APPENDICIES

APPENDIX XX
Business Cases for Strategic Research Networks

AGRI-HEALTH AND VALUE-ADDED PRIORITIES - BUSINESS CASE

1. FOOD INGREDIENT AND FERMENTATION PRODUCTS FROM CROPS - OVERVIEW

Alberta's advantages in crop production are the foundation to establish a new $2 billion world-scale extraction, conversion, and fermentation industrial sector. The global food ingredient and fermentation markets are large and growing with innovation leading to new and enhanced consumer and industrial products. Today crop ingredient and fermentation products only provide a small contribution to Canada's $31 billion (**1997**) manufacturing shipments of food ingredients, chemical and biochemical products. Current export volumes of wheat, coarse grains, oilseeds, and pulses could provide excellent feedstock for the extraction and conversion of starch, protein, oil, fibre, and cellulose into valuable ingredients. Also, the feedstock could provide derivatives with distinctive functionalities and uses in food, feed and pet food, and as industrial feedstock for further manufacturing.

Vision

An established $2 billion crop extraction, conversion, and fermentation industry that creates new demand for Alberta crops.

Why Now? Why Alberta?

The Food Ingredient and Fermentation Products from Crops science priority focuses on ingredients and bio-chemicals with high value-added use in food. Other uses are in livestock and aquaculture feeds, pet foods and personal care products. Some ingredients and by-products could also serve as feedstock for industrial bio-products manufacturing.

Alberta produces large volumes of wheat, barley, oats, canola, pulses, sugar beet, potato, and forage products. These crops contain the essential building blocks for Canada's food and future bio-industrial economy – starch, protein, lipid, fibre, cellulose, and a host of useful secondary metabolites, e.g., starch, protein, lipid, fibre, cellulose, and a host of useful secondary metabolites.

Export crops, unprocessed or low value-added crop products, are potential resources that are lost to Alberta for wealth creation and employment in the province.

This priority recognizes that:

- The grains, oilseeds, pulses, and forage crops produced beyond Alberta's needs are potential feedstocks for new industrial engines of growth, much like corn and soybean fueling large industrial bio-refining complexes in the U.S.
- Unprocessed or low value-added products such as canola meal, millfeed, mash, and **stillage** are also sources of valuable food and bioactive ingredients.

- **Food ingredient, fermentation chemicals, and industrial bio-products could fuel demand for crop materials and require common science, engineering and industrial infrastructure for value-added processing.**
- **After common feedstock and processing intermediates, the manufacturing and related science priorities for food ingredient, fermentation chemicals, and industrial bio-products diverge with conversion technologies, utilization, distribution and regulatory requirements**.
- The technologies and products resulting from investment in this strategic research priority could create many new large volume, value-adding manufacturing businesses, and continue to a sustainable domestic demand for crops produced by Alberta farmers.

Situation Analysis

Drivers

Food ingredients and fermentation products are sold business-to-business, i.e., they are goods purchased by industrial customers, not individual consumers. Food manufacturers' purchase decisions are typically based on:

- An ingredient's functional properties, utility, and performance in specific formulations.
- Superior product quality.
- Competitive pricing that is determined by the relative costs of raw materials, energy and input labor; processing efficiencies; and the costs of capital assets and finance.
- Locational advantages in production, markets, infrastructure, regulations, taxation, and incentives.
- Supplier services – quality control and technical support for new product development.
- Value chain organization and behavior.

Alberta R&D Capacity in Food Ingredients & Fermentation Chemicals

For Alberta to increase its share of value-added processing for the food ingredient and fermentation chemical markets, extensive collaborations and partnering will be required from the basic science through to engineering, product development, commercialization, and marketing.

Throughout the province, there are about 8 food science and engineering professionals FTE (full time equivalents) engaged in research and product development in food ingredients and fermentation chemicals at universities and in industry. The major science activities are centered at:

- Agricultural, Food and Nutritional Sciences, University of Alberta –12 permanent FTE food scientists and engineers in its Food Science & Technology group of which about 4-5 FTE are committed to R&D in food ingredients.
- Leduc Food Processing Development Center, Alberta Agriculture, Food and Rural Development –3 - 4 permanent FTE food scientists and engineers contributing to process and product development activities of Ceapro Inc., Cevena Bio-Products and other small-scale processors and new ventures.
- Alberta Research Council –minimal activities related to food ingredient and fermentation chemicals. However, ARC has extensive related science, engineering, and technology capacity in fermentation, carbohydrates, biotechnology, contract manufacturing, and analysis that may be applied to this science priority.

Research Program Scope

Strategic focus areas for development are in:

1. Separation and Extraction
    - Food ingredients obtained from Alberta crops. Examples are native and modified wheat, canola, mustard, and pea protein isolates; wheat and barley starch; and *b*-glucan, pentosans and other dietary fibres from barley, oats, and wheat and other cereals; modified canola oil.
    - Fractionation technology in laboratories and in pre-pilot plants.

2. Characterization
    - Functional properties such as chemical, physical properties, and molecular structure of native and modified ingredients.
    - Nutritional properties in human and animal diet.
    - Identification techniques - including High Performance Liquid Chromatography, Gas Chromatography, Material Science, and Nuclear Magnetic Resonance.
    - Certification of novel foods and novel feeds meeting standards and regulations of U.S. Food and Drug Administration, European Union, Food and Agriculture Organization, World Health Organization, Health Canada, etc.

3. Conversion
    - Conversion technology dealing with chemical, physical, thermal, and enzyme modification of native isolates.
    - Processing technology involving chemical, physical, and engineering properties of materials during processing, process system, processing equipment, and quality control in production.
    - Utilization of product formulation and applications for current and potential markets. Examples include fabricated protein / starch co-polymers, films, and other composite food materials.

4. Fermentation
    - Food hydrocolloids. Examples include food-grade polymers from fermentation processes.
    - Fermentation technology involving biological conversions of fermentable sugars to new compounds of interest.

Research Activities for Investment in Food Ingredient and Fermentation Products from Crops – 5-Year Plan

Category	Description	Investment
Infrastructure (linked with other Infrastructure Investment)	Pre-pilot and clinical	*$10.0 million
Cereals Science Team	4 fully supported FTE per year for 5 years	$6.0 million
Fermentation Science Team	4 fully supported FTE per year for 5 years	$6.0 million
Edible Composites Science Team	4 fully supported FTE per year for 5 years	$6.0 million
Byproducts Science Team	4 fully supported FTE per year for 5 years	$6.0 million
Market Research, Regulatory, Due Diligence, IP	Contracted	*$2.0 million
Science Team Investment		$24.0 million

Research funds are recommended to be invested as follows:

- Initial pre-pilot plant infrastructure and equipment investment of $10.0 million – to address a common need, be incremental, and be shared with the Health, Wellness and Performance Products from Agriculture science priority and the three Industrial Bio-products science priorities.

- $24 million over 5 years for four multidisciplinary food science and engineering development teams, each aligned and focused to discover and develop a technology platform, or to pursue a specific crop or fermentation chemical product objective.

As market opportunities and technology platforms are identified, additional science teams can be assembled to pursue additional initiatives. For planning purposes, the increments for scientific personnel and R&D investment for additional teams will be similar to those noted in the table above.

For basic and applied R&D investment, Alberta's provincial contribution to this priority could be leveraged during the first five years at on a one-to-one ratio with federal resources. **On patenting of a technology platform, creation of new R&D venture corporation to develop the technology, and progression of new ingredients to clinical and commercial trials to assess food safety and utility, leveraging of provincial contributions could increase to at least 4:1. This leveraging could occur through the attraction of private risk capital and federal scientific research and experimental development tax credits available to the R&D corporations, new ventures or private sponsors.**

Policy Supports

Policy to accept this printing should involve:

- The emergence of novel traits obtained through conventional and biotechnology developments and innovative processing.
- Traceability systems linked to sustainable production methods that are accepted by consumers.
- Competitive regulatory framework for novel food ingredients and fermentation chemicals.

2. VALUE-ENHANCED MEATS AND MEAT PRODUCTS - OVERVIEW

Value-enhanced meats and meat products represent a $3.0 billion value-added growth opportunity for Alberta, in a meat manufacturing sector that in 2001 achieved $3.6 billion shipments from animal slaughtering (not including poultry) and $1.6 billion shipments in processed meat and poultry products.

Investments in meat R&D and increasing commercialization activities will build on existing Alberta's world-class R&D and manufacturing strengths in livestock production, meat slaughtering, meat quality, and food safety. Analysis (Alberta Agriculture, Food Rural Development 2001) revealed that Alberta's primary livestock and meat production sectors are globally competitive. However, increasing the value, volume and share of Alberta meat products in domestic and export markets is seen to be key to industry viability. Value enhanced products could enable Alberta food processors to reach domestic and international customers with a variety of new, appealing, safe, and nutritious meat products.

Vision

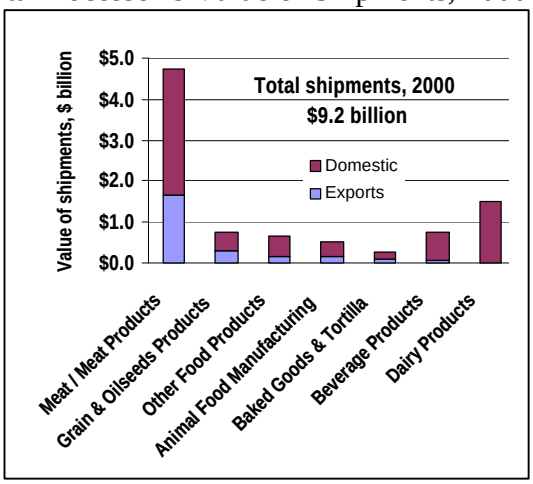
A profitable and dynamic meats sector shipping $4.6 billion per year of branded, value-enhanced meats and meat products to targeted domestic and international markets.

Why Now? Why Alberta?

This science priority focuses on helping the industry ensure food safety and build demand for Alberta branded meat products through product innovation, focusing on consumers needs in export markets.

The meat processing industry, including animal slaughtering, is Alberta's third largest manufacturing sector. The sector processes beef, pork, lamb, horse, and other meats into primal or sub-primal cuts, portion cuts, and a variety of processed meats and prepared foods. Also included are the processing of chickens, turkeys, ducks, geese, and game birds into fresh and frozen poultry products.

Alberta Processor's Value of Shipments, 2000



Meat processors dominate Alberta's agricultural processing sector, in both domestic and export activity. Meat processors account for approximately 68 percent of Alberta's agricultural processing exports.

The value-enhanced meats and meat products priority recognizes that:

- The livestock and meat processing industries contribute significantly to Alberta's economy.

- The meat processing industry comprises local, regional, national, and global players.
- The industry faces many fundamental threats, particularly concerning food safety, consumer behavior, and advances by competing proteins.
- Country-of-Origin labeling requirements imposed by the U.S. presents significant market access and market maintenance challenges for Canadian meat processors.
- Product innovation and product integrity are critical to building demand for Alberta meat products in target markets such as U.S., Mexico, Japan, Korea, and other Asian countries.

New product, processing, and cold chain technologies resulting from investment in this strategic research priority could assist processors of all scales of manufacturing to achieve new standards of excellence in food safety, enhanced access to export markets, increased sales of value-added meat products, improved production and distribution efficiencies, and increased profitability to all members of the value chain.

Situation Analysis

Drivers

Global consumption of meat and processed meat products is increasing driven by several factors:

- Global population growth.
- As developing countries grow and incomes rise, there is a tendency for meat consumption to increase.
- Consumer's belief systems, i.e., ethnic, religion, tradition, organic, animal care, etc.
- Product traits, i.e., taste, tenderness, consumer perceptions of health and safety, convenience, presentation, etc.
- Relative product prices of different meat groups, and with other protein sources, i.e., plant, fish and dairy protein.

Since the early 1980s, global meat consumption, output, and trade have expanded considerably, particularly for poultry and pork. Industry expansion is being fueled by population growth, increased access to some international markets, rising incomes in developing countries, urbanization, and changing diets in both developed and developing countries.

Global meat consumption is forecast to increase 2 percent annually through 2015. Most of this increase is anticipated to occur in the developing world, where consumption is expected to grow 2.7 percent per year, compared to 0.6 percent per year in wealthier nations (FAO).

China having more than 21 percent of the world's population, a strengthening domestic economy and a growing middle class, a relatively small increase in per capita consumption of meat by the Chinese has potential to translate into very large increases to global meat consumption. The potential to expand sales of Alberta beef and pork in the Asia-Pacific region is evident.

While consumption is increasing and industry expansion is evident, intensification of livestock production, the increased volume of international trade, and improvements in transportation, infrastructure and technology provide some risks, e.g., animal welfare issues, disease risks, and increased protectionism among trading nations.

In addition, food safety and health concerns from animal disease outbreaks such as mad cow disease or bovine spongiform encephalopathy (BSE) that have occurred in other countries, and food borne diseases caused by pathogens such as *E. coli*. and salmonella are serious threats to the meat industry. A very real concern is that each occurrence, whether in distant markets or in Canada, has potential to direct consumers away from meat products to alternate proteins.

Shifting consumer preferences for variety, new innovative products based on vegetable and marine protein, on-going concerns about the safety and health attributes of meat products, and rules and regulations by imposed by our trading partners, e.g., country-of-origin by the U.S., are good reasons for Alberta to be pro-active to support of R&D and product innovation in the province.

Alberta R&D Capacity in Value-Enhanced Meats and Meat Products

Alberta has about 30 permanent science and engineering professionals engaged meat research. Meat R&D and commercialization activities are located at:

- Lacombe Research Center, Agriculture and Agri-Food Canada (AAFC)- 12 FTE professionals with a national AAFC mandate, research abattoir, microbiology, physical / chemical and sensory laboratories to conduct research on the ante- and post-mortem factors that influence red meat yield, quality, safety and preservation. The focus of research is primarily fresh meat products.
- Leduc Food Processing Development Center, Alberta Agriculture, Food and Rural Development –4 permanent FTE food scientists and engineers, a federal inspected pilot plant, and product development laboratories to assist meat processors evaluate new technology and develop new and improved precooked and cooked products and processes.
- Agricultural, Food and Nutritional Sciences, University of Alberta –12 permanent FTE food scientists and engineers in its Food Science & Technology group. However, only 1 - 2 FTE is committed to R&D in value-added meats and meats products. The focus of this research in food safety, meat bio-preservation and poultry processing. Canbiocin is a UofA R&D spin-off company that is developing microbial inoculant systems for bio-preservation of packaged and processed meats.
- Alberta Agriculture, Food and Rural Development – Food Safety Division.

Recent infrastructure investments for meats research and product development by AAFC, AAFRD and UofA include:

- Meat Safety and Processing Research Centre at theUofA. $3.2 million in 2002. A unique national Level ll bio-containment facility for research with foodborne pathogens in meat and meat products.
- Poultry Research Centre, U of A. (Related research centres, e.g., swine.)
- Leduc Food Processing Development Center, AAFRD. $5.3 million in 2001/02 of which 50 percent was directed to meat processing activities. Multipurpose continuous oven – breaded meat and cooked meal products for use in home meal replacements.
- Lacombe Research Centre, AAFC. $4.1 million in 1998 to expand and improve its research abattoir and related meat R&D laboratory facilities.

These most recent infrastructure investments in meats R&D have been focused on fresh, chilled and frozen meats, food safety, with relatively little investment on the value-added processing of meats.

Research Program Scope

Opportunities for innovation in value-added processing and product development exist:

- In all meat groups.
- For all sizes of meat processing operations in Alberta.
- Through the value chain and cold chain, from farm to fork.

Strategic focus areas for development are in:

- Food safety.
- Export market maintenance and market development.
- Branded value-added meats and meat products.

In order for Alberta's meat processing industry to achieve $3 billion in value-added sales, the following science technologies need to be addressed:

- Processing, equipment and measurement technologies that ensure food safety.
- Processing, automation and information technologies that improve carcass utilization, product quality, product utilization, packaging and product presentation.
- Value chain technologies that provide for rapid instrumental objective analysis, identity preservation and traceability of specific output traits such as conjugated fatty acids (CLA).
- Cold chain technologies that ensure product integrity, shelf life and taste in distance markets.

Alberta's R&D capacity in livestock product quality, safety and preservation of fresh meats is world-class, but small relative to the size and importance of the industry. Development of the value-added meat processing sector is hampered by:

- A lack of significant facilities and professional expertise for processed meats R&D, experimental equipment design, engineering and prototype fabrication, and evaluation methods.
- Weak collaborations between Alberta R&D science and engineering performers and industry processors.
- A lack of science and technical collaborations along the cold chain to distant markets.
- Limited industrial R&D and engineering capacity and experience in meat processing. Note: Alberta's large scale plants are associated with national and multinational firms where corporate R&D, equipment, process design. Product design functions are located outside Alberta.
- An availability of skilled researchers, food processing engineers, and graduates to service industry needs.

Additional infrastructure facilities, equipment, and operating capital are required for:

- Product development research.

- Experimental equipment and process design, engineering, and fabrication.
- In-plant process research, product research, and continuous improvement.
- Training and development of future meat scientists and graduates for industry.

Research, Technology and Pre-Commercialization Activities for Investment in Value-Enhanced Meats and Meat Products – 5-Year Plan

Research funds are recommended to be invested as follows:

- Initial infrastructure and equipment investment of $6.0 million for equipment and process design and development, fabrication and testing facility for experimental value-added meat processing.
- $6 million over 5 years to expand value-added meats and meat products science and product development capacity, with a primary focus on new products for distant foreign markets.

Category	Description	Investment
Infrastructure	Meat Manufacturing Research	*$6.0 million
Value-Added Meat Product Development Team	4 fully supported FTE per year for 5 years	$6.0 million
Food Safety/Cold Chain Development Team	4 fully supported FTE per year for 5 years	$6.0 million
Manufacturing Research Support Team	4 fully supported FTE per year for 5 years	$4.0 million
Strengthening Industrial R&D and Personnel	4 professional placements in industry for 5 years	$3.0 million
Market Research, Regulatory, Due Diligence, IP	Contracted	*$1.0 million
Science Team Investment		$19.0 million

*Included in global budgets

- 4 million over 5 years for engineering and technical support for expanded experimental value-added meat processing and product development infrastructure.

- $3 million over 5 years to strengthen R&D and experimental development capacity in the meat industry with placement of 4 industrial researchers, hired by industry with 80 percent of their work focused on the objectives of this science priority.

For basic and applied meat science activities, Alberta's provincial contribution in this priority could be leveraged during the first five years at a one-to-one ratio with federal resources. For strengthening industrial R&D and experimental development capacity within industry, Alberta's resources could be leveraged more than 10:1, after considering the industry's internal process and product development and pre-commercialization costs in foreign markets.

Policy Supports

Policy to support this priority should involve:

- Reversal (or minimization of the impacts) of Country-of-Origin labeling provisions of the 2002 U.S. Farm Bill.
- Implementation of science-based HAACP.
- Strengthening of industrial R&D and experimental development engineering capacity in industry.

- Permanent meat science, engineering, and market research capacity to support export product development and market development.
- Distance learning and graduate studies in meat science at Universities and Colleges in Alberta that build on Alberta's R&D capacity at federal laboratories and manufacturing facilities not located on educational campuses.

3. HEALTH, WELLNESS, AND PERFORMANCE PRODUCTS - OVERVIEW

Health, Wellness and Performance (HWP) products utilizing bio-actives obtained from agriculture represent a $1.0 billion opportunity for Alberta. Growth is projected for HWP products in many categories. Aging demographics and consumers taking responsibility for their health, wellness, and performance are fueling nutraceutical, functional food, personal care, alternative medicine, and pharmaceutical markets. Technology innovation is also creating and developing new opportunities in HWP products.

Global sales of plant-derived medicines, both prescribed and non-prescribed, were projected at $US30.7 billion for 2002 (RIRDC 2002). World demand for nutraceutical chemicals by 2004 is projected at $US11.2 billion, supplying a $US162 billion nutritional products industry (Freedonia 2000). U.S. functional foods sales were US$18.5 billion in 2001 (3.7 percent of the total U.S. food market) and projected to reach $US31 billion by 2010 (Nutrition Business Journal 2002).

Research in many laboratories around the world has identified health benefits concerning disease management and disease prevention associated with bioactive constituents from plants. Examples include constituents from tomatoes, soybeans, grapes, fruits, herbs, and even forest products.

New health and wellness products are emerging that contain dietary fibres, polyunsaturated fatty acids, oligosaccharides, phospholipids, phytosterols, phytoestrogens, antioxidants, peptides, and probiotic bacteria. The possibilities for proprietary "blockbuster" products are attracting global food, pharmaceutical, chemical, and venture capital firms. Several initiatives in Alberta are probing bio-actives, biopharmaceuticals, and novel product delivery vehicles, but these are in their infancy, requiring focus, scientific and institutional collaborations, infrastructure, critical mass, and investment.

Vision

A new consumer-oriented $1.0 billion bioactives industry supplying a range of innovative and branded health, wellness, and performance enhancing products from Alberta crops and livestock.

Why Now? Why Alberta?

This science priority focuses on the development and manufacturing of biologically active compounds and ingredients from existing crops and livestock. The science priority also focuses on the molecular farming of novel crops and livestock modified to produce enhanced molecular products.

Value-added uses for these bioactive ingredients could be in two areas: 1) pharmaceutical and veterinary products including edible vaccines, plantibodies, etc, and 2) cosmeceuticals, functional foods, and as dietary supplements.

Alberta has an extensive and diverse agricultural base to produce an array of special purpose crops and livestock for the production of bioactive ingredients for health, wellness, and performance products useful to humans. The same technology platforms maybe applied to livestock health and food safety issues.

Molecular farming of high-value agricultural crops and livestock requiring intensive and knowledge-based identity-preserved and identity-contained production should be feasible given the advanced skills, production capacity and adaptability of Alberta farmers, and the production, scientific and business infrastructure potentials in Alberta. (SemBioSys and UofC are currently developing a molecular farming technology.)

The Health and Wellness and Performance Products priority recognizes:

- Alberta's world-class bench strength and capacity for medical, health, and biological science research at Alberta's universities.
- The emerging and potentially world-class biopharmaceutical clusters developing in the Edmonton and Calgary areas.
- The rapid and accelerating convergence of science, engineering, and information technology disciplines, with the accompanying creation of new disciplines, discoveries and new product opportunities at the frontiers and interfaces of these disciplines.
- The potential for creation of new technology platforms and output traits capable of supporting the creation of new ventures, new product categories, and new industries.

The novel processing activities of these new outputs from agriculture will create many new value-adding activities, and a diversity of technology and knowledge intensive enterprises with economic and social benefits contributing to both rural and urban Alberta.

Situation Analysis

Products

Markets for HWP products are rapidly growing in Canada. Products and technologies could come from both Alberta-based and other major manufacturers. Anticipated Alberta products include:

Nutraceuticals - products which are concentrated, isolated or purified from foods; that are generally sold in medicinal forms not usually associated with food, and are demonstrated to have a physiological benefit or provide protection against chronic disease.

Functional foods – products which are similar in appearance to, or may be, a conventional food; are consumed as part of a usual diet, and are demonstrated to have physiological benefits that enhance human performance and/or reduce the risk of chronic disease beyond basic nutritional functions.

Cosmeceuticals – over-the-counter products that provide a health benefit in addition to traditional cosmetic qualities and are positioned between cosmetics that cleanse and beautify, and pharmaceuticals that cure and heal.

Biopharmaceuticals – prescriptive and preventative medicines produced by molecular farming of domesticated plants and livestock.

Drivers

The key drivers for the HWP market are:

- Aging demographics and consumers taking more responsibility for their health, wellness, and performance.
- Increased interest in disease management and disease prevention by consumers and government.
- Technological innovations.

Scientific evidence suggests that HWP products have enormous potential for improving the health, wellness, and performance of consumers. Individual consumers are increasingly receptive and becoming more sophisticated in their choices, and are demanding exceptional quality, efficacy and safety in products that help the body heal itself and maintain body tone.

Technological innovations could enable firms to meet consumer expectations. It is recognized that the efficacy of HWP products must be demonstrated through science-based clinical and community based research. Also, science must be linked with sound marketing, product positioning, manufacturing excellence, access to distribution channels and shelf space, and a supporting regulatory environment.

Alberta R&D Capacity in Health Wellness and Performance Products

Alberta has about 50 science, medical, and engineering professionals engaged in research and product development in HWP products at universities and in industry. The major science activities are centered at:

- SemBioSys Genetics Inc. – a University of Calgary spin-off company. Through international partnerships, SemBioSys has raised more than $40 million of industry, public and venture capital funds. It has a new private pilot plant, extensive laboratories and more than 50 employees engaged in research, product development and commercialization.
- Several firms including CV Technologies Inc., Ceapro Inc., and Cevena Bioproducts a new spin-off company from the Uof A, are emerging in an HWP technology cluster in the general Edmonton area.
- Banner Pharmacaps is a soft-gel capsule manufacturer located in Olds. Banner manufactures dietary supplement and pharmaceutical capsules for many national and international firms.
- University of Alberta Agricultural, Food and Nutritional Sciences – 12 permanent FTE food scientists and engineers in its Food Science & Technology group. From 3 - 5 FTE are committed to R&D in bioactive ingredients and functional foods and 8 – 10 FTE work in nutritional science, several spin-off companies, and other allied faculties including physical education, pharmacology, pharmacy, medicine, and law.

- Leduc Food Processing Development Center, Alberta Agriculture, Food and Rural Development – permanent FTE food scientists and engineers contributing towards the process and product development activities of Ceapro Inc., Cevena Bioproducts, CV Technologies and several other small-scale processors and many other companies.
- Alberta Research Council – 2 FTE professional in its Nutraceutical and Pharmaceutical Chemistry business unit who are developing and commercializing novel compounds for use in functional foods and nutraceuticals. ARC also has extensive fermentation and contract manufacturing capabilities.
- University of Calgary faculty of medicine and biosciences.
- Olds College Centre for Innovation –2 FTE professionals in natural products chemistry and crop processing and is constructing a new micro-scale pilot plant for bioactive ingredients.

Research Program Scope

Opportunities exist in health, wellness and performance products that build on Alberta's:

- Medical/nutritional science capacity supported by the Alberta Heritage Foundation Trust Fund (AHFTF).
- Strengths UofA medical science, agricultural science, biological science, food and nutritional science, medical science and engineering, the UofC medical and bioscience, and the Lethbridge research cluster of AAFC, ADRI and UofL.
- Emerging manufacturing industry (Ceapro and others).
- Emerging medicinal plant industry.

Strategic focus areas for development are in:

- Functional bio-active ingredients obtained from Alberta crops and animals. Examples are dietary fibre ingredients from wheat, oats and barley, and phytosterols from canola. Also included are probiotic food microorganisms.
- Molecular farming. Examples include antibodies, vaccines and other biopharmaceuticals, and industrial enzymes from transgenic plants and animals with novel traits.
- Products in functional foods, nutraceuticals, cosmeceuticals, and biopharmaceuticals.

The following technologies could enable Alberta's emerging HWP industry to capitalize on opportunities:

- Extraction and purification technologies.
- Conversion and processing technologies.
- Bioactivity of extracted and modified ingredients - identification, analysis, standardization, quality assurance, and bioactivity.
- Formulation, product development and delivery systems for bioactive ingredients, i.e., over-the-counter nutraceutical, functional food (dairy, beverage, RTE cereal, meal bar, snack), cosmetic or personal care product and/or biopharmaceutical.
- Demonstration of product efficacy, clinical trials and community-based research for targeted HWP prevention, disease, and performance conditions.
- Regulation, ethical, and legal issues.

Development of this industry is hampered by:

- Capacity that is fragmented and not aligned with industry needs.
- A lack of scientific and institutional collaborations linking agricultural, biological and medical scientists amongst Alberta's R&D performers.
- High cost of efficacy testing and clinical trials.
- Low margins experienced by the Alberta food processing industry, making it difficult for most firms to invest in long-term and expensive R&D.
- A lack of federal supporting regulations.

Additional infrastructure facilities, equipment, and operating capital are required for:

- Pre-pilot plant basic and applied processing research and development.
- Research for development of new technology platforms from which to build new industries and products.
- Industry-driven new product development for functional foods, nutraceuticals and biopharmaceuticals.
- Training facilities for industry.

Investment in these areas will address the opportunity available by Alberta to build international capacity and reputation in HWP products, in areas of science and business strength, and addressing consumer needs for efficacy, safety, and quality.

Research Activities for Investment in Health Wellness, and Performance Products – 5-Year Plan

Category	Description	Investment
Infrastructure	Extraction, Fraction Equipment & Facilities	$10.0 million
Nutraceutical and Functional Food Team	4 fully supported FTE per year for 5 years	$6.0 million
Molecular Farming Team	4 fully supported FTE per year for 5 years	$6.0 million
Cancer and Diabetes Products Research Team	4 fully supported FTE per year for 5 years	$6.0 million
Market Research, Regulation, Due Diligence, IP	Contracted	*$2.0 million
Science Team Investment	HWP science priority	$28.0 million

Research funds are recommended to be invested as follows:

- Initial pre-pilot plant infrastructure and equipment investment of $10.0 million– this investment is intended to address a common need, be incremental, and be shared with the Food Ingredients & Fermentation Chemicals science priority

and the three Industrial Bio-products science priorities.

- $18 million over 5 years for three multidisciplinary biological, medical, and engineering science teams, each aligned and focused to discover and develop a technology platform, or to pursue a condition-specific HWP product objective.

With a focus on basic and applied R&D, Alberta's provincial contribution in this priority will be leveraged during the first five years at a one-to-one ratio with federal resources. **On patenting of a technology platform or progression of a lead compound to a Phase 1 clinical trial, leveraging of provincial dollars will increase to 4:1, primarily through the attraction of private risk capital.**

Policy Supports

Policy to support this priority should involve:

- Competitive Canadian regulatory frameworks for functional foods, natural health products, and molecular farming.

BIO-PRODUCTS PRIORITIES – BUSINESS CASE

1. BIO-BASED MATERIALS TECHNOLOGIES AND PRODUCTS - OVERVIEW

Bio-based materials offer Alberta a major opportunity to meet global market demands for new materials, products, and technologies based on our resources. Bio-based materials include bio-composites (building products, agri-fibres) and bio-polymers (bio-plastics). Novel applications of science and technology can create new value added ways to use Alberta agriculture and forest products on a sustainable basis. Globally, forest resources are limited, population demands are increasing for housing and basic goods, consumers are seeking new environmental products, trade, and other policies are encouraging industrial developments. Canada lags behind all others in the bio-products area, with the EU and U.S.A as leaders. Biomass fibre markets are estimated at $570m with a farm value of $200m (AAFC, 2001). Currently, the Alberta bio-based materials industry is small, but the Alberta R&D effort is emerging. The agri-fibre project experience to date has been risky with 3 unsuccessful plants. This priority allows significant regionally- based growth from Alberta strengths in crop and forest resources, industry, research infrastructure, and a critical mass of innovative researchers. It also links to life sciences and common sector growth issues.

Vision

A vibrant Alberta bio-based materials processing industry in the order of $1b by 2020, supplying a range of novel products for consumer and industrial markets. Sourcing of crop materials will be regional, rural- based, and within profitable supply chain relationships.

Why Now? Why Alberta

- Alberta has a strong base of resources in agriculture and forestry.
- Alberta has interested industry partners in the product area.
- Alberta has science and technical expertise to address research questions.
- Industry needs research support and direction to meet market trends and demands.

Situation Analysis

Markets for bio-based materials include several product areas:

- Bio-composites, fibreboards and specialty paper products from non-wood supplies for consumer, auto and building product applications.
- Bio-polymers and bio-plastics for industrial and consumer applications.
- Bio-composites include using crop-based materials in related composite products (combining 2 or more materials into a new superior one). It also includes potential uses of crop fibres in auto parts such as molded components (dashboard, casings, recycled newsprint in packaging) and car doors. The EU auto industry has a demand for 100,000 t/yr of natural fibres and now uses about 28,000 t/yr. German car manufacturers have invested about EU 90 million over ten years in this R&D effort, with about 50 percent from government. Hemp and flax are about 85 percent of natural fibres used in composites. Paper products include specialty papers in a variety of niche markets. Some of the Canadian market estimates for bio-based products are in the order of $570m with a benefit to participating farmers at $200m (AAFC).
- The fibreboard market represents a global products market requiring housing and industrial products. Market studies forecast a global shortage of fibre in the order of 100-125 m tones annually by 2010. World populations will be in the order of 8 billion by 2025 and fibre supplies globally are limited or declining. Similarly, Alberta wood supplies are allocated among current manufacturers. A global trend of setting aside forests for wildlife and recreation pursuits is limiting the area of natural forests. Private plantation supplies are increasing to fill the gap. This implies a strong and growing demand for additional sources of fibre. This is driving a need for other materials, and even the use of new faster growing species (hybrids). In Australia, New Zealand, the U.S. and Brazil species of Eucalyptus, aspen, and southern pine are competitive fibres. In Europe bast fibres have been used as alternate fibres (see www.nf.2000.org).

In Canada, some agri-fibre board plants have been attempted in Manitoba (Eli- one owned by Dow), Saskatchewan and Alberta (2, one now converted to wood products, another in process of startup). These new plants have had difficult commercialization issues. One industry report indicated the high amount of agriculture feedstocks available in Canada compared with the USA and EU regions. Canada exports about 42 percent of cereal grains, compared with the U.S. at 25 percent and EU at 15 percent. Oilseed exports are higher at 50 percent compared with USA at 25 percent and EU at 17percent. This may provide an agriculture supply base for possible bio-product use.

Alberta R&D Capacity in Bio-Based Materials, Technologies, and Products

Bio-composites, agri-fibres, and specialty pulp/ papers- Alberta has science and technology development capacity in fibreboard, and pulp and paper applications through the Alberta Research Council (ARC). The ARC has potential in agri-fibres research and product development. ARC has a well-recognized research centre of over 20 staff, a pilot panel mill, and conducts project work for global companies. (Note: ARC was instrumental in developing the OSB technology platform that helped to create a new Alberta industry). Agri-fibre work has also been completed in research applications of wheat straw and hemp. The pulp research unit has completed projects in the application of agri-fibres for specialty pulp and specialty papers that also need a “green” image. For example, flax is used in currency and cigarette papers. This broad

market offers many niches with potential for growth, and Alberta has 3-4 global pulp plants that may have an interest in this endeavor.

Additional expertise is available with the Centre for Agri-Industrial Technologies of AAFRD with about 3 engineers and 3 technologists. OCCI has a new bioprocessing lab and 2 researchers to further add some capacity. Together, the capacity of the two organizations offers some over 27staff for project work.

- Bio-Polymers and Bio-Plastics- Alberta is an emerging player in this area and has 2-7 researchers at the University of Alberta with an interest in bio-plastics from crops.
- The University of Calgary (Bio-sciences, Sembiosys) and Lethbridge (Ag Lipids Technology) have related bio-materials work in plant biotech with canola.
- A newly formed Alberta Bio-Plastics Network comprises University of Alberta staff, CAIT and AAFRD to help further develop this technology interest.
- ARC has a composites unit of about 6 including 2 PhDs who also can assist in product applications. However, this is a new area for the province and will need to be augmented with expertise from the Canadian Plastics Industry Association and Alberta manufacturers who show interest. (Note: extraction, fraction and related processes and equipment will also be needed).

Research Program Scope

Capturing the potential in bio-based materials growth opportunity will depend on four issues:

- Research funds to advance the priority.
- Specific fibre supply base development.
- Industry partners to commercialize technologies.
- Policy supports providing the market opportunity.

Research Questions

Key issues for the Alberta bio-based materials priority are novel technology platforms, fibre quality (strength, color and utility), and adequate supply. Research needs to address fibre quality in the Alberta context, process and engineering and market needs for bio-based products.

Fibre Supply Base Development

As these technology platforms and applications are developed, new supply bases will need to be developed in addition to utilization of current agriculture commodities. This will provide new market driven opportunities for biotech applications through technology platforms of triaglycerides (TAG), PHB, and others that modify plants for manufacture of new high value components in advanced materials. One of the possible limiting factors for large-scale industry investments is an adequate supply base. This needs to be considered in a strategic view.

Industry Partners for Development

Bio-based material technology applications and resulting new products will require a global industry partner in most cases. These applications are likely to be highly capital intensive but will be rural-based to access the raw materials for manufacturing purposes. Further, strategic alliances with global distribution partners into other market channels may also be appropriate. In

some cases, a new large-scale mill may emerge in Alberta, but is risky and difficult to forecast given the global market offers incentives that influence siting decisions.
A strategy of "mini-mills" can be employed as adjunct to existing large-scale mills in some cases where a sharing of utility, roads, distribution, and other critical "market" infrastructure is needed. A "mini-mill" for processing agri-fibre for specialty papers may be co-located with another forest products pulp mill, given a local supply base. Mini-mills will likely be in the order of $30m to $50m.

Most of these technologies are not likely to be small and medium sized enterprise (SME) applications. It is possible to stimulate early stage adoption of certain technologies by SMEs through purchasing policies and related public sector supports (see for example www.carbohydrateeconomy.org/).

Research Activities for Investment in Bio-Based Materials Technologies and Products

The science and technology questions are mainly in the applied research and technology development stage of the R&D system. Research funds are recommended to be invested as follows:

- Bio-composites and agri-fibre applications- a 3-year technology transfer/ product development program in the order of $500,000 per year. This would provide for industry projects annually on a cost-shared basis. It includes building products, molded products and specialty papers. Total $1.5m.

- Bio-polymers and bio-plastics applications- a 5 year basic and applied research program in the order of $1 million annually for 5 years, totaling $5 m. This will provide for some application discoveries within a 3-year window. Total $5m.

Category	Description	Investment
Infrastructure (linked with other Infrastructure Investment)	Bio-based extraction and fraction	*$15.0 million
Bio-based composites/ fibres Science	Tech transfer over 3 years	$1.5 million
Bio-polymers & Bio-plastics	Research program for 5 years	$5.0 million
Advanced Composites	Research over 10 years	$10.0 million
Total Investment		$16.5 million

* Included in global budgets.

- Advanced composites- a 10-15 year basic and applied research program focused at flexible cellulosic bio-materials for ICT/ medical device and nanotech applications to replace rigid silicon boards with renewable carbon-based disposable products. $1m annually for 7 years with renewal potential. Total $10m.

- Facilities and equipment for extraction and fraction work to support the crop assessments needed, which has been forecast at $15m.

- Total budget- ten years estimated at $16.5m research, $15m equipment. Leverage of 4-5:1 is possible.

Policy Supports

Policy supports will be a consideration for this science priority in view of Alberta growth goals to $20 billion by 2010. Some of the obvious policy issues include:

- Trade policy with the U.S. for enhanced forest products market access to allow Alberta industry to expand into new alternative fibre products.
- Trade policy recognizing best fibres within forest products.
- Building codes which support use of alternative building products and agri-fibres.
- Minimum content policies that encourage purchases of new bio-materials.
- Technology commercialization policy to overcome technology transfer barriers.
- Life cycle analysis that supports use of agriculture and forestry materials and assesses greenhouse gas emission (GHG) amounts versus known benchmarks.

2. BIO-ENERGY TECHNOLOGIES & PRODUCTS - OVERVIEW

Bio-energy is an opportunity to meet energy and transport industry market demands for alternative fuels and clean renewable sources of energy. Bio-energy includes: bio-fuels (bio-diesel and ethanol/ methanol) and co-generation (including bio-gas). Science and technology oriented to utilization of Alberta agriculture and forest commodities/ waste residues, new energy sources can be developed. Globally, energy supplies are limited, population demands are increasing, societies are seeking new processes (reducing emissions), and trade/ other policies are encouraging these industrial developments elsewhere. Canada lags behind others in the bio-energy area (notably EU and the U.S. where major research programs are underway. The U.S. ethanol market is 6.1 b litres/ yr, forecast to be 28.4 b l/ yr by 2010; Canada is 240 ml/yr and could be 1 bl/yr by 2010. U.S. bio-diesel is 132 ml/yr. The EU desires to have 2 percent of fuels by 2005 from renewables- currently at 500,000 t/yr of bio-diesel).

Currently, the Alberta bio-energy industry is very small but Alberta R&D interest is emerging. Alberta has significant latent resources to bring to bear on the priority. Bio-energy allows for significant regionally- based growth from Alberta agriculture and forestry resources. It can stimulate use of current industry infrastructure and innovative researchers. It also links to life sciences and common sector growth issues.

Vision

A renewable resource-based bio-energy industry in the order of $500m or more by 2015, providing alternative energy sources through Alberta developed technologies and products and new opportunities for industry competitiveness and innovation.

Why Now? Why Alberta?

- Deregulated energy markets create new technology opportunities.
- Bundling of technologies with industry waste products meets need.
- Market and legislative drivers encourage developments.
- Extensive research work elsewhere can be harvested for AB benefit.
- Situation Analysis.
- Bio-Energy Market Potentials and Developments.
- Responds to driving needs for renewable energy sources.
- Creates opportunity for Kyoto targets from Alberta based technologies.

- Provides industry with solutions for by-product utilization.
- Provides environmentally friendly products for forestry/ agriculture/ waterways/ consumers.

Markets for bio-energy products include:

- Co-generation.
- Bio-diesel and bio-fuels.

Co-generation of electrical power and heat from agriculture and forestry residuals is possible and is emerging in the province. Markets are seeking power from alternative sources and in recognition of creating new revenues from waste residuals. This is driven from the Kyoto agenda and from a need for renewable sources of energy.
In Alberta, wood waste and manure are two common residuals for consideration in the co-generation area. Wood waste in the province is a common problem, given about 50 percent of raw material is not useable in the final product form. In Alberta, Canfor, Grande Prairie is interested in a possible co-gen plant to utilize its waste wood. Al-Pac is generating about 9 MW of power into the power grid.

Manure from beef cattle feedlots, dairy operations, and other intensive livestock operations can create a sustained feedstock in a location. Manure management (and public concerns) is a problem in many areas of Western Canada due to a variety of reasons affecting soil, water, and air quality.

Manure management for reducing risks to human health has been a key driver to many recent changes in the agri-food system in North America, Europe, and Asia. Food safety, disease prevention, and use of best environmental practices are very important considerations in all food systems today. Based on the an average of 17kg per head of manure output and the five year beef cattle population averages, Alberta annually has about a total of 14m tonnes of beef feedlot manure to manage (e.g., AB average beef population (2.2 m head x 17 kg x 365)/ 1000= m tonnes). The Natural Resource Conservation Board (NRCB) is involved in any expansions and new operations of a semi-commercial size. ARC has a technology platform (IMUS) that may provide a commercial solution.

In the world, co-generation is a proven technology that can be adapted to Alberta for use as a cost-reducing technology for many types of operations. It needs to be scaleable, affordable, linked to the power grid, and easy to maintain and service. Alberta is in the process of learning how the de-regulated markets are performing, but long term price forecasts for power are in the $40-$45 per MW range and it may be a feasible technology option in the marketplace. Co-generation can be developed through several technology platforms and has a possible benefit of CO2 offsets. It is a cost-reducing technology, can be adapted to Alberta conditions and has a demonstrated private sector interest in the province. However, more technology development and transfer is needed.

Bio-fuels in Canada are not common. Total Canadian production of ethanol is about 238 m litres annually. This is reported to be 0.3 percent of gasoline value and 0.4 percent of total volume. However, ethanol has been used in Canada since 1981 and is available in 1400 service stations in

a blended form. Alberta has one company- API (Agri Partners International) in Red Deer (26m l/yr) which fractions wheat for food and co-product ethanol. This provides some Alberta capacity. In Canada, 5 other ethanol plants are reported- Mohawk- Manitoba (10ml/yr from wheat), Pound Maker- Saskatchewan (12ml/yr from wheat), Tembec- Quebec (17 ml/yr from forestry base), Commercial Alcohols- Ontario (23 m l/yr from corn) and Commercial Alcohols- Ontario (150m l/yr from corn).

New incentives in Ontario and Saskatchewan are aimed at increasing the industry base. Ontario has a new co-op plant to be built at Cornwall ($48m, 66 m l/ yr) and a 14.7 cent per litre exemption until 2010 is in place. The U.S. is noted to have 32 plants in 1995 with ADM controlling 50 percent of production (AAFC). Io-Gen, an Ottawa based company, has received US$29 m from Shell for commercializing its technology which uses straw in a fermentation process for ethanol. Shell sees renewables as key strategic resources. A concern is a supply base. Currently, some bio-diesel is produced in Canada presently. Milligan Biotechnology (SK-400k-500k l/yr) uses canola, Biox (Ont), a spin-off company is attempting to start operations in Ontario with animal renderings and waste fast food oils/ fats.

Table 4- Summary of Energy Use- 2001

Region	Ethanol- m litres	Cdn $-m	Biodiesel-m litres	Cdn $-m
Canada	175	$90	0	$0
USA	6,127	$3,000	23	$14
European Union	270	$225	820	$900

The U.S. is projected to increase its use of ethanol to about 11 billion litres by 2020 through the use of cellulosic biomass (conversion technologies) to ethanol. The U.S. Technology Roadmap 2020 indicates a need for the U.S. to develop renewable supplies of energy and chemical sources from agriculture commodities. The goal is to have 10 percent of USA supplies from plant-derived renewables by 2020 and 50% by 2050. A Department of Energy (DOE) program in the order of $250m has been implemented in the U.S. to advance this goal. See www.oit.doe.gov/agriculture. A recent U.S. study shows regional ethanol processing plants using corn are economic engines, provide $142m in one-time investments, $110m annually and creates 694 full-time related jobs.

The conversion of starch-based crops like corn and wheat using an enzymatic hydrolysis process (converts starch to sugars) has been in commercial production for more than two decades in the U.S. and elsewhere. There are two major types of processing technologies used to convert corn grain to fuel-grade ethanol (a major U.S. industry with 58 plants): wet mills (commonly known as corn refineries) and dry mills (AAFC). Conversion of lignocellulosic materials for ethanol is complex and not advanced, which is a research question. The technology hurdles include:
1) separation of the lignin from the cellulose and hemi-cellulose; 2) hydrolysis of cellulose and hemi-cellulose; and 3) the hydrolysis process yields a variety of sugars, with pentose sugars being difficult to ferment (AAFC).

The U.S. Department of Energy has a renewables research program seeking new energy sources. See http://www.eren.doe.gov/. They have four technology interests: biomass, bio-power, biofuels, bio-chemcals and materials, and integrated systems and assessments.

Bio-diesel was first used in 1900, with a Rudolf Diesel engine that burned peanut oil at the World's Fair in Paris. In World War II, Brazil, Argentina, China, and India used vegetable oils due to shortages. In the U.S. in 1998, a bill was passed to encourage use of bio-diesel, with estimated savings to the government of $40 m over 5 years. Current bio-fuel products in the U.S. include SoyGold as an additive, produced by Ag Processing Inc., Sergent Bluff, Iowa.

The UK is examining bio-diesel and bio-ethanol for fuel use. The world market is reported at 31.2 b litres and their research interest is in ethanol from lignocellulosic materials (wheat straw, wood waste, etc). Bio-diesel research interests are in esterified rapeseed oil as a transport fuel. "*Renewable sources of energy make an important contribution to secure, sustainable and diverse energy supplies and are an essential element of a cost-effective climate change programme. The Government is proposing that 5 percent of UK electricity needs should be met from renewables by the end of 2003 and 10 percent by 2010, as long as the cost to consumers is acceptable. These targets are intended to act as a stimulus to industry and provide milestones for progress monitoring." Minister of Energy and Competitiveness, Europe*. See http://www.dti.gov.uk/renewable/

The UK is investing in renewable energy from crops, agriculture and forestry wastes in addition to wind and other power sources. The technology of deriving alcohol fuels from ligno-celluose is at the R&D stage, so costs should reduce significantly from the current level if this work is successful. Clearly, renewable energy is seen as a strategic research priority for the UK. Their research interests include waves, hydro, energy fro wastes, landfill gas, energy crops, agriculture and forestry residues, fuel cells, active solar heating, photvoltaics, passive solar, and cross technology issues.

The EU has made a commitment to renewables. In November 1997, the European Commission (EU) adopted a White Paper which set out a comprehensive strategy and action plan to achieve an ambitious goal - doubling the renewables' share of the EU's total energy supply, from 6 percent to 12 percent, by 2010. The Strategy's main features are the reinforcement of policies, such as agricultural and rural policy, regional policy, and internal market measures in the regulatory and fiscal areas, affecting market penetration by renewables. The strengthening of co-operation between EU Member States is also proposed, along with measures to facilitate investment and information dissemination. "*A Campaign for Take Off*", targeting the key renewable energy sectors, represents a key element of the strategy and action plan.

Targeting the PV, wind and biomass sectors, the *Campaign for Take-Off* aims to accelerate the development of the Strategy in its early stages (to the year 2003) by stimulating increased private investment in renewables, with an emphasis on near-market technologies. The following deployment objectives will be pursued during the Campaign: 1,000,000 PV systems; 15 million m2 of solar collectors; 10,000MW of wind turbines; 10,000MWth of combined heat and power biomass installations; 1,000,000 dwellings heated by biomass; 1000MW of biogas installations; 5 million tonnes of liquid biofuels. Investment

opportunities will be highlighted by promotional activities focusing on the key sectors, and national and EU programmes and schemes will trigger and complement private capital.

Campaign for Take-Off has already stimulated considerable interest is the identification of 100 communities aiming to meet 100 percent of their energy needs from renewables. As part of this initiative, a number of pilot communities, regions, cities and islands are being identified.

Barriers to this Canadian opportunity are public policy and technology research issues. Technology is available and can be adapted to Canadian conditions in addition to augmenting current research and industry efforts. Significant benefits are possible.

Alberta R&D Capacity In Bio-Energy Technologies & Products

While research and engineering capacity exists in Alberta it is not currently a main research area. Some capacity in bio-energy is located at the Alberta Research Council in a project team and in the Fuels and Lubricants Group (total 5-7). The ARC has a lab for testing and certifying oil/gas products that requires certification for warranty and performance evidence. Other allied capacity exists in universities, private sector (consulting engineers), OCCI and in the public sector. Mobilizing the vast energy expertise in Alberta through a bio-energy strategy will bring new opportunities. (Note: extraction, fraction and related processes and equipment will also be needed).

Research Program Scope

Capturing the potential biomaterials growth opportunity will depend on four issues:

- Research funds to advance the priority.
- Specific supply base development.
- Industry partners to commercialize technologies.
- Policy supports providing the market opportunity.

The science and technology questions are in the applied research and technology development stage of the R&D system. Some of these technologies are developed in a number of other jurisdictions and can be adapted to Alberta conditions for Alberta benefits. In other cases, applied research and piloting is needed to developed Alberta based data and results.

Research Activities for Investment in Bio-Energy Technologies and Products

Research funds in Applied Research and Technology Transfer Activities Research are recommended to be invested as follows:

Category	Description	Investment
Co-gen Science and engineering	Applied Research & Tech transfer over 5 years	$5.0 million
Bio-diesel & bio-fuels	Applied Research program for 5 years	$5.0 million
CO2 offsets, legal, policy, life cycle	Research over 5 years	$1.0 million
Total Investment		$11 million

- Co-generation technology applications- a 5-year technology transfer/ development program in the order of $1m per year. This would provide for industry projects annually on a cost-shared basis. It includes wood waste, agriculture waste and other by-products. Climate Change Central is involved with some demo pilots. Total $5m.

- Bio-diesel and bio-fuels- a 5 year applied research program in the order of $1m annually, totaling $5 m. This will provide application discoveries and process efficiencies within a 3-year window. The economics and policy area are key questions. Total $5m.

- CO2 offsets, market mechanisms, legal and policy issues for agriculture commodities. This area of production & processing systems, economics and policy is not well understood. Research in life cycle analysis, emissions and the Kyoto Protocol will be needed. Estimates at $200,000 annually for 5 years. Total $1m.

- Total budget- five year estimated at $11m research. Leverage of 3:1 is possible.

As these technology platforms and applications are developed, supply bases will need to be enhanced as a feedstock for bio-energy production. This will provide new market driven opportunities for crop biotech applications and technology platforms, agriculture commodities, and waste by-products. One of the possible limiting factors for large-scale industry investments is an adequate supply base.

Bio-energy technology applications are not dependent on a global industry partner. These technology applications are likely to be capital intensive but will have rural-based sites to access raw materials. Further, strategic alliances with global distribution partners into other market channels may also be appropriate as a viable Alberta technology platform is developed. Most of these technologies are likely to be SME applications. It is possible to stimulate early stage adoption of certain technologies by SMEs through policies and related public sector supports (see for example www.carbohydrateeconomy.org/).

A strategy of locating "mini-processing plants" producing bio-energy can be employed adjunct to existing farms, feedlots, and processing plants where a sharing of labor, utility, roads, distribution, and other important infrastructure is needed. This approach provides the impetus for a technology transfer approach in cost-reducing and competitiveness solutions for Alberta industry, given a local supply base of adequate feedstock. Co-generation investments are in the order of $1m per MW of power and the Alberta Power Pool will accept excess power at spot prices (see www.powerpool.com).

In the case of bio-diesel and bio-fuels, larger retail distribution partners will be needed. Ethanol is being produced at API, Red Deer and in a number of other Canadian locations. However, distribution and marketing contracts are critical to success. For bio-diesel and related fuels, a similar need exists.

Policy Supports

Policy supports will be a consideration for this science priority in view of Alberta growth goals to $20 billion by 2010. Some of the obvious policy issues include:

- Recognize bio-energy as a part of the Alberta energy policy.
- Policy encouraging technology use and adoption (see U.S. incentives).
- Policy encouraging minimum use of alternative energy sources.
- Policy to enhance technology commercialization processes.

- Life cycle analysis supporting the use of agriculture and forestry materials and assesses greenhouse gas emission (GHG) amounts versus known benchmarks.

3. BIO-INDUSTRIAL CHEMICAL TECHNOLOGIES & PRODUCTS – OVERVIEW

Bio-industrial chemicals offer opportunity for an economic contribution from new means of supplying naturally derived chemical products for global industrial markets. Bio-industrial chemicals include chemical feedstocks (platform chemicals), bio-lubricants, bio-cosmetics, and resins. With interesting and novel applications of science and technology, new ways to utilize Alberta renewable agriculture and forest crops can be discovered. Example products include: bio-plastics, natural polymers and biodegradable films, and packaging. Globally, populations are expanding, consumers are seeking new environmental biodegradable products, and policies and programs are encouraging "green" chemicals and products. The EU, the U.S., and Japan are transitioning to a bio-products economy (Japan's 2010 target is 30 percent of use from bio-chemicals). The Canadian market is estimated at $1.6 b, with a farm value of $170m (AAFC, 2001). Alberta's chemicals industry is large and the Alberta R&D effort recognizes the new demands. This priority allows for growth from Alberta strengths, crop resources, industry, research infrastructure, and a critical mass of innovative university researchers. Alberta efforts are not far behind others (some discoveries are in progress) and several university/company project collaborations exist.

Vision

A renewable resource-based bio-industrial chemicals industry in the order of $1 billion by 2015, supplying a range of novel biodegradable products for consumer and industrial markets.

Why Now? Why Alberta?

- Markets for bio-chemical products offer Alberta a strong opportunity to develop new industries.
- Alberta has extensive agriculture commodities which used for bio-chemicals
- A strong research cluster of resources exist with ARC, University of Alberta, Calgary, and Lethbridge, and the private sector
- Alberta researchers are involved in bioplastics, chemicals, and agri-materials.

Situation Analysis

Markets for bio-chemical products include:

- Bio-industrial feedstocks and platform chemicals.
- Bio-lubricants.
- Bio-cosmetics.
- Resins.

This market niche is vast. It involves a large number of products, by-products, and co-products for industrial markets. Platform chemicals are a broad category and may include:

- Lactic acid.
- Ethanol (industrial).

- Furfural.
- Glycerol (by-product of bio-diesel).
- Fatty acids.
- Many other products (e.g., acids from sugars and starches, isoproponal, phenols, sorbitol, ethylene, methanol- ILSR).

The chemical industry size is noted in the table below which shows it is a significant employer and consumer of various products. The U.S. denoted as a strategic industry.

Table 5- Summary of Chemical Industry- 1997

Region	Businesses	Sales- $B Cdn	Employment	Products
Canada	1,385	$31	87,600	NA
U.S.	12,000	$534	1,033,800	70,000
European Union	NA	$545	1,707,000	NA

Source: AAFRD

Also, the table indicates the potential to expand the Canadian industry size and employment through a new bio-chemicals technology approach. The Canadian industry has 8 main segments:

- Industrial chemicals- $9b
- Agriculture chemicals- $2.6b
- Plastics and resins- $6.0b
- Pharmaceutical- $4.9b
- Paint and varnish- $1.7b
- Soap and cleaning- $1.5b
- Toilet preparations- $1.1b
- Other- $3.9b

Industrial chemicals can be grouped in to organic and inorganic chemicals. Inorganic chemicals do not contain carbon molecules. Organic chemical companies produce their products using petrochemical feedstocks that are fossilized carbon from plant materials, and from animal fats and vegetable oils. The U.S. government is targeting this product area for development.

Manufacturers need both ingredient chemicals and intermediate chemicals for final products. This is the main opportunity for bio-chemicals. Cost competitiveness depends on many factors such as relative price-cost of oil/gas derivatives versus biomass derivatives, supply base, technology platforms for processing, and incentives for bio-chemical developments. In the area of ethanol much has been done to create this industry in the U.S. For example, Cargill-Dow have developed a (Nebraska) PLA plant (poly lactic acid) manufacturing bio-polymers for plastics applications. In the U.S. a number of corn-based plants have been built to utilize this supply base to produce bio-chemicals. These offer biodegradable, renewable and cost-competitive products. (Note: Batelle Labs, Ohio in the 1980s, first explored in the 1940s and PLAs later. The first report of construction of the Cargill-Dow plant was in 1994, with a start date of 1996-ILSR. This shows the development cycle can be long).

Strategies to develop this industry base can be viewed as 1) raw material substitutes for oil/ gas/ coal; 2) basic feedstock chemicals; 3) intermediates; 4) ingredients; and, 5) end products. Many

possibilities exist and need research directions against Alberta crops and livestock from biotech and commodity sources (see www.ILSR.org). Other directional sources are: http://biobased.org, www.oit.doe.gov/agriculture/portfolio, www.carbohydrateeconomy.org, www.nf-2000.org.

Companies producing bio-chemicals:

- **Adhesives – 6**
- **Antifreeze – 1**
- **Degreasers and strippers-14**
- **De-icers- 2**
- **Enzymes- 10**
- **Household solvents- 12**
- **Industrial solvents- 21**
- **Inks- 9**
- **Institutional cleaners- 7**
- **Lubricants- 10**
- **Paints and coatings- 16**
- **Pigments and dyes- 5**
- **Specialty chemicals- 15**
- **Terpenes- 4**
- **Total = 132**

Forestry also offers potential in bio-chemical products. Tall oil from pine trees has been fractioned into fatty acids and used in adhesives, resins, and coatings, for a variety of coatings, soaps, and other products. Competitive products include soy and tallow. Alberta forest potentials in this area are not well understood yet.

In the U.S., soybean oil competes with other oils, particularly linseed and tall oils, as a major ingredient in alkyd resins when it is dissolved in carrier solvents to make oil-based paints. Recent United Soybean Board (USB) research resulted in modifying soybean oil that can be used as active dilutents for alkyd coatings. Soybean oil, as it is commercially available in an unrefined or refined, edible-grade state, is a fairly stable, non-volatile and slow-drying oil used to provide curing characteristics desirable in a base for coatings. Additional research is under way to increase drying rates while reducing unwanted color development in soy-based alkyd paints. The USB, composed of 61 U.S. soybean farmers, oversees soybean-checkoff-funded investments in foreign market development, human and animal health and nutrition, research and development of new uses, and agronomic research in soybeans.

In 1999, the U.S. Department of Energy launched the Education Initiative (PDF 285 KB) to promote graduate-level, multi-disciplinary research, teaching in biobased products, and close interaction between universities and industry. Under the initiative, grants will be awarded to foster the development of the interdisciplinary curriculums required by the biobased products industry. The Agriculture R&D Portfolio (PDF 200 KB) also includes other projects sponsored throughout OIT. Current and past OIT Chemical Industry of the Future projects that also support agriculture research needs. This helps set out the agenda for the U.S. in bio-chemcials.

Other OIT programs are applicable to the agriculture industry and may provide additional opportunities during implementation to the vision and roadmap. These programs include:

- OIT Forest Products Program, including an emphasis on Sustainable Forestry.
- Enabling technology R&D programs that are of a more generic, cross-cutting nature which support the agriculture industry as well as other industries, including Industrial Materials for the Future, Combustion, and Sensors and Controls.
- Technical assistance programs including Motor Challenge, Steam Challenge, and Compressed Air Challenge.

OIT has been a partner with American agriculture and related industries for over 20 years, with significant technology developments that promote energy efficiency and environmental benefits. The basis for OIT's partnerships with industry has always been to improve energy efficiency, promote environmentally sound industries, and enhance economic well-being. Many of OIT's previous agriculture R&D activities have been in partnership with related industries, such as textiles and food processing.

Overall, DOE spends upwards of $150 million per year in agriculture-related R&D. DOE's Office of Energy Efficiency and Renewable Energy (EE) has come together in conjunction with United States Department of Agriculture (USDA) to lead the implementation of the *Biomass Act of 2000*. EE conducts R&D through three of its offices. The Office of Transportation Technologies focuses on using biomass for transportation fuels. The Office of Power Technologies emphasizes power from biomass. This web site describes the activities conducted under EE's OIT Agriculture Industry of the Future activity. Basic research is also conducted under DOE's Office of Science Energy Biosciences Division.

Bio-lubricants are degradable oils derived from agriculture materials and can be safely used in a sensitive environment such as forestry, wildlife, public parks, mountains, fish habitats, and similar areas. Typically, these will be sourced from a vegetable oil product such as soybean, canola, and corn. These types of products are in the product introduction stage in the USA and account for less than 1percent of industrial lubricant markets. Uses include lubricating engines and parts, hydraulic fluids, and total loss oils (e.g., chainsaws). The U.S. biodegradable fluids market size is estimated at 43 million gallons or about $US385 million

The EU market is also interested in these products, with the chainsaw market at 30,000 tonnes, concrete release agents at 11,000 tonnes, hydraulic oils at 51,000 tonnes, and an annual growth rate of 16 percent per year. Most of the crop input is rapeseed. The UK has set bio-fuels and rapeseed as target priorities. See www.dti.gov.uk/renewables/.

Cargill announced that it purchased Waverly Electric's technology and patents for unique, soy-based transformer oil used in electrical transformers and related products. Cargill will make this BioTrans brand soy-based product the cornerstone for a line of biobased transformer fluids employing Waverly's technology -- enhanced by Cargill's existing patented technologies. The U.S. market is said to be 40 million gallons annually.

Alberta has the potential to build from its canola industry base into these new markets and has a number of processing plants. Supply base and price are issues. Bio-lubricants meet the need for environmental products for niche markets.

Cosmetics are a very high-value product industry and had had global sales of about $103 billion in 2000, with an annual growth rate of 3 percent expected for the next five years. Skin care and hair care products are two of the high growth segments with the industry. New products are incorporating anti-aging ingredients. A new segment in the cosmetics industry is cosmeceuticals, products that claim a therapeutic benefit with ingredients of alpha hydroxy acids, beta hydroxv acids, and vitamins. One report puts the global market at $35 billion.

Skin is the largest organ of the human body. Skin offers a barrier from stresses such as sun, wind, temperature, noxious substances, diseases, and enables human health. Natural lipids (fats) are beneficial for maintenance and enhancement of skin properties. Vegetable oils are mainly triacylglycerols and have many positive effects for skin. Natural oils from these plant sources for cosmetics are highly desirable and some sources include cocoa butter, Illipe butter, Kokum butter, Mango butter, Sal butter and Shea butter. These products provide moisture, lubricity, and better skin longevity. Cosmetics companies use large amounts of lipids and fatty acids for products. Alberta has strength in plant lipids research.

Alberta has one company (other micro companies sell animal oil products) in the cosmetics industry; Ceapro is focused on therapeutic products based on oat beta-glucans in products like *Oats Shampoo and Oats Ear Cleanser*. It is developing products and expertise in ingredients, therapeutics, and diagnostics (Type 2 diabetes and glucose tolerance). In 2001, it had sales of $1.1m. More product applications can be developed given a research direction.

Resins are used in the plastics industry for creating various industrial and consumer products. Resins commonly used today are derivatives from petrochemicals. A significant market need exists for bio-feedstocks that can supply functionality and utility equal to petrochemicals. Developing a technology platform to use a renewable and sustainable agriculture supply can produce new product opportunities up the chain.

One growth market for resins is in medical applications and devices. That market is said to be about 20 m tonnes with an annual growth rate of about 6 percent to 2004. The Canadian resin market is in the order of $5 billion. This is another high volume market that has a need for sustained feedstocks and links with platform bio-chemicals.

Alberta R&D Capacity In Bio-Chemicals Technologies & Products

Canada and Alberta have little dedicated capacity in bio-chemicals. This area can be developed as Alberta has a strong and expanding petrochemicals industry, a strong specialty chemical industry and expertise in the ARC and universities.

- ARC has a lubricants testing lab that can certify products for warranty purposes. This capacity is augmented with expertise in plant biotech for engineered crops. Canola, for example, can be designed to “manufacture” a specified amount of required TAG (triacylgylcerol) material for a specific bio-application.
- The University of Alberta has researchers (2) in the bio-plastics area. The University of

Lethbridge has a Team with expertise in related plant biotech/ lipids. However, the universities, ARC, private industry and public agencies can combine in new ways to provide sufficient expertise to address the research questions. There is much latent talent and capacity in Alberta to address this area.

Another expansion potential is in fermentation and conversion processes to transform inputs into intermediate and final product forms. ARC has some fermentation capacity and more will be needed. Fermentation is a conversion process used to create products. (Note: extraction, fraction and related conversion processes and equipment will also be needed).

Research Program Scope

Capturing the potential bio-chemicals growth opportunity will depend on four issues:

- Research funds to advance the priority.
- Specific supply base development.
- Industry partners to commercialize technologies.
- Policy supports providing the market opportunity.

Bio-Chemicals Supply Base Development

As these technology platforms and applications are developed, supply bases will need to be developed as a feedstock for bio-chemical production. This will provide new market driven opportunities for crop biotech applications and technology platforms, agriculture commodities and waste by-products. One of the possible limiting factors for large-scale industry investments is an adequate supply base and this needs to be considered.

Industry Partners for Development

These bio-chemical technology applications will require global industry partners in certain product processing applications/distribution. These applications are likely to be capital intensive but will be rural based to access the raw materials. Further, strategic alliances with global distribution partners into other market channels will be critical to assist as a viable Alberta technology platform is developed. For platform chemicals, larger retail distribution partners will be needed.

Some of these specialty chemical technologies are likely to be SME applications. It is possible to stimulate early stage adoption of certain technologies by SMEs through policies and related public sector supports (see for example www.carbohydrateeconomy.org/).

Research and Science Questions

The science and technology questions are in the basic and applied research of Alberta based crops that can offer bio-chemical potentials. This also has a link to the value added research in extraction and fraction and materials characterization. Alberta based materials need to be identified for specific industry applications and new platform technologies need to be developed to utilize these materials.

Research Activities for Investment in Bio-Industrial Chemical Technologies and Products

Research funds are recommended to be invested as follows:

- Platform chemicals characterization technology applications- a 5 to 7-year research program in the order of $2 million per year. This would provide for industry projects annually on a cost-shared basis. It includes crop and livestock applications. Total $14million.

Category	Description	Investment
Platform chemicals Research	Research over 7 years	$14 million
Bio-lubricants Research	Applied Research & Tech Transfer program for 3-5 years	$5.0 million
Bio-cosmetics research	Market Research and research over 3 years	$225,000
Resins research	Research on industrial products	
New Scientists	Build capacity	$20 m over 5 years
Total Investment		$40 million

* Included in global budgets.

- Bio-Lubricants- a 3 to 5 year applied research program in the order of $1m annually, totaling $5 million. This will provide for some application discoveries within a 3-year window. Economics and policy area are important questions. Total $5m.

- Bio-Cosmetics- a 3-year surveillance and market research program to better understand the market scope, possible Alberta opportunities and policy issues for agriculture commodities. This area of standards, market requirements & processing systems is not well understood. Estimated at $75,000 annually for 3 years, with an evaluation for the next 3 years to follow. Total $225,000.

- Resins- part of the bio-chemicals research budget.

- New scientists/ highly skilled professionals-est. at $20 m.

- Total budget- seven years estimated at $40m. Leverage of 3:1 is possible.

Policy Supports

Policy supports will be a consideration for this science priority in view of Alberta growth goals to $20 billion by 2010. Some of the obvious policy issues include:

- Recognize bio-chemicals as a part of the Alberta industry future.
- Policy encouraging technology use and adoption.
- Policy encouraging minimum use of alternative sources.
- Policy to greatly expand technology transfer & commercialization efforts.
- Life cycle analysis to support the use of agriculture materials and assesses greenhouse gas emission (GHG) amounts versus known benchmarks.

SUSTAINABLE PRODUCTION PRIORITIES - BUSINESS CASE

1. Sustainable Production Systems for Specific Traits in Crops and Livestock- Overview

This Research Priority contributes to the Agriculture and Food Industry through the growth of:

Sustainable Practices *–long-term activities that balance economic, environmental and social needs*

Social Responsiveness –*social climate is considered in developing research outcomes*

Synergy in the R&D system –*additional outcomes are possible as a result of the R&D teams formation*

Profitability – *of current and new industries*

Vision

Sustainable production systems provide the agri-based ingredients for a dynamic and profitable value-adding sector in Alberta (expected economic value to the production sector increase by 10-20% by 2010).

Situation Analysis

The production and sales of raw commodities from crops and livestock account for almost 9B$ to Alberta's economy. Rising from this production capacity, is a diverse range of products specific for their quality structural or functional properties. The focus of the research continuum is on ensuring the sustainability of production systems that provide a greater variety of specific traits to support the emerging opportunities in Bio-Products, and Value Added Food and Agri-Health. The production system diversifies to higher value trait identified, including commodity, and niche opportunity

Why Now? Why Alberta?

Benefit / Impact for Alberta

- Alberta is a leader in the development and application of Sustainable Production technology and knowledge
- Create a special trait environment that encourages private investment in research
- New information flow and supply chain bridges, enhancing investment
- Enhanced Social and Environmental health
- The Ag Industry achieves greater profitability, employment and shareholder value
- Create a specific traits investment model (franchising) for world showcasing

Focused research is required to create, evaluate, acquire and adapt technology and product platforms to:

- Exploit Alberta's comparative advantages in sustainable primary production.
- Meet targeted regional and global demand for bio-based ingredients.
- Alignment in AG R&D to enable a systems approach to producing a wider range of traits.
- Identify emerging science worldwide to import into Alberta and adapt technology for the sustainable production of specific traits
- Develop and enable the supply of value enhanced ingredients and products.
- Create new opportunities with desired output traits identified.

- Accelerate the adoption of world technologies leading to practice change
- Identify and alleviate risk to new technologies and practice change
- Establish price discovery and specific market mechanisms, including contracting, relationships and protocols through the value chain for specific traits
- Address Issues of due diligence around Intellectual Property for special traits

Research Program Scope

- Sustainability of production systems.
- Creation of new marketable traits and specific differentiated products from crops, livestock and forestry genomics, and management in Alberta with competitive and sustainable advantage.
- Supply and quality of constituents and specific traits to meet market and value chain needs.
- Competitive inputs (E, labour and sustainable)(including Traceability) and knowledge.
- Innovation—conversion of knowledge to technology.

Measures

Short Term

- Industry recognizes the sustainable production of specific traits as a viable business strategy
- Alignment in Alberta R&D system to enable a systems approach to producing a wider range of traits.
- Increased new sustainable production opportunities identified and simultaneous discovery initiated to remove commercialization barriers (e.g. IP, Traceability, QA).

Medium Term

- Formal institutional collaborations of Alberta R&D performers with selected foreign R&D institutions in order to collaborate, benchmark, and develop multi-disciplinary, systems approaches to targeted production.
- First generation value enhanced ingredients developed and ready for evaluation and commercialization by industry partners.
- Demonstrated special trait yield increase of 30% in specific crops
- Rate of new crop introductions with specific value traits
- Diversion of current crop and livestock production into trait based systems

Long Term

- Sustainable production systems provide trait-based sales through Value Chains in Food, Agri-Health and Bio Products
- Alberta is a leader in responding to market/output trait based production.
- Supply of crops and livestock yielding diversified products with diverse functionality.

Required Science Capacity

- Sustainable Production Network - A multi-disciplinary and collaborative and innovation network in Alberta to help catalyze and develop Alberta's crop and livestock traits into market value.

- Basic science, business and environmental expertise in Alberta's research performing community focused on sustainable production research.

Implications for R&D System Business Plan

- Networked teams across sectors and institutions
- Alignment of Alberta and federal science programming in sustainable production science so as to enable the development and establishment of new specific trait industries
- Alignment of production research toward trait based economic opportunities.
- New domestic and international industrial collaborations of Alberta science performers
- Leaders identified and equipped to ensure cooperation in meeting a unified strategy that seeks out new collaboration opportunities

2. Nutrient efficient systems in crop and livestock production- Overview

Vision

A systems approach to integrated crop and livestock management systems provides a framework for production research, and contributes to profitability and environmental sustainability.

Why Now? Why Alberta?

The production and sales of raw commodities from crops and livestock account for almost 9B$ to Alberta's economy. Production systems that enhance the efficiency of production from crops and livestock and contribute to a healthier environment represent long-term profitability. Nutrient Systems is a framework for integrated crop and livestock management systems that enable an integrated approach to the factors affecting the partitioning of nutrients into economic product. Environmentally, these systems balance nutrients over the long term.

Situation Analysis

Focused systems research is required to create, acquire and adapt technology in nutrient models to:

- Exploit Alberta's comparative advantages in sustainable primary production.
- Enhance the efficiency of nutrient conversion into economic product.
- Invoke practice change
- Create a convergence of science into a new body of knowledge
- Enhance resource care and rural health.
- Link production goals to environmental capacity
- Access emerging science worldwide and integrate with Alberta R&D for nutrient efficient systems development
- Reduce external inputs that contribute to waste streams ("lean practices" – Toyota production system)
- Enhance the linkage between cropping and livestock production to increase nutrient efficiencies

Research Program Scope

- The integration of knowledge through nutrient systems research to enhance sustainable production systems.
- Finding alternative methods for long-term nutrient balance between soils, water, air and the economic products of agriculture.
- Increasing the efficiency of nutrient stocks and flow among crop and livestock systems
- Introduction of new crops and livestock to optimize nutrient cycling in agriculture
- Innovation—conversion of knowledge to practice
- Identify and manage greenhouse gas outflow from livestock and crop production systems to address issues emerging from climate change
- Impact of timing and amount of water available for crop growth on nutrient budget

Measures

Short Term

- Alignment of Alberta sustainable production systems research as part of Canada's contribution to climate change remediation (industry benchmarks are established).
- Alignment in Alberta R&D system to enable Alberta's response to climate change.
- A framework for research on integrated crop and livestock management systems is established.

Medium Term

- Formal institutional collaborations of Alberta R&D performers with selected foreign R&D institutions in order to collaborate, benchmark, and develop multi-disciplinary, systems approaches to targeted production.
- Identify options for Best Practices in nutrient management systems

Long Term

- Sustainable production systems provide economic and environmental stability through efficient nutrient conversion to economic product
- Alberta is a leader in applying integrated crop and livestock management practices to farming systems.
- Environmental benchmarks are reviewed for nutrient targets

Required Science Capacity

- A multi-disciplinary and collaborative and innovation network in Alberta to help catalyze and develop Alberta's sustainable crop and livestock industries.
- Basic science, business and environmental expertise in Alberta's research performing community focused on nutrient systems research.
- Bio-informatics enables data mining to enhance the integration of science activities

Implications for R&D System Business Plan

- The Sustainable Production Network provides leadership and direction to strategic research investment
- Alignment of Alberta and federal science programming in climate change and sustainable production science.

- New domestic and international collaborations of Alberta science performers in climate change.
- Leaders identified and equipped to ensure cooperation in meeting a unified strategy that seeks out new opportunities in collaboration with industry
- Commodity and industry investment in nutrient systems and practice change requires long term resource commitments
- Research into the economic instruments and incentives are required to encourage

3. Microbial Management Systems- Overview

Vision

Microbial management systems research enhances the productivity, profitability, and safety of crop, livestock, and microbial production systems. Health and Food Safety risks from microorganisms in the $9B agricultural production system are mitigated through a systems-based management approach that spans the environment, through to the feeding and animal management practices.

Why Now? Why Alberta?

Research Theme Priorities

Outcomes

- Production systems are economically, environmentally and socially sustainable
- The microbial population is modeled to understand and manage the microbial cycle in the agricultural production system
- New microbial based products
- Production strategies, and new technologies reduce the risk of antibiotic resistant microbes
- Microbial- based food safety and quality concerns are addressed at the source
- Microbials contribute to sustainable production, organic waste management and resource care
- Understand and modify microbiology of plants, animals and environment
- Higher consumer satisfaction for safe, longer shelf life products
- Knowledge which enables practice change and implementation

Situation Analysis

The production and sales of raw commodities from crops and livestock account for almost 9B$ to Alberta's economy. A systems approach to microbes creates opportunities to enhance livestock and crop health and profitability. Advances in soil microbiology represent the opportunity to manage nutrient cycles for production and remediation, microbial based waste management and co-generation systems, Microbial system understanding enables enhanced use of beneficial microbes in probiotics and molecular and metabolite farming from the rumen, and other microbial systems. The whole 'production system' approach offers remediation solutions

to microbial contamination incidents that have been tied to agricultural operations. Systems based-approaches offer the management of microbes throughout the crop and livestock production system, mitigating health, and food safety risks at the source.

Alberta's foundations for globally competitive industries include the safe food production through systems of microbial management. Microbial management systems focusing on beneficial opportunities, including molecular and metabolite farming produce products for, and from agriculture-based production. The foundations of this work are:

- Bio-informatics
- Microbial ecology and management
- Microbial genomics, proteomics and metabolomics
- Food safety
- Animal Health
- Pest management
- Integrated Crop and Livestock management systems
- Occupational safety
- Innovation—conversion of knowledge to technology.

Research Program Scope

- Focused research and technology transfer is required to create, acquire and adapt technology and product platforms to:
- Expand Alberta's comparative advantages in sustainable primary production.
- Establish probiotic and prebiotic products for human and animal health
- Enhance bio-security and risk assessment
- Identify microbial loading and management strategies throughout the feed, food production and processing system.
- Develop bio-remediation strategies for air, water, and soil quality, and food safety
- Replace management practices contributing to microbial antibiotic resistance
- Enhance the microbial bio-diversity and population ecology in agricultural systems to combat pathogenic populations
- Enable rapid microbial testing
- Develop pathogen traceability systems
- Establish predictive microbial modeling systems for Agriculture

Measures

Short Term

- Alignment in Alberta R&D system to enable a systems approach to managing microbial health and food safety risks
- Develop benchmark data on current practices with antibiotics
- Technologies emerge to replace sub-therapeutic antibiotic usage

Medium Term

- First generation commercializable technologies in microbial management.
- First generation microbial –derived products are commercialized

- Formal institutional collaborations of Alberta R&D performers with selected national and international R&D institutions in order to collaborate, benchmark, and develop multi-disciplinary, systems approaches to microbial management
- Bio-informatics support the development of predictive microbial population models
- The majority of livestock producers eliminate sub-therapeutic anti-microbial use

Long Term

- Sustainable production systems provide economic and environmental stability from trait-based sales
- Improved understanding of the ecology and evolution of pathogenic microorganisms.
- Microbial production systems contribute to bio-product and food/agri-health products
- Alberta is a leader in developing alternative technologies for microbial management.

Benefit / Impact for Alberta

- Alberta is a leader in the development and application of microbial management technology and knowledge
- Livestock sector products are recognized as high quality, safe and responsive to microbial threats
- Crops sector has tools for microbial threat management
- Crops sector has microbial-based tools to enhance productivity
- Scientific capacity to ensure bio-security of the food supply
- Recognized bio-security and microbial risk management system
- Enhanced Social and Environmental health through reduced antibiotic use, and nutrient management.
- The Ag Industry achieves greater profitability, employment and shareholder value
- A gate to carcass microbial management system is implemented

Required Science Capacity

- A multi-disciplinary and collaborative and innovation network in Alberta to help catalyze and implement whole system microbial management strategies.
- Basic science, business and environmental expertise in Alberta's research performing community focused on microbial management systems research.
- Bio-informatics – a real-time bio-security information system on microbial management

Implications for R&D System Business Plan

- Alignment of Alberta and federal science programming in sustainable production science so as to enable the development and establishment of trait based market economies in Alberta.
- Industry groups support and science based microbial management systems which contribute to new Best Management Practices
- CFIA and Ag Canada approve and support systems based approaches
- Major processors should be integral contributors to the science planning
- Audit methodology must be considered in delivering a microbial management strategy
- New domestic and international collaborations of Alberta science performers.

APPENDIX YY
Environmental Scan