

Topic: Saskatchewan Agricultural Biotechnology

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1. Introduction

“World leaders,” “innovative” and “competitive” are just a few of the terms used to describe the burgeoning agricultural research industry in Saskatchewan. According to the Government of Saskatchewan, the province is “Canada’s fastest growing ag biotech centre,” with 30 per cent of the industry located here (*Wide Open Future* “Industry Sectors”). Specifically, the city of Saskatoon has emerged as the center for agricultural biotechnology in the province. From the pages of the *Wall Street Journal* to *Time Magazine* to the *National Post*, Saskatoon has been identified as a major player in the global science community (Armstrong, E1). In *Time Magazine*, reporter Chris Turner described Saskatoon as “one of the world’s foremost centres for agricultural biotechnology” (Turner as quoted in Armstrong, E1). As reported in the *PBI Bulletin*, 2002 Issue 3, “Saskatoon’s agrifood biotech cluster is one of the few identifiable agricultural and food biotechnology clusters in the world” (“Saskatoon’s AgriFood Biotech Cluster”) Factors contributing to Saskatoon’s success are described in *Agricultural Biotechnology in Saskatchewan*:

Saskatoon is recognized as one of the top agricultural biotechnology centres in the world due to our exceptional infrastructure and the co-operation that exists both within the industry and at all levels of government. The synergy that exists due to the development of Innovation Place with its close ties to the University of Saskatchewan, to scientists in private corporations, and to publicly funded institutes creates a unique environment for success (Ag-West Biotech Inc., 2).

2. What is agricultural biotechnology?

The online publication *From Field to Plate* provides an explanation of the science involved in agricultural biotechnology:

Agricultural biotechnology is a modern tool in the old science of plant and animal improvement. It involves applying cell and gene (DNA) splicing technologies to improve crops and animals, or to produce new products. However, the term "agricultural biotechnology" is also used to describe processes other than gene splicing. Some examples include micropropagation (a technique used to mass-produce identical plants); diagnostics, to help detect plant and animal diseases; biofertilizers (which use natural means such as bacteria to fertilize crops); and

biopesticides (which use natural agents such as fungi or predator insects to protect crops from pests.)

Agricultural biotechnology brings together advanced disciplines such as biology, genetics, molecular biology, biophysics, biochemistry, chemical engineering and computer science. Biotechnology activities include: using molecular biology to understand how cells and organisms work so that their activities can be altered; modifying micro-organisms, cells, plants or animals by recombinant DNA techniques and methods other than traditional breeding; and using microorganisms, plant cells, animal cells or parts of cells to produce commercial quantities of useful substances (e.g. vaccines) (Ag-West Biotech “What is Agricultural Biotechnology”).

Refer to the attached time line developed by the Biotechnology Industry Organization for an historical overview of biotech through the centuries

(<<http://www.bio.org/speeches/pubs/er/timeline.asp?p=yes&>>, May 2004)

3. Areas of Expertise

The Government of Saskatchewan identifies several key areas of strength in the province’s agricultural biotechnology sector, including: genomics, animal health products, animal vaccines and food safety products, new crop varieties and crop identification systems, microbial bio-controls, microbial bio-fertilizers and plant nutrient systems as areas of strength.

Several additional areas are emerging in the province including plant micropropagation, biological water quality and detection systems, cosmetics and skin care products and bio-pharmaceuticals and bio-industrial feedstocks (Government of Saskatchewan *Industry and Resources* “Agricultural Biotechnology”).

3.1 Saskatchewan - A Genomics Leader

Genomics is cited as one of the key areas of strength in the province’s agricultural biotechnology sector, and Saskatchewan researchers are emerging as national leaders in this field of study. On a basic level, genomics is defined as the “study of genes and their function” (Ag-West Biotech, *Ag Genomics Powerhouse*). Saskatchewan has become a leader in cutting-edge genomics research:

Saskatoon has the greatest concentration of agricultural genomics knowledge and expertise in Canada. Capitalizing on these strengths and leveraging the funding currently in place, gives Saskatoon the potential to further develop both the private and public genomics industry making Saskatoon a powerhouse for genomics research and commercialization (Ag-West Biotech, *Ag Genomics*

Powerhouse).

Currently in Saskatchewan, greater than \$120 million in genomics funding has been invested. Notable research initiatives include:

- The NRC's Plant Biotechnology Institute's "Enhancing Canola through Genomics" study may potentially lead to new varieties with improved characteristics like "seeds that tolerate heat better, mature more rapidly, and have thinner coats and therefore higher commercial value." Agriculture and Agri-Food Canada is also partnered with PBI in comparative genomics studies of *Brassica* species, as well as their own *Brassica* research (Ag-West Biotech, *Ag Genomics Powerhouse*).
- Researchers in the University of Saskatchewan's Department of Plant Science are investigating the effects of the Canadian environment on canola and wheat crops at the genetic level, with the "potential to improve agricultural productivity around the world" (*PBI Bulletin, 2002 Issue 3* "Campus a Global Leader in Bio-Innovation").
- Touted as the "world's single largest research program in animal health genomics", the \$27 million research project entitled Functional Pathogenomics of Mucosal Immunity, sees the partnering of Saskatoon's Vaccine Infectious Disease Organization (VIDO), Pyxis Genomics Inc. and Inimex Pharmaceuticals Inc. The scope of the project and its potential impacts are described as follows:

Functional Pathogenomics of Mucosal Immunity , a \$27.5 million research project funded in part by Genome Prairie, is working to increase the understanding of how natural mucosal immunity to infectious agents operates. These findings will be used to develop this characteristic thereby developing new and effective strategies for improving human health and animal productivity. Animal health and welfare, food safety, and the economic viability of the livestock industry in the Prairies, Canada, and elsewhere will be increased as a result of this work (Ag-West Biotech, *Ag Genomics Powerhouse*).

- Additional genomics activity is taking place in the University's Department of Animal and Poultry Science and at the Saskatchewan Research Council. Various research projects are underway involving breeding and genetics of cattle (Ag-West Biotech, *Ag Genomics Powerhouse*). A recent notable achievement in genomics research at the University of Saskatchewan was the development of "world's first reliable DNA test for selectively breeding beef cattle with superior meat quality—a discovery that could mean more than \$100 million a year in increased revenues to Western Canada's beef industry." A variant in the gene for leptin corresponds to increased fat marbling and the potential for

cattle to grade AAA or better. The variant was discovered by a graduate student in the Department of Animal and Poultry Science, and a company called Quantum Genetics Inc. was started by another graduate student to market the test to ranches and feedlots (University of Saskatchewan “DNA Research Breakthrough Potentially Worth Millions to Beef Industry”). In July of 2003, Quantum Genetics Inc. entered into a “global marketing agreement” with Merial, a world-leading animal healthcare company, to market a kit directly to beef cattle producers called the IGENITY™ L Test (Peck).

- Bova-Can Laboratories, which is part of the Saskatchewan Research Council, is credited with the development of DNA microsatellites for determining the parentage of llamas, elk, sheep, goats and swine (Ag-West Biotech, *Animal Biotechnology in Saskatchewan*).

4. Key Players

4.1 University of Saskatchewan

The University of Saskatchewan is an integral part of the “Science City” being built in Saskatoon. The University contributes beyond the level of basic funding to its colleges and departments and the string of qualified graduates trained within its greystone walls. The campus is home to major national research centers including Agriculture and Agri-food Canada’s Saskatoon Research Station, the National Research Council’s Plant Biotechnology Institute, the Saskatchewan Research Council, POS Pilot Plant and Innovation Place - one of the most successful research parks in North America. “The College of Agriculture is at the forefront of world-class innovation in agricultural education, research and outreach, and is a world leader in agricultural crop research for the Great Plains” (University of Saskatchewan *Research* “About U of S Research” “Overview”). The University’s role in the agricultural biotechnology cluster is further strengthened by the Crop Development Center, which is Canada’s largest plant breeding operation (Government of Saskatchewan *Wide Open Future* “Industry Sectors”). In addition, the world renowned Vaccine Infectious Disease Organization (VIDO) is owned by the University, and conducts research into human and animal vaccines. The University also established a virtual, interdisciplinary College of Biotechnology, which began offering courses in September of 2000. According to the College’s website: “The new biotechnology programs at the University of Saskatchewan are unique in Canada, and offer the potential and synergistic crossovers between industry, education and research. The programs will enhance the University’s current reputation as an innovative leader in the field” (University of Saskatchewan *College of Biotechnology*). The new Canadian Light Source Synchrotron and the Saskatchewan Structural Sciences Centre on campus provide invaluable research tools and facilities to support existing research and to attract new projects to the province.

4.2 Technology Commercialization

The establishment of The University of Saskatchewan Technologies Inc. (UST) in 1990 was an important step for the University. UST was set up as a “technology commercialization arm of the University of Saskatchewan” (UST Inc.”General Information”). A significant number of success stories like Philom Bios are spin-off companies from the University. A 2001 survey identified 33 companies which have spun-off from the University (Jenkins, E3). The Industry Liaison of the University of Saskatchewan (ILUS) was set up in the fall of 2003 to replace the UST. In a press release, U of S Vice President of Research, Steven Franklin explained that “This reorganization reflects the growing importance of bringing together university inventors and business partners to capitalize on technology transfer opportunities that can help ensure Canada’s economic health in a knowledge-based economy” (University of Saskatchewan “New Industry Liaison Office at U of S”).

4.2.1 Philom Bios - the inoculant company

Incorporated in 1980, Philom Bios continues to serve the agricultural market with high quality inoculants which “help farmers improve crop productivity and profitability.” Philom Bios defines an inoculant as follows: “An inoculant is a live micro-organism which, when added to the soil or applied to the seed, gives growing plants access to important nutrients like nitrogen and phosphate.” The company has developed the world’s first and only phosphate inoculant - Jumpstart, and the first and only phosphate and nitrogen combination inoculant - TagTeam. Philom Bios estimates that an astounding \$30 million in increased net profits to Prairie farmers using their inoculant products in 2003 alone. The company is based out of Innovation Place, with a number of sales representatives serving the North American market (Philom Bios).

4.3 The Vaccine & Infectious Disease Organization (VIDO)

The Vaccine Infectious Disease Organization, formerly known as the Veterinary Infectious Disease Organization, was established in 1975 as a public, not-for-profit research institute, located on campus and wholly owned by the University of Saskatchewan. “The Vaccine & Infectious Disease Organization (VIDO) is a global leader in food and infectious disease research and in the development of livestock vaccines. It delivers leading edge technology for disease solutions, to benefit livestock producers, the food industry and society as a whole” (VIDO “About Us”). VIDO is a world renowned research institution with five world firsts in livestock vaccine to its credit, including the world’s first genetically engineered animal vaccine, Pneumo-Star™, and the first vaccine against calf scours in the late 1970s (Vido “About Us” University of

Saskatchewan *First & Best*). VIDO was also the first to show the effectiveness of DNA immunization in cattle, which is “known to lead to a long-lasting and broad spectrum immune response” (VIDO “About Us”).

The following chart, describing notable VIDO successes in livestock vaccine development, is reproduced from the VIDO website (“About Us”).

- Products in bold were world firsts of their type.

Product	Sector	Application	Disease impact/year
Vicogen TMTM	Cattle	Prevention of calf scours	\$300 million in economic losses
Ecolan RC ^{TMTM}	Cattle	Prevention of bacterial and viral calf scours	\$300 million in economic losses
Hevlan TC ^{TMTM}	Poultry	Prevention of enteritis in turkeys	\$20 million in economic losses
Pneumo-Star ^{TMTM}	Cattle	Prevention of Pasteurella infection in cattle (part of Bovine Respiratory Disease (BRD) complex)	\$1 billion in economic losses
Somnu-Star ^{TMTM}	Cattle	Prevention of Haemophilosis in cattle (part of BRD complex)	\$1 billion in economic losses
Somnu-Star Ph ^{TMTM}	Cattle	Prevention of Pasteurellosis and Haemophilosis in cattle (part of BRD complex)	\$1 billion in economic losses
Pleuro-Star 4 ^{TMTM}	Swine	Prevention of Porcine Pleuropneumonia	\$100 million in economic losses

As of 2004, VIDO has been awarded 60 patents, and has 30 patents pending (VIDO “About Us”). VIDO is also doing important work to improve human health as well as that of livestock. Currently, a vaccine to reduce *Escherichia coli* 0157:H7 in cattle is being developed, with important implications for humans including safer beef products and reduced water contamination (Tranberg, 108). VIDO has also had a hand in developing potential vaccines against the Severe Acute Respiratory Syndrome or SARS coronavirus (VIDO “VIDO News”). Both the *E. coli* and SARS vaccines are in the testing phases (VIDO “Research”). As previously mentioned in section 3.1, VIDO is a partner in the “world’s single largest research program in animal health genomics” - the \$27.5 million Functional Pathogenomics of Mucosal Immunity

study (Ag-West Biotech *Ag Genomics Powerhouse*).

4.4 Advancements in Artificial Insemination, In-Vitro Fertilization and Embryo Transfer at the University of Saskatchewan

The Department of Animal and Poultry Science and the Western College of Veterinary Medicine at the University of Saskatchewan have been key contributors to reproductive science in the areas of artificial insemination, in-vitro fertilization and embryo transfer. The application of artificial insemination techniques and the use of frozen semen were important developments for improving dairy cattle. The University of Saskatchewan's Department of Animal and Poultry Science has been involved in artificial insemination research since the 1950s. Western Canada's first frozen semen calf was born at the University in October of 1955 (Bell, 19).

Saskatchewan researchers are leaders in the development of techniques and procedures for artificial insemination, in-vitro fertilization and embryo transfer in livestock.

Dr. Reuben Mapletoft of the Western College of Veterinary Medicine has made significant contributions in this field. The University of Saskatchewan writes: “

Dr. Mapletoft is renowned for his work in bovine embryo transfer, ovulation synchronization and superovulation. He has been instrumental in developing the embryo transfer industry in Canada and around the world. ... His embryo transfer protocols have become the de facto standard for clinical use worldwide.

He patented a substance that replaces serum in culture and cryopreservation procedures used when transporting embryos. He also developed a drug to induce superovulation in cattle, as well as one of the first practical methods to synchronize estrus cycles for “artificial insemination by appointment” in cattle. These developments allow increased embryo production in superior animals and allow producers to preschedule embryo transfer and artificial insemination (Investing in Ideas - U of S Research, “About U of S Research”).

4.5 Canadian Light Source Synchrotron

The Canadian Light Source Synchrotron, scheduled to open in 2004, is owned and operated by the University. At an estimated cost of \$173.5 million, it is considered to be Canada's largest science project in 30 years. The CLS Synchrotron has great potential to serve the agricultural biotechnology sector. “A synchrotron acts like a gigantic microscope that generates intense beams of light to view the microstructure of materials.” An estimated 2000 research personnel from around the world will travel to use the facilities each year (Canadian Light Source Inc. “Quick Facts”).

4.6 Saskatchewan Structural Sciences Centre

The \$11.4 million Saskatchewan Structural Sciences Centre (SSSC) opened in September of 2003 on the University of Saskatchewan Campus. The SSSC is a “world-class facility filled with high powered lasers, X-rays and microscopes” (Tranberg, 108). The facilities and staff of the SSSC will “complement” the work done at the Canadian Light Source Synchrotron in agricultural biotechnology as well as a myriad of applications for other life and earth science disciplines (University of Saskatchewan *Saskatchewan Structural Sciences Centre* “News”).

4.7 POS Pilot Plant Corporation

Since it opened in 1977, the POS Pilot Plant Corporation has evolved into a world renowned bioprocessing facility, which “rents out its brainpower and high-tech equipment” to clients from across the globe (Olijnyk). In *Saskatoon: Canada’s Science City*, the Saskatoon Regional Economic Development Authority Inc. describes the POS Pilot Plant:

POS is the largest pilot plant operation of its kind in North America, with 5 separate processing areas and 11 fully-equipped laboratories in a 54,000 ft² facility. Located on the University of Saskatchewan campus, with a team of more than 80 specialists and support staff, POS is a confidential contract research organization for grams-to-tonnes process and product development and specialty toll processing, providing international clients with bioprocessing solutions.

The POS Pilot Plant assists small and large companies in taking their ideas to commercialization. A wide range of products including: “food and ingredients, fats, oils and lipids, nutraceuticals and functional foods, animal feeds and functional feeds, cosmetics, cosmaceuticals and fragrances” are processed by POS (Agriculture and Agri-Food Canada as qtd. in *The Business Link*). Interesting examples include a tasteless broccoli extract, containing an important antioxidant for fighting cancer, developed for Brassica Protection Products of Baltimore, USA which markets a tea containing the extract. POS assisted the country of Burkina Faso to develop a process to produce shea butter from shea nuts, rather than just exporting the raw product (Olijnyk). Right here at home, POS worked with the University of Saskatchewan spin-off company Saskatoon Colostrum Co. Ltd. to develop a procedure to spray dry valuable, immune boosting colostrum - the first milk produced by mother cows after birth which contains important antibodies. By spray-drying, the colostrum can be turned into a powder with a long shelf life, and is available to farmers who need to feed weak calves or poor sucklers. Headstart, the Saskatoon Colostrum Co. Ltd.’s product, has become “one of the most successful products of its kind in the world” (Olijnyk).

4.8 Saskatchewan Research Council

Established in 1947 in Saskatoon, the Saskatchewan Research Council (SRC) has become an important component of the successful “agrifood biotech cluster.” The SRC’s operations are based out of Innovation Place. According to the Council’s website, “SRC’s advanced facilities ensure that testing and R&D for the biotechnology sector are carried out in highly controlled conditions to meet rigorous guidelines.” Genetic testing of traditional and specialty livestock is carried out through the SRC’s BovaCan Laboratories where “parentage verification, chromosome analysis, and tests for production traits and genetic defects” are carried out. GenServe Laboratories is operated by the SRC as well, and offers “genetic services and applied research to the biotechnology and agriculture industries.” The SRC’s Fermentation Technologies branch is also an important contributor to the research industry, as they “enable biotech clients to improve processes or to develop new products - such as vaccines, inoculants, and bio-control agents - by scaling up laboratory processes to commercial production” (Saskatchewan Research Council “Research & Technology”).

4.9 National Research Council’s Plant Biotechnology Institute

The National Research Council chose the University of Saskatchewan campus as the site of its Prairie Regional Laboratory in 1948. The name was changed to Plant Biotechnology Institute in 1983. In a 2002 *Saskatoon Star Phoenix* article entitled “National research organizations in expansion mode,” Byron Jenkins described PBI:

PBI promotes and conducts collaborative plant biotechnology research with universities, other government departments and agricultural biotechnology companies. It assists with transferring research to product development and commercialization and is a training centre for plant biotechnology scientists (E6).

Scientists working at PBI were involved in the development of the world’s first transgenic GM (genetically modified) canola. Released under the name Innovator in 1995, the canola “was resistant to herbicides known as Liberty, Ignite, Basta (and others) containing the active ingredient phophinothricin.” AgrEvo was the company responsible for the commercialization of the first transgenic GM canola (Dr. Wilf Keller, personal communication).

An important contribution to Saskatchewan’s agricultural biotech industry was the creation of an the NRC-PBI Industry Partnership Facility, which opened in 2003. The \$15.4 million facility provides an “industry incubator facility” which provides lab, research and office space for start up companies (Jenkins, E6).

4.10 Agriculture and Agri-Food Canada's (AAFC) Saskatoon Research Centre

AAFC's Saskatoon Research Centre is an important component of Saskatoon's agricultural biotechnology cluster. Expansion of the Centre in 1998 provided room for "scientific support facilities, a new greenhouse complex and Plant Gene Resources of Canada, the home of Canada's national seed collection" (Armstrong, E1). "Agriculture and Agri-Food Canada's (AAFC) Saskatoon Research Centre has built its reputation upon successes as improvements to oilseed and forage crop germplasm and the invention of the process to make conjugated fatty acids" writes Janice Tranberg in "Saskatchewan Agricultural Biotechnology" (108).

4.11 The Role of Innovation Place

Innovation Place is the world's foremost center for agricultural biotechnology, home to companies that have amassed a long list of important breakthroughs in crop engineering. It is also one of Canada's new high-tech incubators, where locally grown IT companies that [sic] do everything from developing components for wireless communication networks to pharmaceutical researchers.

- *Time Magazine* (as quoted by Tourism Saskatoon, E6).

Innovation Place plays a pivotal role in Saskatoon's renowned agricultural biotechnology cluster, and is "considered one of the most advanced and successful research parks in North America, if not globally" (PBI, *PBI Bulletin*, 2002 Issue 3 "Innovation Place"). In the over 20 years since it opened in 1981, Innovation Place has grown to become the home of 116 organizations, employing 2000 people, and contributing more than \$248 million to the economy annually (InnovationPlace). Innovation Place is strategically located close to its neighbour - the University of Saskatchewan, "...and builds on the strengths of the University in Agriculture, information technologies, resources and the life sciences, as well as the strengths of the Federal and provincial agencies either in or immediately adjacent to Innovation Place" (Innovation Place).

Innovation Place is a good example of what partnerships between universities and government can accomplish. In a 2002 interview, Eldon Lautermilch, then Saskatchewan Minister of Industry and Resources, expounded on the successful partnership by saying, "That very visionary position of viewing research and innovation as tools of economic development has steered the success and growth of Innovation Place throughout the past two decades" (Lautermilch as quoted by Armstrong, E2). Innovation Place is a model of success on the world stage as well. In "Saskatoon's AgriFood Biotech Cluster," Peter McCann, then President of Ag-West Biotech Inc., reported that "Innovation Place in Saskatoon is a shining example of the power of technology clusters to boost economic development in a region. Every year visitors from around the world come to learn how we did it."

4.12 Ag-West Bio Inc.

Ag-West Bio Inc. was formed in the spring of 2004 when Ag-West Biotech Inc., Bio-Products Saskatchewan Inc., and the Saskatchewan Nutraceutical Network merged (Ag-West Bio Inc. “News Releases”). In the article “Saskatchewan Agricultural Biotechnology,” Janice Tranberg describes Ag-West Bio Inc.:

As Saskatchewan’s main force for supporting and promoting strong, vibrant, profitable bio-based industries, Ag-West Bio Inc. works at all levels to encourage the development of clients’ ideas into commercial successes. Ag-West has seeded new initiatives and accommodated expansion, contributing approximately \$9.3 million towards 46 projects in 37 organizations and companies since 1989. It hosts seminars, workshops and conferences to further foster productive relations among research, business and financial professionals (109).

The inception of Ag-West Biotech Inc., “an independent, non-profit agency devoted to advocacy, sector liaison, financing, communication and networking within the agricultural biotechnology industry,” by the Saskatchewan Government in 1989, was a critical step in establishing Saskatchewan’s position as a leader in agricultural biotechnology (University of Saskatchewan *College of Biotechnology*).

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