring the potential for Saskatchewan lentils to be used in dietary solutions for iron deficiency and arsenic toxicity that can occur in some diets in Bangladesh.

DivSeek – Mobilizing genetic diversity to accelerate improvements in crops.

With researchers around the world working on enhancing agricultural productivity, sustainability and resilience of crop varieties and agricultural systems, there is already a wealth of plant germplasm that could help develop more resilient and productive crops at a faster rate. In fact, DivSeek estimates that roughly seven million crop varieties are currently conserved in gene banks, facilities that securely store plant samples, around the world.

DivSeek is a group of organizations that have come together to coordinate how to best access and leverage the genetic information that is contained in these gene banks. DivSeek's goal is to empower gene bank managers, breeders, researchers and farmers to better characterize, disseminate and utilize plant genetic variation for accelerated crop improvement, strategic research, and sustainable production of food and agricultural products around the world.

GIFS is working with DivSeek to assist in its development, strategic planning and research coordination efforts with numerous labs around the world. GIFS is partnering with Genome Canada to provide support and facilities for DivSeek to grow and build momentum in the use of biodiversity to assist plant breeders produce resilient crops for the expanding world population.

GIFS Postdoctoral Fellow **Dorota Paczesniak** conducts research with Zephyr, a liquid handling robot that uses automated protocols for sample handling and preparation, and helps scientists to achieve consistent and precise experimental outputs more quickly.

GIFS Technician **Rick Goertzen** uses a Flow Cytometer, a laser-and fluorescence-based technology that conducts analyses to determine if a seed is apomictic.

Building state-of-the-art labs for food security research

Postdoctoral fellows, researchers and graduate students at GIFS have access to new, state-of-the-art equipment to conduct their research. With support from lab managers and technicians, GIFS is creating a flexible, customized learning environment where researchers can explore their passions and potential in a supportive, diverse and collaborative setting.

GIFS Main Laboratory

GIFS newly renovated laboratory gives postdoctoral fellows, researchers and graduate students access to the most up-to-date state-of-the-art precision agriculture using high throughput digital phenotyping of crops integrated with genomics data and analysis expertise. These technologies, combined with genetic information (genomics) is a powerful tool for plant breeders.

Omics and Precision Agriculture Laboratory

This fall, Western Economic Diversification Canada provided a $1.35 million contribution to purchase equipment for a new GIFS Omics and Precision Agriculture Laboratory (OPAL). This state-of-the-art laboratory will serve as a hub for agricultural research in Canada by offering services which enhance precision agriculture. Using research conducted at OPAL, plant breeders can ensure that crop inputs like water, fertilizer and plant protection products are used at the correct time and place to increase productivity and maximize yields, in a sustainable manner.

Dr. Patrick Man Pan Yuen

Dr. Donald Baxter Scholarships for Global Food Security

The Baxter Scholarships reward achievement and recognize graduate students from the People's Republic of China and Hong Kong interested in research and study in the areas of: biology, plant sciences, soil science, computer science, genomic sciences, biotechnology, food health and nutrition, and agriculture and agri-food policy.

The Dr. Donald Baxter Scholarships for Global Food Security was established through a $1 million endowment from Dr. Patrick Man Pan Yuen, MD, FRCP(C), an alumnus from the University of Saskatchewan's College of Medicine, class of 1964. GIFS is also contributing $40,000 per year to the Scholarships.

Two $40,000 Scholarships are will be awarded each year for 25 years. More information is available at www.usask.ca.

Scaling up Pulse Innovations for Food and Nutrition Security in Southern Ethiopia

One of the most populous countries in Africa, Ethiopia is also one of the oldest agrarian cultures in sub-Saharan Africa. The countries estimated population of about 104 million people continues to grow, and coupled with climate change, Ethiopia's agricultural productivity and food security is being threatened by population pressure and poor agricultural practices.

For the past two decades, researchers from the University of Saskatchewan (U of S) and Hawassa University in Ethiopia have been working with Ethiopian researchers and farmers to develop new farming practices, technologies, institutional capacity building and policies aimed at improving food and nutrition insecurity in the region through holistic nutrition and gender sensitive agricultural interventions.

With funding from Canada's International Development Research Centre (IDRC) and Global Affairs Canada, Dr. Carol Henry and a team at the U of S have been working in close collaboration with researchers at Hawassa University and other regional and local partners to bring higher-yielding, more nutritious chickpea and bean varieties to more than 70,000 households involved in farming in two of the most populous regions in Ethiopia, Southern Nations Nationalities and People (SNNPR) and Oromiya regions. The project promotes women empowerment, nutrition education and behavioural change communication as key strategies along the production value chains.

The multi-disciplinary nature of this project incorporates the work of plant scientists, soil scientists, food scientists and nutritionists to improve the nutritional status and livelihood of a vulnerable, poor population – small farmers and their households in Ethiopia - through the introduction of pulse crops. The project is also using social scientists to look at the social dynamics taking place with respect to gender, and economists and marketing experts to look at marketing models to commercialize the crops.

And the project is seeing great success. Farmers are benefiting from the 'shoulder crop' nature of pulses – they can be can be planted after fields of wheat and maize have been harvested so do not require additional land. The planting of pulse crops also improves soil fertility through nitrogen fixation. Another result has been increased institutional capacity within the local government.

Because they are inexpensive, pulses are also providing local women with opportunities not only to nourish their families economically with very high-quality protein and other nutrients, but also to contribute to the economic success of their families by selling their crops in markets.

Over the past two years, GIFS has provided funding to support the work of a Postdoctoral Fellow with expertise in socio-economics and gender issues and to conduct a workshop on capacity building in scaling up pulse crops.

This past fall, Henry and members of her team visited Ethiopia to present a workshop on gender sensitization to local women, men, farmers and government workers about the role of women in pulse crops, and to solicit input on the project and its future in the region.

Team visits to Ethiopia also typically include tours of pulse fields that include talks with farmers and the local communities surrounding the remote fields to find out what makes a successful crop season for them. For example, farmers have found that using a cluster

Photo: Petterik Wiggers/Panos Pictures

Carol Henry is working with Ethiopean researchers and farmers to enhance pulse crops in the region.

approach to planting, where five or more farmers come together to produce a larger crop or rent out to others to farm, provides additional economic benefits.

Today, Ethiopian farmers are growing pulse crops in areas where pulses never grew before. And newer varieties of pulses, with shorter growing times and higher nutrients are replacing more traditional pulse varieties. In addition, where traditional varieties of pulses died during the flood season, the crops are now sustaining water and growing tall and strong. Farmers are also benefiting from good agriculture management practices.

In the area of nutrition, women are learning about the quality of pulse crops, and are actively seeking them out in markets because they know how to prepare the crops for their families – pulse crops are no longer just poor man's food, they are for everyone, and are particularly beneficial in terms of nutrients for children to combat 'stunting'.

Other project results include capacity building, not only in Ethiopia, but in developed countries as well. Graduate students from Hawassa University are coming to the U of S to study, and are taking the knowledge, tools, and technology they acquire back to their home country to share.

Highlights of work completed by GIFS' sponsored Postdoctoral Fellow Dr. Esayas Geleta include:

- Visited with 10 of the 15 district project sites to discuss the project.
- With the Hawassa team, worked with the districts' agricultural extension workers, women's affairs officers in the agricultural bureaus, and leaders of the bureaus of women and children affairs and others to undertake gender analysis, monitoring, and evaluation to enhance the gender outcome of the project.
- Identified and embarked on research at three research sites (Sodo, Meskan and Halaba) to determine a comprehensive gender analysis.
    - Conducted interviews with 45 males and 45 females at the three research sites and held two focus groups and conducted 200 short surveys at each research site.
    - Established network and potential collaboration with Feed the Children Canada.
    - Published policy relevant articles on women and gender issues in an international reputable journal.

GIFS also co-sponsored a Round Table on Gender in May 2017 entitled: "Global Food and Nutrition Security through a Gendered Lens" Opportunities and Challenges.

Photo: Petterik Wiggers/Panos Pictures

Independent Auditor's Report

July 18, 2017

To the Board of Directors of the Global Institute for Food Security

We have audited the accompanying financial statements of Global Institute for Food Security, which comprise the statement of financial position as at April 30, 2017 and the statements of operations and unrestricted net assets and cash flows for the year then ended, and the related notes which comprise a summary of significant accounting policies and other explanatory information.

Management's responsibility for the financial statements

Management is responsible for the preparation and fair presentation of these financial statements in accordance with Canadian accounting standards for not-for-profit organizations, and for such internal control as management determines is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

Auditor's responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with Canadian generally accepted auditing standards. Those standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the entity's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion, the financial statements present fairly, in all material respects, the financial position of Global Institute for Food Security as at April 30, 2017 and the results of its operations and its cash flows for the year then ended in accordance with Canadian accounting standards for not-for-profit organizations.

PricewaterhouseCoopers LLP

Chartered Professional Accountants

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Statement of Financial Position

As at April 30, 2017

	2017 $	2016 $
Assets		
Current assets		
Cash held by University of Saskatchewan (note 3)	28,340,954	32,434,548
Liabilities		
Current liabilities		
Accounts payable and accrued liabilities	92,458	57,170
Unrestricted net assets	28,248,496	32,377,378
	28,340,954	32,434,548

Economic dependence (note 1)
Commitments (note 5)

Approved by the Board of Directors

The accompanying notes are an integral part of these financial statements.

Statement of Operations and Unrestricted Net Assets

For the year ended April 30, 2017

	2017 $	2016 $
Revenue		
Contributions from founding partners (note 4)	2,000,000	17,000,000
Interest income (note 3)	508,044	376,591
	2,508,044	17,376,591
Expenditures		
Administration		
Salaries and benefits	847,228	695,819
Occupancy costs	503,289	184,434
Communications and marketing	155,630	151,466
Travel and recruitment	124,660	144,438
Office operations (note 3)	79,223	80,493
Board costs (note 3)	61,525	23,962
Consulting	44,923	-
	1,816,478	1,280,612
Research and education		
Grants and awards (note 5)	4,710,125	2,761,225
External science advisory	68,537	204,043
Salaries and benefits	41,786	38,933
	4,820,448	3,004,201
	6,636,926	4,284,813
Excess (deficiency) of revenue over expenditures	(4,128,882)	13,091,778
Unrestricted net assets – Beginning of year	32,377,378	19,285,600
Unrestricted net assets – End of year	28,248,496	32,377,378

Statement of Cash Flows

For the year ended April 30, 2017

Cash provided by (used in)	2017	2016
Operating activities		
Excess (deficiency) of revenue over expenditures for the year	(4,128,882)	13,091,778
Changes in non-cash working capital items		
Cash held by University of Saskatchewan	4,093,594	(13,027,230)
Accounts payable and accrued liabilities	35,288	(64,548)
	4,128,882	(13,091,778)
Net change in cash	-	-
Cash – Beginning of year	-	-
Cash – End of year	-	-

The accompanying notes are an integral part of these financial statements.

1] Nature of business

The Global Institute for Food Security (the "institute" or "GIFS") was established by a Memorandum of Agreement (the "agreement") dated November 19, 2012 between the University of Saskatchewan, the Government of Saskatchewan, and Potash Corporation of Saskatchewan. The institute is a Type B Centre of the University of Saskatchewan (the "university"). The mandate of the institute is to place Saskatchewan among global leaders in food security research and policy development. The operation of the institute is economically dependent on the funding from Potash Corporation of Saskatchewan and the Government of Saskatchewan (note 4).

2] Summary of significant accounting policies

a) Basis of presentation

These financial statements include the accounts of the institute and are presented in accordance with Canadian accounting standards for not-for-profit organizations ("ASNPO").

b) Use of estimates

The preparation of financial statements in conformity with ASNPO requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities and disclosure of contingent assets and liabilities at the date of the financial statements and the reported amount of revenue and expenditures during the reporting period. Actual results could differ from these estimates.

c) Revenue recognition

The institute follows the deferral method of accounting for contributions which includes funding from the Government of Saskatchewan and Potash Corporation of Saskatchewan as well as other funding sources.

Unrestricted contributions are recognized as revenue when received or receivable if the amount to be received can be reasonably estimated and collection is reasonably assured. Restricted contributions for expenses of the current period are recognized as revenue in the current period and restricted contributions for expenses of one or more future periods are deferred and recognized as revenue in the same period or periods as the related expenses are recognized.

Investment income earned on the cash held by University of Saskatchewan is recognized as revenue when the university can measure and transfer the income to the institute.

Contributions of materials and services are recognized only when a fair value can be reasonably estimated and when the materials and services are used in the normal course of the institute's operations and would otherwise have been purchased.

d) Financial instruments

Financial assets and financial liabilities, consisting of cash held by University of Saskatchewan and accounts payable and accrued liabilities, are initially recognized at fair value and subsequent measurement is at amortized cost. The institute does not consider itself to have significant exposure to credit risk, currency risk, interest rate risk, liquidity risk, market risk or other price risk.

3] Related party transactions

During the year ended April 30, 2017, the institute purchased goods and services from the university in the amount of $15,935 (2016 – $20,046), which are included in expenditures. During the year, the university provided the institute with access to facilities, phones, computer networks and financial administrative systems needed to support the operational needs of the institute. Of the grants made during the year ended April 30, 2017 by the institute, $4,429,610 (2016 – $2,761,225) were made to the university, including individuals or entities related to or employed by the university.

All funds received by the institute are held in, and payments to vendors of the institute are made from, bank accounts administered by the university, which are included on the statement of financial position as "Cash held by University of Saskatchewan". The average monthly balance earned a rate of 1.6% during the year (2016 – 1.5%) and interest income of $508,044 (2016 – $376,591) was received from the university during the year.

During the year ended April 30, 2017 members of the institute's Board of Directors received payments for per diems and expenses of $61,525 (2016 – $23,962).

All related party transactions described above are measured at the exchange amount, which is the consideration established and agreed to by the parties.

4] Contributions from founding partners

The agreement (note 1) features a funding commitment of $15 million from the Government of Saskatchewan over seven years ending April 30, 2020 and a provisional donation to the institute of up to $35 million by Potash Corporation of Saskatchewan over seven years, subject to an annual review of the institute including certain reporting requirements being met and satisfactory performance against certain objectives and metrics. The provisional donation from Potash Corporation of Saskatchewan may be structured such that funds are provided evenly over the seven year period, or proportionally matched with the growth of the institute, or by some other agreed upon manner. Potash Corporation of Saskatchewan will determine on an annual basis whether or not to make a contribution during any fiscal year.

As of April 30, 2017, the funding received to-date is $9 million from the Government of Saskatchewan and $31 million from Potash Corporation of Saskatchewan.

5] Commitments

a) Funding awards

One of the core activities of GIFS is to provide grants to eligible scientific investigators for the purpose of research in a wide range of issues related to food production and food security. As of April 30, 2017, funding commitments have been made toward twelve projects with multi-year grants. The total maximum commitment on these projects is $21,245,040, of which $4,710,125 was funded during the year (2016 - $2,761,225) and of which $8,857,050 has been funded in total as of April 30, 2017. These commitments include $7 million for the creation of a Chair in Seed Biology to support the "Seed" pillar of GIFS' strategic plan to address food sustainability. As of April 30, 2017, $4 million of the $8,857,050 funded to date relates to this item.

Based on the above, total anticipated maximum commitments over the next five years are as follows:

	$
2018	3,169,375
2019	3,290,055
2020	2,048,560
2021	1,040,000
2022	1,040,000
Thereafter	1,800,000

Included in the maximum commitments disclosed above is an annual contribution of $1 million from GIFS to the university, for a 7-year period commencing in the year ended April 30, 2017, related to the $10 million Canada Excellence Research Chair (CERC) funding which was awarded to the university during the year ended April 30, 2017. The Research Chair is held by the Associate Director of GIFS and supports the "Roots" pillar of GIFS' strategic plan to address food sustainability.

Also included in the maximum commitments disclosed above is an annual contribution to the university of $40,000 from GIFS, for a 25-year period commencing during the year ended April 30, 2017, related to funding the Dr. Donald Baxter Scholarship for Global Food Security, which was created during the year ended April 30, 2017 by means of a gift of $1 million to the university. The scholarship fund will be endowed and awarded annually from the scholarship fund administered by the university by a committee comprised of members from GIFS and the university.

During the year ended April 30, 2016 the Canada First Research Excellence Fund (CFREF) Steering Committee approved funding to the university, for the application entitled Designing Crops for Global Food Security submitted by the university, for a total amount of $37.24 million between September 2015 and August 2022. The university delegated management of the research program and fund management responsibilities to the CEO and Executive Director of GIFS. The program focuses on the "Digital Agriculture" pillar of GIFS' strategic plan to address food sustainability. GIFS has no financial commitments related to the CFREF funding and no responsibilities as an organization beyond those delegated and designated to its CEO and Executive Director.

b) The university is party to "License to Occupy Premises at the National Research Council" agreements on behalf of the institute for office and laboratory space. The minimum future commitments under the agreements are as follows:

	$
2018	560,350
2019	562,530
2020	352,331
2021	357,400
2022	271,599

Included in the minimum future commitments immediately above is $165,000 related to fit-up and leasehold improvement costs for the 2018 fiscal year, $190,000 for the 2019 fiscal year and $90,000 per year for the 2020 through 2022 fiscal years.

GIFS | GLOBAL INSTITUTE FOR FOOD SECURITY

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