

# GENOME CANADA - INDUSTRY SWINE GENOMICS WORKSHOP

Friday, May 4<sup>th</sup>, 2007

The Westin Bristol Place Hotel, Toronto Pearson Airport

## Report and recommendations to the Science and Industry Advisory Committee and the Board of Directors of Genome Canada

Report prepared by Dr. Denis Petitclerc on behalf of the Swine Genomics Workshop  
Steering Committee:

- Dr. David Bailey (chairperson), Genome Alberta
- Dr. Cindy Bell, Genome Canada
- Dr. Karen Dewar, Genome Canada
- Dr. Klaus Fiebig, Ontario Genomics Institute
- Dr. Pramod Mathur, Canadian Centre for Swine Improvement
- Dr. Stephen Morgan Jones, Agriculture and Agri-Food Canada
- Dr. Denis Petitclerc, Le Groupe Créa Inc.
- Mr. Clare Schlegel, Canadian Pork Council
- Dr. Steve Scherer, The Centre for Applied Genomics, University of Toronto



## Executive summary

The swine genomics workshop, support by Genome Canada in partnership with the Canadian Pork Industry, through the Canadian Centre for Swine Improvement, gathered leading researchers from the animal genomics, animal genetics, and biomedical research communities as well as stakeholders throughout the pork value chain to discuss how to best consolidate Canada's strengths in the area of swine genomics. Participation in this workshop was excellent with 48 people attending and expressing their commitment to a role of swine genomics in the swine industry.

In parallel to this workshop, Genome Canada has engaged in a priority-setting/ position paper process designed to identify Strategic Research Themes that will have the capacity to generate socio-economic benefits for the Canadian public. Out of this process emerged an Agriculture-Animal Theme, that has produced a Position Paper making a case for investment in the area of animal (including swine) genomics. This could potentially lead to a investment in animal genomics and would provides funding opportunities for the Canadian swine genomics community to contribute to a Canadian swine genomics strategy

The pork industry is the largest value-added export sector in Canada. Swine production represents \$3.4 billion in farm cash receipts, or almost 11% of total farm cash receipts in Canada. Canadian pork exports alone account for a total economic activity of \$7.7 billion and approximately 42,000 jobs across the country. Canadian pork exports represent 21% of world pork exports. In fact, Canada exports 55 % of its production to 88 countries.

A key challenge to this industry is to offer the best quality pork at a competitive price. Over the years, implementation of genetic programs (Canadian Centre for Swine Improvement, breeders, and private companies) has allowed the industry to make tremendous improvement in both production performance and meat quality. However, the number one issue facing producers today is disease resistance and herd health while the pork processing industry is faced with higher processing costs in relation to its competitors. Since the entire swine industry is so highly dependent on exports, a single foreign disease outbreak could have devastating consequences leading to border closure, market collapse, and total loss of export income with all markets closed except for the local Canadian market.

Genomics combined with traditional genetic selection can be used to strengthen the competitive position of the Canadian swine industry. A combination of quantitative and molecular approaches using specialized SNPs database along with phenotypic information and bioinformatics support will be essential to the long term success of the industry. The International Swine Genome Sequencing Consortium (ISGSC) has entered phase IV with the goal of generating a high quality assembled, annotated draft DNA sequence (greater than 6 X) of the pig genome. However, additional dollars (\$2.5 million US) are critically needed to complete this essential phase in order to generate a high-quality sequence from which SNPs database could be generated for genetic selection purpose (see letter from Dr. Larry B. Schook, chair of ISGSC – annex 4).

Overall, a Canadian participation through Genome Canada in the ISGSC effort was supported by workshop participants. Regional and national genomic organizations along with industry should be engaged in these discussions to determine the level of interest and potential for shared contributions. Canadian contributions to the ISGSC effort should be part of a Canadian swine genomics strategy .

A committee of champions was put in place to help move forward a Canadian swine genomic strategy; this group should be expanded in the near future. After the workshop, industry stakeholders in swine genetics stated that the following activities are required to meet Canadian swine genomics priorities (see letter of support – annex 5):

- *“Participation in the international swine genome sequencing project to make it more accurate through performing part of the sequencing within Canada for specific regions and/or contribution to the ISGSC;*
- *SNP and other discovery, functional genomics, proteomics and bioinformatics in Canadian populations through university/genome centre/private labs in Canada;*
- *Collection and use of phenotypic and genotypic data from Canadian breeding herds, and*
- *Development of marker assisted selection methodologies for traits of importance to the Canadian swine industry.”*

*“Canada’s swine genomics efforts will be supported by industry stakeholders in swine genetics to ensure successful research and development according to industry needs.”*

## Introduction

A Genome Canada - Industry Swine Genomics Workshop was held on May 4, 2007 at the Westin Bristol Place Hotel, Toronto Airport. This initiative was spearheaded by Genome Canada's Science and Industry Advisory Committee (SIAC) in partnership with the Canadian Pork Industry, through the Canadian Centre for Swine Improvement. The workshop was sponsored by Genome Canada's SIAC through their Genomic Solutions for Industry initiative.

This workshop gathered leading researchers from the biomedical / research communities as well as stakeholders throughout the pork value chain to discuss how to best consolidate Canada's strengths in the area of swine genomics.

The specific objectives of the workshop were to:

- 1) Determine swine genomics priorities for Canada; and
- 2) Determine how to use existing Canadian institutions and resources to improve Canada's competitiveness in the international pork industry market.

Readers can find attached to this report the agenda for the workshop (annex 1), the composition of the workshop steering committee (annex 2), and the list of participants (annex 3). Participation to this workshop was excellent with 48 people showing their commitment to the swine industry.

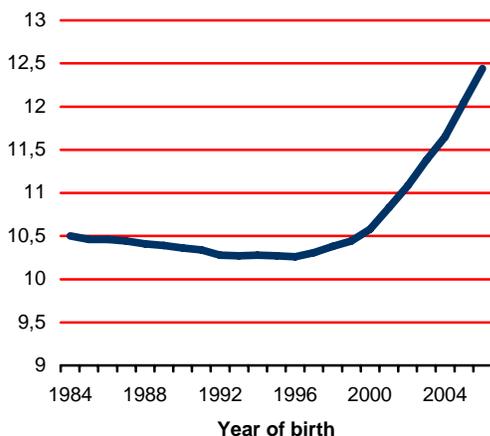
## Highlights of morning presentations

**Dr. David Bailey**, CEO of Genome Alberta, welcomed the workshop participants. The initiative for this workshop came to Genome Canada by way of a request by members of the Canadian pork industry. The USDA announcement of \$10 million for sequencing the swine genome in June 2006 created considerable interest in this topic, in both the USA and here in Canada. Thus important questions were raised relating to our (Canadian) potential involvement, the level of involvement in this large project, and the resulting longer term outcomes or benefits. Given the competitive conditions facing international markets, Canadian producers expressed an interest in knowing more about swine genomics and questioned how they would benefit from a Canadian investment into this new consortium lead by the USDA. Genome Canada, through its Science and Industry Advisory Committee approved funds to co-sponsor with the Canadian swine industry such a workshop – so here we are today. Our facilitator, Dr. Denis Petitclerc walked us through the agenda and helped keep us on track. Dr. Bailey stated that we were here to discuss whether genomic tools can help the competitiveness of the Canadian pork industry and if so, at what cost and in what areas should we focus our research. If we could identify the top research priorities for a Canadian investment in genomics, what would they be? Should we simply support the completion of the swine genome or should we focus on improving herd health or identifying SNPs that influence meat quality? Dr.

Bailey also stated that participants have generously given us this day so we could have a healthy discussion and hopefully finish this afternoon with a clear direction and recommendation(s) that can go back to SIAC and Genome Canada.

**Dr. Pramod Mathur**, chief geneticist of the Canadian Centre for Swine Improvement (CCSI), informed the audience that Canada is one of the leading exporters of pork around the world. He stated that the CCSI's mission is to enhance the ability of the Canadian swine industry to compete domestically and abroad, by providing leadership, coordination, and services for swine genetic improvement. The Centre represents the industry's four regional genetic testing organizations dispersed across Canada: 100 herds, 9,400 nucleus sows, and more than 90,000 pigs tested per year for production performance. Canada has natural advantages to support swine production, its industry is mature and well-organized, and Canadian scientists over the years have made significant contributions in many areas of the pork value chain. Nowadays, the major issue facing the industry is "*How do we continue to strengthen our competitive position*"?

In his presentation, Dr. Mathur reviewed swine genetic research in Canada, the impact of genetic improvement, the potential for genomic research in Canada, and ways that the swine industry could move into genomics. Indeed, because of genetic selection, days to 100 kg has decreased by 26.4 days over the past 22 years, our pigs are marketed almost one month sooner compared to 1980 levels which represents a value of \$11.80 per market hog due to savings in feed and overhead costs. Furthermore, Dr. Mathur demonstrated that when a trait is targeted and we have the ability to carry out genetic selection, tremendous improvement can occur. In fact, prior to 1996, no appreciable progress had occurred in total number of pigs born per sow (see figure below). Implementation of a genetic program to improve this trait led, in the first 10 years, to more than 1.4 pigs weaned per litter of genetic improvement, an additional 2.5 pigs weaned / sow / year with an added value of \$ 76.00 per commercial sow or \$ 106 M for Canada.



Genomics combined with traditional genetic selection can be used to strengthen the competitive position of the Canadian swine industry. A combination of quantitative and molecular approaches along with bioinformatics support from the CCSI will be essential to the long term success of the industry. Canadian genetics is recognized internationally. We have the Canadian herd book and 100 years of breed registration, supported by the Animal Pedigree Act, and phenotypic records on over 3.5 million pigs. Canadian research institutions can support genomic research along with our national genetic improvement program and help

coordinate these efforts among our value chain partners.

Dr. Mathur stated that a national DNA bank with genetic / phenotypic information and a SNP database derived from DNA sequence provided by the International Swine Genome Sequencing Consortium would be a tremendous asset for:

- Genetic diversity, breed purity tests, and parentage verification;
- DNA traceability of pigs and meat products;
- Gene mapping research;
- DNA tests for promising genes;
- Selection programs, especially for traits that are difficult to measure or require sacrificing animals.

**Dr. Steve Scherer**, The Centre for Applied Genomics, University of Toronto and chairperson of Genome Canada's Science and Industry Advisory Committee (SIAC), stated that the mission of Genome Canada is to develop and implement a national strategy in genomics and proteomics research for the benefit of all Canadians in key selected area such as agriculture, environment, fisheries, forestry, health and new technology development. He also presented Genome Canada's portfolio of investments, and discussed the mandate of SIAC in providing strategic advice to Genome Canada board of directors. SIAC has a tradition of hosting workshops on "Big Biology" but the most recent, such as this one, have focused on industry problems and their solutions. Dr. Scherer discussed the universal concepts, applications, and implications of genomics and stated that the real value of traceability using genomic tools was improving the quality of product. Indeed, tracing to improve quality means identifying animals with extreme variation, finding the genes making these differences, and incorporating (or removing) them through genetic selection. It is also recognized that the pig is an important model organism in human research for health issues such as obesity, cardiovascular disease, and organ transplantation. Genomics is technology-driven; datasets are huge and generate data faster than we can analyze it; therefore understanding gene function will be challenging. However, there is tremendous progress on-going in whole genome amplification and next generation sequencing, ultimately leading to the "\$1,000 genome" and the 1 million SNPs microarray for studying genetic diversity, gene function, and conducting genetic selection.

**Dr. Ronnie Green**, National Program Leader, Food Animal Production, USDA / ARS, presented the US federal perspective on funding animal genomic research. Dr. Green stated that the interagency coordination in the US was vital to find dollars needed to support agricultural genomics. The big challenge post-sequencing will be to integrate downstream tools, such as SNP panel, large database handling, and bioinformatics into large-scale genetic selection programs and system biology evaluation. Phenomics will be rate-limiting, especially for difficult or expensive to measure traits such as feed efficiency, meat quality and healthfulness, disease resistance, host-pathogen interaction, and stress resistance.

**Dr. Larry Schook**, Swine Genomics Program, University of Illinois, presented the International Swine Genome Sequencing Consortium (ISGSC) organization, goals, and accomplishments so far. It was stated that "*The ISGSC will strive to advance biomedical research for animal production and health by the development of DNA-based tools and*

*products resulting from the sequencing of the swine genome which will be freely available to all parties.*” Genomics sequencing strategy selected by the consortium was to ensure cost-effective global participation. ISGC project has entered phase IV with the goal of generating a high quality assembled, annotated draft DNA sequence (greater than 6 X) of the pig genome. However, additional dollars are critically needed to complete this essential phase:

- To improve *assembly*;
- To reduce sequencing errors (*SNP discovery*) for LD, HapMaps and WG selection;
- Confirmation of gene structure and content (*annotation*);
- Enhanced utility in *QTL discovery*;
- Research into factors that cause & protect against *disease*.

During his presentation, Dr. Schook suggested the following potential financial and intellectual roles for Canada:

- Contribute up to \$5 million US to whole genome sequencing at Wellcome Trust Sanger Institute to ensure 6x coverage;
- Develop and lead targeted projects (i.e., sex chromosomes SSCX and/or SSCY; immune system); and
- Contribute to SNP discovery and HapMap.

After the workshop, Dr. Schook stated in a letter that the ISGSC was “*critically in need of identifying the remaining US\$2.5M to support the final phase. Timing is also a critical issue, since the sequencing pipeline at the Sanger Institute is closing and we cannot delay our commitment towards finalizing the remaining sequencing*” (see annex 4).

**Mr. Clare Schlegel**, president of Canadian Pork Council, demonstrated the tremendous economical importance of the swine industry to Canada. **Pork industry is the largest value-added export sector in Canada.** Currently, more than 12,000 farms report pig operations and there were 31 million hogs produced in 2006, including 22.2 million processed in Canada and 8.8 million exported live. Swine represents \$3.4 billion in farm cash receipts, almost 11% of total farm cash receipts. Canadian pork exports alone account for a total economic activity of \$7.7 billion (Source: Canadian Pork Council) and 42,000 jobs across the country. The key challenge of the industry is to offer the best quality at a competitive price. Key issues are production efficiency, meat and carcass quality, food safety and biosecurity, environmental responsible production, and preserving biodiversity. However, the number one issue is disease resistance and herd health. Indeed, the entire swine industry is highly dependent on exports. A single foreign disease outbreak can have devastating consequences leading to border closure, market collapse, and total lost of export income with all markets closed except for the local Canadian market. Good science is not enough, but key expectations from genomics are the following:

- Enhance the industry’s ability to compete;
- Reducing cost of production;

- Enhancing quality and uniformity of products;
- Enhance ability to adapt to changes in the market place.

*“Producers need better communication to understand long-term benefits of genomics. Producers need effective tools and guidance to use the technology.”*

**Mr. Don Davidson**, vice-president, Maple Leaf Consumer Foods – Pork Division, stressed that **Canadian pork exports represents 21% of world pork exports**. In fact, Canada exports 55 % of its production to 88 countries. Currently, the industry is in a crisis situation and major restructuring of the Canadian processing sector is on-going. Examples and explanations of what Canada needs to compete were outlined by Mr. Davidson in terms of:

- Cost efficient hog production;
- Carcass quality, uniformity, consistency, and yields;
- Convenience and taste of meat products;
- Health & well-being of animals.

In summary, Mr. Davidson concluded that the Canadian hog / pork industry is struggling and it needs to focus on competitiveness and differentiation. We must have technology that will underpin our competitive position. For the Canadian industry to adapt and innovate, it needs new tools. Factors critical for the Canadian Pork Industry to be competitive are to be aware of and to have access to information from the international research effort on pig genomics. This science will support production efficiency, semen sexing, animal health, meat quality, consistency & taste, and human health & well-being. *“You are what you eat: take out the bad, put in what is healthy.”*

**Dr. Jacques Chesnais**, senior geneticist, The Semex Alliance, gave us a Canadian dairy cattle industry perspective on the use of genomics. Semex is one of the 3 largest single dairy cattle breeding companies in the world based on value of sales and number of bulls tested annually. Several examples of the potential of genomics were provided. Dr. Chesnais concluded that the use of genomics will progressively change methods of dairy cattle selection. It will likely complement but not replace phenotypic selection. It will increase the effectiveness of selection for current traits, and permit selection of new traits. This technology will have a profound effect on the structure of the industry. As far as their participation in the Bovine Sequencing Genome Project (BSGP), he added that the Canadian participation to the BSGP through Genome Canada has been positive for us. However, current Canadian R&D efforts in bovine genomics must increase in order to exploit the benefits of BSGP in Canada. Current support from Genome Canada or Agriculture and Agri-Food Canada for animal genomics research has been very limited to date. The competitiveness of an \$18 billion Canadian industry depends on it. From his point of view, he stated that *“I am pretty sure the same is true for swine”*.

**Dr. Jon Meadus**, meat research scientist, Lacombe Research Centre, Agriculture and Agri-Food Canada (AAFC), looked at the pork industry targets for meat quality and provided partial answer to the following questions:

1. How can genomics help?
2. What are the approaches AAFC can do?
3. What are the Genome Canada cutting edge opportunities?

Dr. Meadus stated that genomics is part of the solution. For example, to treat boar taint with genomics, you need in-line detection technology for its measurement and acceptance by processors. In his opinion, the cutting edge opportunities needed for pig genomics are microarray systems for multiple test categories, whole genome sequencing, proteomic workstations, transgenic animals, by-product conversion: fermentation cultures, and centralized database with traceability, product quality information, and pedigree certification.

**Dr. Bonnie Mallard**, professor in Department of Pathobiology, Ontario Veterinary School, Guelph University, reviewed current problems in animal health. She proposed that one solution to take advantage of natural animal variation is to integrate molecular and quantitative genetic strategies to enhance the immune system and improve inherent disease resistance of food-producing animals. In addition, we need to improve our comprehension of disease resistance by understanding favorable phenotypes, and the underlying genes and proteins that are being produced. This approach has the ability to advance the global competitiveness of the Agri - Food industry. Dr. Mallard gave us several examples of **high immune response and breeding for disease resistance of pigs**. She stated that an immune-endocrine array could be used to evaluate genes associated with high and low immune response or disease resistance. Her take-home message was that substantial genetic variation exists among individuals (pigs & cattle) and between breeds making genetic selection for high immune response possible and beneficial. Many genes regulate host defense, and immune response gene expression varies among animals selected for various traits. Epigenetic modification can also influence immune response gene expression and needs to be investigated further (e.g., IGF-2).

Finally, **Dr. Michael Phillips**, director of Pharmacogenomics, Genome Quebec, University of Montreal, looked at the lessons learned from pharmacogenomics. What are the opportunities for biomedical research in swine? Swine biomedical models offer the possibilities of “pharming”: the production of pharmaceuticals from genetically altered plants or animals, such as xenotransplantation: the production of humanized organs, and the use of pigs as disease models for diabetes, heart diseases, infectious diseases, and other applications. However, for these models and applications, stringent GLP procedures must be carefully followed and would require major investment, effort, and commitment.

## Focus group discussions

In the afternoon, four focus group discussions on production efficiency, meat quality, animal health and disease resistance, and biomedical models were held. Each group was

presented with a pre-determined set of questions and then reported back to the general assembly prior to a general discussion.

### **Production efficiency**

From the point of view of production efficiency, the **strengths of our Canadian swine industry are:**

- Relatively small production units (in comparison to the US) and better management;
- Suitable climate for hog production and lower hog densities in some areas;
- Some good links between industry and the swine research community;
- Canada's ability to do Public Private Partnership can be a huge advantage;
- Production in terms of number of pigs born alive, uniformity, access to low cost feed resources, access to new technologies;
- Animal welfare.

**and the weaknesses of this industry are:**

- Lack of coordination across the country – no structures in place to allow for integration of R&D between industry, universities, and federal research institutions, except for the role played by the CCSI for swine genetic research;
- Need to have a centrally driven plan to coordinate even though forced coordination does not always work well.

***Do you think genomics could help improve some of these strengths or alleviate some these weaknesses? Which one and how?***

Genomics gives us the ability to respond to and integrate many of these issues and help understand complex traits. Without genomic technology, the Canadian pork industry will not be competitive in 10 years. However, we need to obtain phenotypic information to be able to use genomic technology. Genomics will provide additional tools to help understand the relationship with the traits and will allow the study of interaction among genes.

Good examples of use of genomics in the swine industry are the following:

- Used in traceability and in production traits;
- Production companies use a number of markers for their traits; in fact, about 50% of pigs produced in the US today have benefited from a number of improvements due to genomics;
- Biomarkers.

***What is needed for the swine industry to take full advantage of the potential offered by the genomic opportunity?***

Universities need to take a more proactive role to interact with industry – extension and outreach. We need to bring leading breeding companies together; in fact, Canada has a

large number of breeding companies proportionally, even more than in the USA. Furthermore, different segments of the pork chain need to come together and this has to be based on genetically driven forces. Canadian genetic companies need to take the lead. Better yet, we need industry champions that can move the process forward. All successful initiatives must have a champion. The industry needs to become more cost efficient and, hopefully, by having new genomic tools will help achieve these goals.

***How do we participate with the International Swine Genome Sequencing Consortium?***

Canada is a small country and needs to be strategic. There is a need for a balance between benefits to the whole group and benefits to Canada (such a balance between contribution towards the sequencing and post-sequence questions). Canadian institutions can participate in the research effort but we must earmark some funding for post-sequence applications. In some cases, technology can be applied fairly soon.

Overall, participants felt that we are more interested in an integrated North American community than a provincial one.

**Meat quality**

From the point of view of production efficiency, the **strengths of our Canadian swine industry are:**

- Improved slaughter methods (stress resistant animals);
- Taste, marbling, texture, and colour;
- Meat safety (in relation to disease resistance);
- Yield.

**and the weaknesses of this industry are:**

- Consistency in meat quality;
- Transfer of information and knowledge across the value chain;
- Losing competitive advantage;
- Useful and affordable SNP panel;
- Deficient in phenotypic information.

***Do you think genomics could help improve some of these strengths or alleviate some these weaknesses? Which one and how?***

This group identified the following issues before we could take advantage of the potential offer by genomics in meat quality:

- Currently, there is no specific program at Agriculture and Agri-Food Canada;
- We do not have critical mass of researchers;
- There is insufficient public dollars invested relative to the size of the industry;
- Availability of animals for research is a problem;
- Our current infrastructure to evaluate meat quality is adequate.

***What is needed for the swine industry to take full advantage of the potential offered by the genomic opportunity?***

Some of the needs identified are as follow:

- National will to undertake a coordinated effort to take advantage of genomics;
- Systems biology approach: integration of genetics, genomics, and management in order to produce the required quality for different markets;
- Tools to measure meat quality;
- Designer pigs for specific markets (one example was a hairless hog that would substantially reduce processing cost)

***How do we participate with the International Swine Genome Sequencing Consortium?***

*How can we best coordinate research?*

- Information transfer and education on how to use genomics to remain competitive;
- Establish networks to ensure coordination.

***How can industry make use of genomic approaches?***

- Difficult to assess until see actual benefits;
- Need scientific community to guide and, if it demonstrates a use, the industry will adopt.

***How do we participate with the ISGSC?***

- Need to be part of the international effort even though our contribution cannot be big. Our approach must be smart and strategic e.g., do a SNP chip that can be used by the Canadian swine industry.

**Animal health and disease resistance**

From the point of view of production efficiency, the **strengths of our Canadian swine industry are:**

- Reputation (e.g., real and perceived) in animal health;
- Low stocking density of herds;
- Climate;
- Good disease control at border and structure;
- Excellence in genetics.

**and the weaknesses of this industry are:**

- Stocking density is restricted to certain regions in Canada;
- Poor health data collection and sharing of phenotype information;
- Need better early detection and diagnostic tools and disease monitoring systems;
- Poor national strategy for animal health and very limited coordination;
- Lack of research funding in animal health.

***Do you think genomics could help improve some of these strengths or alleviate some these weaknesses? Which one and how?***

Genomics can definitely help to enhance our knowledge of immune response and disease resistance mechanism. However, we will need to work on all three components of the host – pathogen – environment interaction. In addition, there should be a combined interest in animal well-being that includes the role of stress exposure to disease outcome using genomic tools. Funding should help coordinate our force and assemble multi-disciplinary teams. Finally, resource populations are needed and genomics could be a unifying force to support this effort. Key to our success will be sharing the information generated by the genomic effort.

***What is needed for the swine industry to take full advantage of the potential offered by the genomic opportunity?***

The industry needs money, assets, and resources! First, we need to prepare an inventory of all Canadian swine resources, including our skilled workforce. Second, we need to get in the game of swine genomics while remaining focused and strategic in our contribution. Canada needs to look beyond the swine genome sequencing project by looking at how to utilize this information. In animal health, the industry needs effective systems to identify emerging diseases (e.g., diagnostic tools, sharing of information, national / international biosecurity system). Finally, the industry needs lines or resource populations to help improve disease resistance.

***How do we participate with the International Swine Genome Sequencing Consortium?***

Whole genome sequencing has to be done and Canada needs to become involved! The fact that Canada gets into the game later is an advantage because we will then have immediate access to all of the swine sequencing data for a small portion of the total investment. But then, for a true return on its investment, Canada would need to identify specific post-sequencing SNPs which would be of benefit to our industries. Rapid access to SNP panel is essential to develop, as leader, projects supporting Canadian interest built on Canadian expertise - assets have to be built in Canada. Let us make sure we build on Genome Canada's previous contribution and experience with the international bovine genomic project.

**Biomedical models**

The competitive animal models are the rodent (mouse, rat, etc), dogs, and primates. Opportunities identified for pigs as biomedical animal models were the following:

- Models for human disease:
  - Cardio-vascular disease
  - Diabetes
  - Nutrition
  - Immune response
  - Etc.
- Xenotransplants
  - Islet cells

- Heart valves
- Bridging transplantations
- Blood products
- Issues with Zoonoses (transmission of dormant retroviruses)
- Bioreactors
  - Seminal fluid production of recombinant proteins

However, the main barriers to these applications are their high cost, long product development time, and GMO/transgenic issues. In general, advantages associated with pigs as biomedical models are as follows:

- Genetically close to humans;
- Litter bearing species (replicas);
- Size mimics that of human;
- Pig clinical research organization.

On the other hand, disadvantages are the following:

- Large animal (higher costs);
- Longer gestation times;
- No embryonic stem cell techniques available yet / knock outs are difficult;
- Litter sizes do not compare to human.

However, Canada *per se* provides several advantages to the use of swine as biomedical models:

- Large breeding efforts/programs;
- Good herd/breeding records;
- Primary breeders are in Canada;
- Large expertise in genetics (breeding), but not necessarily in genomics;
- Strong GE3LS program.

Nevertheless, several challenges / knowledge gaps were identified:

- Intersection of people using pigs as a model system and genomics may be low;
- Genomics only used for breeding;
- Future studies and comparative studies will tell us if the pig is a good human model;
- Information gap in business development;
- Few incentives to use swine as model system;
- Gap in knowledge transfer.

In the future, greater education in industry and completion of swine sequence may drive more use of swine as a biomedical model system.

## **General assembly deliberation**

The group discussed some of the pros and cons of making an investment in genomics and what would be the advantages to the Canadian swine genomic industry. It was noted that the provinces may be able to get together to leverage investment from Genome Canada

and the industry to allow participation in the international sequencing effort. There is a need to capitalize on this opportunity. In addition, Agriculture and Agri-Food Canada (AAFC) has a bioproducts program and there may be an opportunity for funds from AAFC to support swine genomics in Canada. However, this program needs industry support. Unfortunately, at the moment, this program is over subscribed and the letters of intent have already been received.

In terms of communication, it was stated by participants that there is a need to better explain why genomics is important for the swine industry? Position paper process of Genome Canada will help open up the dialog.

The industry needs a strong leadership from different stakeholders. In terms of genomic capacity, it is clear that Canada has the capacity to develop and take advantage of the SNPs identified from the swine genome sequencing. The sequence provides the reference on which to build SNP discovery but not the SNP discovery itself; this is a later phase where members of a consortium, such as the genoscope, have invested funds for some SNP discovery. This opportunity for Canadian swine improvement was clearly identified by the industry and is easily accessible to them. Furthermore, the Genome Sciences Centre in Vancouver has received one of the new sequencing technologies so we, as a country, would have the capacity to carry out some re-sequencing.

Would it be valuable to bring together champions for the process? These people could form a stakeholder committee from the different sectors involved in the pork value chain. As a whole, we can also take advantage of the expertise gathered today to feed into the position paper process. This information could be use positively in many ways by the different stakeholders.

**A small committee of champions, mostly composed of industry representatives, gathered together spontaneously to move forward a Canadian swine genomics strategy. Composition of this committee will be expanded in the near future especially to include researchers with detailed knowledge of genomic procedures but is made up of the following people for the moment:**

- Dr. David Bailey, Genome Alberta (Public sector)
- Dr. Gijs van Rooijen, Genome Alberta (Public sector)
- Dr. Pramod Mathur, Canadian Centre for Swine Improvement (Industry, National research and development centre);
- Dr. George Foxcroft, University of Alberta (University);
- Dr. Patrick Charagu, Hypor Canada (Industry, Multinational breeding company);
- Mr. Daniel Godbout, Génétiporc Inc. (Industry, Breeding company);
- Dr. Serge Pommier, PIC Canada Ltd (Industry, Multinational breeding company).

## **Conclusion**

The workshop was successful in meeting its objectives. There was a good representation from the pork value chain.

A Canadian participation in the International Swine Genomics Sequencing Consortium effort was supported by participants. The International Swine Genome Sequencing Consortium has entered phase IV with the goal of generating a high quality assembled, annotated draft DNA sequence (greater than 6 X) of the pig genome. However, additional dollars (\$2.5 million US) are critically needed to complete this essential phase and generate a high quality sequence from which SNPs database could be generated for genetic selection purpose (see letter from Dr. Larry B. Schook, chair of ISGSC – annex 4). This report from the workshop to Genome Canada supports and encourages the involvement of Genome Canada in the International sequencing effort.

It is very important that any Canadian contribution to the International Swine Genomics Consortium sequencing effort should be part of a Canadian swine genomics strategy coordinated through a research organization within Canada.

Canada's swine genomics efforts will be supported by industry stakeholders in swine genetics to ensure successful research and development according to industry needs (see letter of support – annex 5).

## **Next steps – Objectives and Recommendations**

The committee should meet to develop a global Canadian swine industry strategy for genomics research in order to:

**First** – To be a player in the swine genomics sequencing effort

- Genome Canada should make a financial contribution to the International Swine Genome Sequencing Consortium in 2007/08;
- Federal and provincial genomic organizations should be engaged to make a similar contribution;
- These contributions would be part of the initial contribution made by these organizations to a national Canadian swine genomic research strategy led and supported financially by the Canadian swine industry.

**Second** – To support research and development making use of the investment in swine genome sequencing for allowing Canadian swine breeding companies a rapid access, for in-house competitive research using SNP panels

**Third** - To support funding for one or several provincial, national or participation in international swine genomics based research projects beneficial to the entire Canadian pork value chain. This support could be obtained from Industry, Provincial Governments, or through funding for the Genome Canada Agriculture-Animal Theme. A position paper entitled Aquatic and Terrestrial Genomics was prepared and submitted to Genome Canada on July 3<sup>rd</sup> 2007. If successful, genomics funding in this area could become available in 2008 with an opportunity for funding large scale genomics projects in 2009.

# Annex 1 – Workshop agenda

## GENOME CANADA - INDUSTRY SWINE GENOMICS WORKSHOP

Friday, May 4<sup>th</sup>, 2007

### The Westin Bristol Place Hotel, Toronto Pearson Airport

950 Dixon Road · Toronto, Ontario M9W 5N4 · Canada ·

Telephone: (416) 675-9444

([www.starwoodhotels.com/westin/search/hotel\\_detail.html?propertyID=1771](http://www.starwoodhotels.com/westin/search/hotel_detail.html?propertyID=1771))

**07:00 Continental Breakfast**

### AGENDA OF MEETING

**08:00 Welcome & Introductions**

Dr. David Bailey, Genome Alberta & Dr Pramod Mathur, CCSI

08:10 Facilitator and details for the day – Dr. Denis Petitclerc, The Groupe Crea Inc.

#### Goals of the Workshop:

- 3) Determine swine genomic priorities for Canada
- 4) Determine how to use existing Canadian institutions and resources to improve Canada's competitiveness in the international pork industry market

08:15 Dr. Steve Scherer, The Centre for Applied Genomics, University of Toronto: Genomics - Universal concepts, applications, and implications. (20 min presentation, 10 min question period)

08:45 International Swine Genome Sequencing Consortium (ISGSC; [www.piggenome.org](http://www.piggenome.org)) – current status report:

- ❖ Dr. Larry Schook, University of Illinois, Team leader ISGSC: update on sequencing (15 min)
- ❖ Dr. Ronnie Green, ARS-USDA: government perspective on financing genomic research (15 min)
- ❖ Questions and discussion (10 min)

09:30 Canadian Industry needs:

- ❖ Dr. Pramod Mathur, CCSI Chief Geneticist: Current status on swine genetic research in Canada and how to move into genomics (15 min)
- ❖ Mr. Clare Schlegel, President, Canadian Pork Council: Economic traits to improve upon - point of view of producers (15 min)
- ❖ Mr. Don Davidson, Senior Vice-President, Maple Leaf Pork: Economic traits to improve upon - point of view of a processor (15 min)
- ❖ Questions and discussion (15 min)

**10:30 Health Break**

- 10:45 Canadian Swine Genomics – current situation
- ❖ Dr. Jacques Chesnais, Senior Geneticist, Semex Alliance: Use of genomic tools by Semex Canada (15 min)
  - ❖ Dr. Bonnie Mallard, Professor, University of Guelph: Genomics to improve immunity for the benefit of producers and consumers (15 min)
  - ❖ Dr. Jon Meadus, Research Scientist, AAFC: Genomics to improve meat quality traits for the benefit of producers and consumers (15 min)
  - ❖ Dr. Michael Phillips, Director Pharmacogenomics, Genome Quebec and Montreal Heart Institute: Functional genomic research – a biomedical point of view (15 min)
  - ❖ Questions and discussion (15 min)
- 12:00 Lunch**
- 13:00 Focus groups on Canadian swine genomic research priority settings (75 min)  
Instructions provided by Dr. Denis Petitclerc, Le Groupe Créa
- ❖ Group # 1: Production efficiency
    - Moderator Dr. Pramod Mathur, CCSI
    - Co-moderator: Dr. Karen Dewar, Genome Canada
  - ❖ Group # 2: Meat Quality
    - Moderator Dr. Stephen D. Morgan Jones, AAFC
    - Co-moderator: Dr. Cindy Bell, Genome Canada
  - ❖ Group # 3: Animal health and disease resistance
    - Moderator Dr. Bonnie Mallard, University of Guelph
    - Co-moderator: Mr. Martin Rice, Canadian Pork Council
  - ❖ Group # 4: Biomedical models
    - Moderator Dr. Michael Phillips, McGill University
    - Co-moderator: Dr. Klaus Fiebig, Ontario Genomics Institute
- 14:30 Reports of focus groups to the general assembly (40 min; 10 min per focus group)  
Moderator: Dr Max. F. Rothchild, Iowa State University
- 15:15 Break**
- 15:30 General discussion – Moderator: Dr. David Bailey, Genome Alberta
- ❖ Feed-back from focus groups
  - ❖ Consensus on priority settings
  - ❖ Funding – HQP, gaps, resources, strategy and timeframe
  - ❖ Next Steps – Assign responsibilities
- 16:30 Closing Remarks** – Dr. David Bailey, CEO, Genome Alberta  
Adjourn

## **Annex 2 – Steering committee composition**

Dr. David Bailey (chairperson), Genome Alberta

Dr. Cindy Bell, Genome Canada

Dr. Karen Dewar, Genome Canada

Dr. Pramod Mathur, Canadian Centre for Swine Improvement

Dr. Stephen Morgan Jones, Agriculture and Agri-Food Canada

Dr. Denis Petitclerc, Le Groupe Créa Inc.

Dr. Steve Scherer, the Centre for Applied Genomics, University of Toronto

Mr. Clare Schlegel, Canadian Pork Council

## **Annex 3 – List of participants**

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## Annex 4 – Letter from ISGCG



University of Illinois at Urbana-Champaign

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July 10, 2007

Martin Godbout  
President & CEO  
Genome Canada

Dear Mr. Godbout:

This correspondence is forwarded on behalf of the International Swine Genome Sequencing Consortium (ISGSC). As you may know, on May 4<sup>th</sup>, David Bailey, Genome Alberta, and Pramod Mathur, Canadian Centre for Swine Improvement, co-hosted a workshop in Toronto that addressed the status of the pig genome sequencing project. Specific topics addressed included the resources required for a "finished" product to serve future applications, potential roles for the Canadian pork industry and biomedical research community, and leadership and support from Genome Canada. I had been invited to provide an overview of ISGSC activities and to identify additional resources essential for having a sequencing product that could support future applications (a copy of my presentation can be obtained from either David or Pramod).

During my presentation, I outlined the approach being taken at the Wellcome Trust Sanger Institute and the remarkable progress made to date. With the US\$20M that had already been raised from the USDA, US and EU pork producers, and the EU Framework Program, the Sanger Institute are producing a draft genome sequence based on 3-4x sequence coverage, with a higher quality sequence, achieved by "pre-finishing" the 4x draft sequence on chromosomes 4, 7 and 14, supported by funding from EU programs. By securing an additional US\$3.5M we could bring the remainder of the genome up to the quality of chromosomes 4, 7, and 14 and thus, achieve a "pre-finished" genome sequence product. While this product would still be a draft and we would anticipate the sequence accuracy to be 99.99%, the sequence coverage would be 99% (missing ~30Mb in small gaps) and the order and orientation of the sequence contigs would be high so that at least 95% of gene structures would be correct. A consensus amongst the scientists is that this is the minimal requirement for the quality of product that is required to support SNP discovery, the identification of economically important traits and understanding gene function in important physiological pathways. Failure to meet this pre-finish standard would leave us with 3-4X coverage that has **biological and technical limits** (i.e., limited SNP discovery, defining haplotypes, genome-association studies, etc.).

During the past year, this message has been shared globally in order to ensure that we can obtain the sequence platform essential for the future applications that all envision. Through the strong leadership of Dr. Ronnie Green, National Program Leader, ARS-USDA, we have just secured a US\$1M pledge towards the required US\$3.5M. Thus, we are still critically in need of identifying the remaining US\$2.5M to support the final phase. Timing is also a critical issue, since the sequencing pipeline at the Sanger Institute is closing and we cannot delay our commitment towards finalizing the remaining sequencing.

Thus, on behalf of the ISGSC we would request that Genome Canada consider a grant of US\$2.5M to ensure the required completion of the pig genome sequencing effort. As stated, it is essential that we complete this phase of the project to ensure its fullest utility in addressing industry needs. Please let me know if I can provide any additional information. We thank you for considering this request.

Sincerely yours,

A handwritten signature in black ink, appearing to read 'L. Schook'.

Lawrence B. Schook, Ph.D.  
Professor of Comparative Genomics, Gutgsell Chair  
Project Director, USDA Swine Genome Sequencing Project  
Chair, International Swine Genome Sequencing Consortium

Cc: P. Mathur, R. Green, D. Hamernik, J. Rogers, K. Eversole

## **Annex 5 – Letter from stakeholders in swine genetics**

**July 6, 2007**

Dr. Martin Godbout  
President and CEO  
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Dear Dr. Godbout,

As industry stakeholders in swine genetics, we are writing this to express our support of the Canadian swine genomics initiative as outlined below on behalf of the swine genetics sector in Canada.

Canada has been a world leader in swine genetics for more than 20 years. Canadian genetics has been a fundamental driver for the Canadian pork industry to become one of the largest exporters in the world through advances in leanness, meat quality, growth rate, feed efficiency and litter size. In addition Canadian genetics has been a valuable export in itself being in high demand by breeders in many countries. A strong competitive and viable Canadian swine genetics sector is required to address the unique needs of the Canadian pork industry.

It is becoming very challenging to maintain this leading position especially due to new emerging requirements in the Canadian and export markets, significant genomics research and development programs by our competitors and increasing competition. Quantitative selection methods have been the backbone of significant genetic improvement in Canadian swine populations. Canada has been a world leader in the development and application of this technology. Additionally we have valuable resources in genetically superior populations, genetic material and research institutions in Canada. Genomic technologies are developing at a rapid rate and their timely application is critical for our competitiveness, especially as these technologies can help address many of the changing requirements being demanded. Maintaining a competitive Canadian swine genetic industry will require new research and development to harness all these capabilities for effective use of swine genomic technologies. Clearly a competitive Canadian pork industry of the future needs to be supported by continued genetic improvement.

We applaud Genome Canada's initiative in working with the Canadian swine industry and organising the swine genomics workshop in Toronto on May 4, 2007. The pork industry has provided clear strategic priorities for Canada in the areas of animal health, food safety and bio-security, meat and carcass quality, productivity and efficiency, environmentally responsible production and biodiversity. These priorities are also integrated within the Aquatic and Terrestrial Animal Genomics (ATAG) Position Paper generated as part of Genome Canada's process to identify strategic research themes of national importance. We support these strategic directions and confirm the commitment of the industry's genetics sector to swine improvement in Canada.

We believe the following activities are required to approach these priorities as part of Canada's swine genomics initiative as follows:

1. Participation in the genome sequencing project to make it more accurate through performing part of the sequencing within Canada for specific regions and/or contribution to the SGSC
2. SNP and other discovery, functional genomics, proteomics and bioinformatics in Canadian populations through university/genome centre/private labs in Canada
3. Collection and use of phenotypic and genotypic data from Canadian breeding herds, and
4. Development of Marker Assisted Selection methodologies for traits of importance to the swine industry

These activities are also aligned with the opportunity set out in the ATAG Position Paper. The Canadian breeding industry needs initial funding from Genome Canada and other public agencies and will be making private investment for research and development in the application and use of the genomic tools to enhance genetic improvement in several traits.

Canada's swine genomics efforts will be supported by industry stakeholders in swine genetics to ensure successful research and development according to industry needs.

The swine genomics initiative will provide fundamental research and development allowing the Canadian swine genetics sector to strengthen their competitive position and maintain their reputation as world leaders. A stronger Canadian swine genetics sector directly supports increased competitiveness of Canadian pork. We would like to express our sincere support and cooperation for this important initiative.

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	GAP Genetics	Susan Mary Joyal
	Genesis	Robert Kemp
	Genetiporc	Daniel Godbout
	Hypor	Patrick Charagu
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	Peak Swine Genetics	Alfred Wahl
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