ALBERTA'S AGRICULTURE AND FOOD RESEARCH & DEVELOPMENT & TECHNOLOGY TRANSFER SYSTEM

SITUATION ANALYSIS REPORT

BENCHMARK DOCUMENT/2001

PREPARED FOR

ALBERTA AGRICULTURAL RESEARCH INSTITUTE

EDMONTON, ALBERTA

ALBERTA'S AGRICULTURE AND FOOD RESEARCH & DEVELOPMENT AND TECHNOLOGY TRANSFER SYSTEM

SITUATION ANALYSIS REPORT

BENCHMARK DOCUMENT/2001

PREPARED FOR

ALBERTA AGRICULTURAL RESEARCH INSTITUTE

EDMONTON, ALBERTA

PREPARED BY

SERECON MANAGEMENT CONSULTING INC.,

TOMA & BOUMA MANAGEMENT CONSULTANTS, & S.J. CAMPBELL INVESTMENTS LTD.

EDMONTON, ALBERTA

OCTOBER, 2001

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

Alberta's agri-food system is facing significant global market opportunities and challenges from many socio-economic sources and influences including technology, competitiveness and consumer markets. Alberta Agricultural Research Institute (AARI) as a major funder and coordinator, has initiated this review of the current research and development system to begin to respond to these challenges. This report provides a benchmark of Alberta's agriculture and food Research & Development and Technology Transfer System as of the fall of 2001.

This Situation Analysis report is organized in six chapters:

Chapter 1. Overview and Contribution of the Agriculture and Agri-Food Sector in Alberta. A brief summary of the Alberta agriculture agri-food sector in the context of its historical and current economic activity, and its potential in the global context.

Chapter 2. The Alberta Research and Development and Technology Transfer System. A review of the major existing and future clients of the system, a summary of the focus, core competency and partners of the system providers, and a summary of the results of the analysis of the interviews and consultations conducted as part of this review. Some 60 completed surveys were analyzed which provides good input, and also indicates the high degree of interest in the review and future needs.

Chapter 3 Investment in Alberta's Research and Development and Technology Transfer Systems. A summary of the current level of expenditures within the Alberta system as of 2000/2001 year.

Chapter 4. Significant Research and Economic Factors. An identification and assessment of some of the significant research trends impacting, and driving the industry and society.

Chapter 5. Comparative Research and Development and Technology Transfer Models. A review of relevant research and technology transfer models in Canada and internationally, about which Alberta may be able to learn and benefit.

Chapter 6. Results and Major Conclusions. A summary of findings and conclusions following from the consultations, surveys, and research for this situation analysis.

1.0 OVERVIEW AND CONTRIBUTION OF AGRICULTURE SECTOR

1.1 ECONOMIC OVERVIEW

This section provides an overview of some of the important characteristics of the agriculture and food industry in Alberta. Table 1.1 traces trends in primary production and secondary manufacturing sector output (food and beverages shipments) over the period 1992 to 2001. Values are estimated for 2001.

Cash farm receipts have nearly doubled between 1992 and 2001 and are now over $7 billion annually. Livestock receipts continue to dominate the primary sector. In 2000, livestock receipts represented 60% of total receipts. Crop receipts were 30% and government transfer payments were 10%. This compares with the situation in 1992, at which time livestock receipts were 52%, crop receipts were 30%, and government transfers were 18%.

Alberta has gradually caught up to Ontario with respect to the level of primary agriculture production. Historically Ontario has led all provinces in primary agriculture production. In 1980, Alberta's primary agriculture production was 71% of Ontario's. By 2000, Alberta was at 95% of Ontario's production. In fact, in the first six months of 2001, Alberta for the first time has exceeded all other Canadian provinces in primary agriculture production.

Table 1.1
Comparison of Primary and Secondary Sector Economic Indicators

Year	Primary Sector				Secondary Sector				
	Total Cash Receipts ($B) [1]	Crop Receipts ($B)	Livestock Receipts ($B)	Net Receipts ($B)[2]	Food & Beverage Shipments ($B)	Surplus Shipments Over Net Receipts ($B)[3]	Value-Added[4] ($B)	Value-Added %[5]	Value-Added % of Cash Receipts[6]
1992	4.95	1.50	2.56	4.06	4.80	0.74	1.80	37.4	36.3
1993	5.06	1.57	2.91	4.48	5.30	0.82	1.81	34.2	35.9
1994	5.57	2.17	3.02	5.19	5.80	0.61	2.50	43.2	44.9
1995	5.95	2.64	3.14	5.77	6.40	0.63	2.89	45.2	48.6
1996	6.57	3.04	3.38	6.42	6.90	0.48	3.24	47.0	49.4
1997	6.48	2.69	3.57	6.26	7.30	1.04	3.72	51.0	57.4
1998	6.39	2.49	3.66	6.15	7.40	1.25	3.43	46.3	53.6
1999	6.51	2.34	3.95	6.28	8.10	1.82	3.32	40.9	50.9
2000	7.34	2.20	4.43	6.62	9.20	2.58	3.74	40.6	50.9
2001(est)	7.49	2.43	4.62	7.05	10.40	3.35	4.96	47.7	66.2

[1] Total cash farm receipts includes total of livestock and crop receipts, and government transfer payments
[2] Value of crop and livestock receipts, net of government transfer payments
[3] Difference between value of shipments and net farm receipts, before government transfer payments.
[4] Value-added is defined as food and beverage receipts + exports – imports – total cash receipts.
[5] Value-added as percent of food and beverage shipment.
[6] Value-added as percent of total

Food and beverage shipments are a measure of wholesale activity in the sector and have grown from $4.8 billion in 1992 to $9.2 billion in 2000. They are estimated to grow to $10.4 billion in 2001. It is important to note that in 1992, the level of shipments in fact were below that of farm sales. This occurred due to the high level of government transfer payments in 1992.

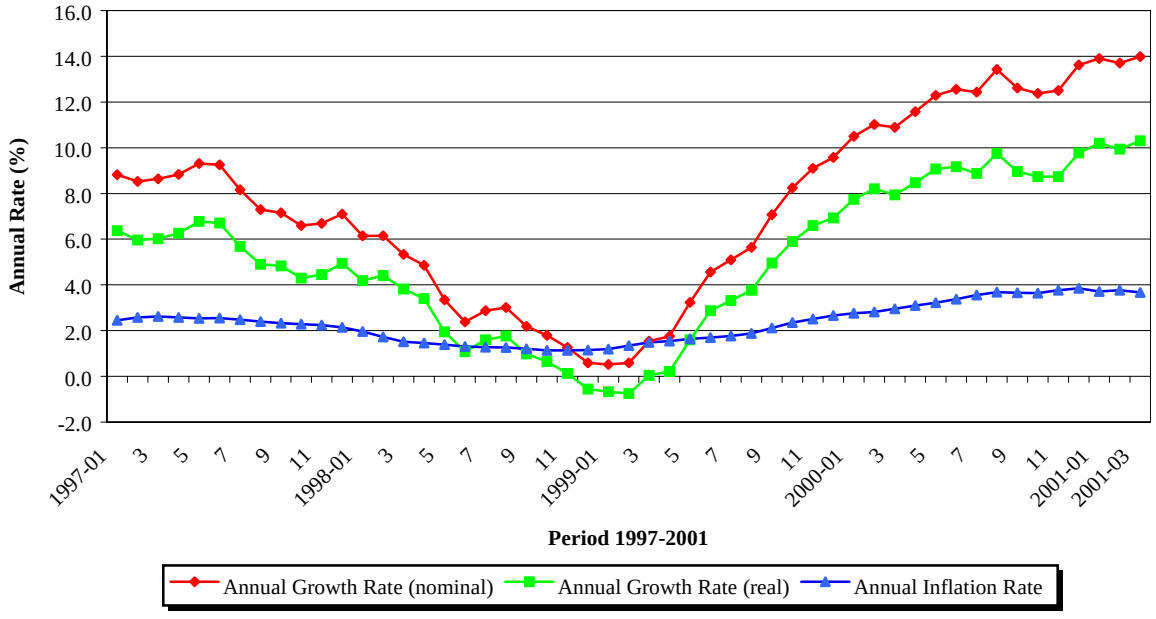
On a national basis, Alberta has slowly increased in food and beverage manufacturing, relative to other provinces. In 1990, Alberta's food and beverage manufacturing represented 11% of the Canadian total. Over the years, Alberta's share increased to 12.22% by 1995, and to 13.7% by 2000 (Statistics Canada Annual Survey of Manufacturers).

A more important measure of value added for the sector is defined as the total value of shipments, plus exports, less imports and farm cash receipts. Using this definition of value added, the sector has grown from a level of value added of $1.8 billion in 1992 to $3.74 billion in 2000. Value added could potentially reach $4.96 billion in 2001. Value added has therefore increased 2.8 fold over this 10-year period, an annual compound rate of over 10%. This is a significant growth rate.

A further measure of direction and change in economic activity in the sector is shown by the growth rates in food and beverage manufacturing shipments over the last few years. Figure 1.1 traces the growth rates in real and nominal terms.

Figure 1.1 shows that there can be very significant changes in growth over time. In early 1999, the annualized growth rates in real terms were in fact negative. Growth rates are currently running at 14% on an annualized basis.

Figure 1.1
Moving Average Annual Growth Rate, Alberta Food & Beverage Shipments



Source: AVAC Ltd., Agrivalue Economic Measuring System For Alberta, 2001

Table 1.2 provides summary statistics of Alberta's agriculture and agri-food industries, and some comparisons with Canada's.

The key points from the table are:

- Alberta has about 21% of Canadian farms;
- Alberta's farm cash receipts represent 23% of the Canadian total;
- Alberta's primary production now leads all provinces;
- Alberta has over 50% of the cattle and calves in Canada;
- Alberta net farm income is 13.6% of Canadian farm net income;
- Alberta represents 76% of the Canadian beef exports, 30% of the wheat exports, 45% of the live cattle exports, 32% of the canola seed exports, and 12% of the pork exports;
- Alberta represents 19% of Canada's agricultural exports to the U.S., and 31% of exports to Asia; and,
- Alberta's food and beverage manufacturing shipments represent approximately 14% of the Canadian total.

This data provides evidence the agriculture and food industries in Alberta are becoming more diversified and respond well to markets when provided with the opportunity, resources, and adequate leadership.

Table 1.2
Key Activity Indicators for Alberta's Primary Agriculture and Secondary Food and Beverage Processing Industries

	Current Reference Period	Alberta Current Period	Canada Current Period	Alberta %/Canada
Number of Farms (Census of Agriculture)	1996	59,007	276,548	21.3
Population	Apr 1/01	3,036,059	30,949,914	9.8
Total Crops ($ million)	2000r	2,253.2	13,114.3	17.2
- Wheat	2000r	912.4	3,080.5	29.6
- Canola	2000r	529.2	1,581.1	33.5
- Barley[1]	2000r	202.7	569.0	35.6
Total Livestock and Livestock Products ($ million)	2000r	4,447.8	16,827.2	26.4
- Cattle and Calves	2000r	3,338.7	6,667.7	50.1
- Hogs	2000r	500.5	3,380.3	14.8
Program Payments to Farmers ($ million)	2000r	710.7	2,825.8	25.2
Farm Operating Expenses ($ million) (1)	2000r	5,837.7	25,716.2	22.7
Total Net Farm Income ($ million)	2000r	408.8	3,004.2	13.6
Farm Debt as at December 31 ($ million)	2000p	8,842.8	38,068.4	23.2
- Animal Slaughtering (excludes poultry)	Jan-May 01	1,422.9	4,318.3	33.0
Employed Labour Force - Agri-Food Industries	Jun-01	84,000	640,600	13.1
Number of Cattle and Calves on Farms (head)	Jun-01	5,224,000	12,786,000	40.1
Number of Hogs on Farms (head)	Apr-01	1,756,200	12,133,600	14.5
International Agri-Food Exports ($ million)	2000p	4,545.2	22,080.2	21.8
- Beef	2000p	1,225.6	1,649.0	76.0
- Wheat	2000p	993.1	3,396.7	30.0
- Live Cattle	2000p	461.8	1,071.3	45.2
- Canola Seed	2000p	427.4	1,334.8	32.3
- Pork	2000p	106.4	1,043.0	12.2
Exports to United States Only ($ million)	2000p	2,566.4	13,419.1	19.2
Exports to Asia Only ($ million)	2000p	1,104.8	3,966.8	30.9

p - preliminary r - revised f - forecast estimate (1) After Rebates
Data Sources: Alberta Agriculture, Food and Rural Development; Statistics Canada; and Canfax.
[1] Significant value of feed grains and forages that are fed on the farm are not reflected in this figures.

1.2 ALBERTA OPPORTUNITY IN THE GLOBAL CONTEXT

Alberta is somewhat unique in Canada - it has a strong human and physical resource base, which, when combined with a highly entrepreneurial culture, creates a dynamic outward looking sector serving both domestic and export markets. The many export market opportunities create the market pull, and the scientific and resource groups offer the expertise and technical push to assist farmers and entrepreneurs to successfully act on the opportunities. Further, the province has financial resources, extensive export capacity and orientation and is developing a knowledge-based economy through its efforts in the ICT, health and oil/ gas sectors with specific strategies. The section below indicates more specific Alberta primary production potentials for the agri-food sector.

Crop Development in Alberta- Alberta has a very strong and well established crop production and crop improvement research base which contributes significantly to the diverse economic base of the province. The province has expertise in three provincial AFRD Crop Development Centres (Edmonton, Brooks, and Lacombe), Alberta Research Council (Vegreville), three universities, two Agriculture and Agri-Food Canada research centres (Lethbridge, Lacombe/Beaverlodge), and in several private plant biotechnology firms. This capacity across the province is world class in many areas of crop development and in dryland and irrigation crop production.

Wheat - The wheat market can be segmented into several types – high protein hard red spring wheat for which Canada is renowned; Canada Prairie Spring wheat which is used for flour milling, feed and industrial processing; lower protein content wheats for noodles and blending including soft white and winter wheats, and durum wheat for pasta.

Canada is uniquely positioned in global markets for the quality of its hard red spring wheat, but has global competitors in all classes of wheat. Currently, most of the world market is for lower protein wheat. Canada's highest quality protein wheat is often used to "top up" the quality of the flour used for bread or other purposes. Alberta produces six classes of wheat, depending on the content and characteristics of the protein and gluten (wheat is 75% starch, 10 to 15% protein and gluten, among other micro-components). In 1998, Agri Partners International Inc. of Calgary designed and commissioned a novel wheat fractionation and bio-processing plant in Red Deer to produce wheat gluten, ethanol fuel and other products.

Barley - Alberta has a significant acreage in barley every year with 50% being sown as malt varieties. However, due to management and climate, only about 15% of barley produced is graded as malt quality. Barley, like wheat, has sub-segments which can be further developed. There is opportunity in foods for rice extenders, nutraceuticals (beta-glucans / soluble fibre for cholesterol reduction) and specialty flours. The second segment is for feed which require protein and energy quality specifications. An emerging area in the feed market is hull-less barley which has a higher digestible energy content and less manure residual. The third market is in specialty malt varieties grown for a specific malt house. Barley also has non-food uses such as ethanol and other industrial markets.

Through biotechnology and plant breeding, it will be possible to differentiate Alberta barley and develop unique products based on new quality specifications. Alberta has R&D capacity in this niche which is world class. Research is occurring at the University of Alberta in the use of barley as an agri-health product. A private company with farmers and non-farm investors as shareholders is developing a branded barley food products value chain.

Oats – Oats have a future in high value uses in functional foods and nutraceuticals for human health products and cosmetics. Oats contains beta-glucans which have been shown to reduce health risks related to cholesterol and heart related diseases. Oats as a soluble fibre source is cheaper to use than drugs in cholesterol reduction (University of Illinois). Health and cosmetic applications for oat constituents are being developed in Alberta through companies such as Ceapro Inc.

Canola and other oilseeds – Oilseeds are Alberta's second largest crop in terms of farm cash receipts. Several companies operate canola crushing and refining operations in Alberta. Crude canola oil, refined canola oil and canola meal are sold by Alberta processors in bulk and packaged formats to customers in Canada, the U.S., and off-shore.

Canola oil is recognized world-wide for its nutritional attributes as a low-saturate high-oleic edible oil. In 1985, Canola oil was one of the first food ingredients for which the U.S. FDA allowed a label claim that related the composition of the food ingredient to a health benefit. This claim has proven to be instrumental in allowing canola oil to capture a price premium in U.S. markets relative to soybean oil and to achieve 25% of the retail shelf space for packaged salad oils. Canola oil's advantage over soybean oil however will be challenged in the next three years as competing qualities of soybean oil are brought to the market in the U.S.

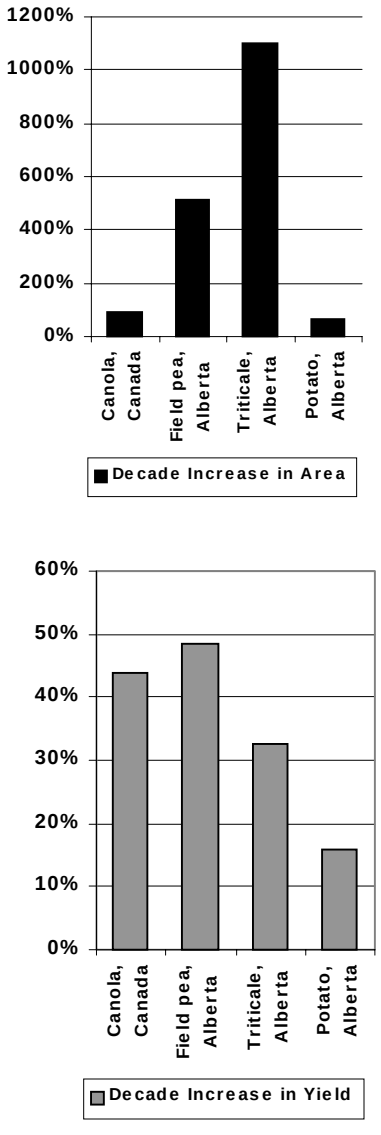
In the late 1990s, Dow AgroSciences, Intermountain Canola – a Cargill subsidiary, and Pioneer Hi-Bred – a Dupont subsidiary, all launched high-oleic low-linolenic specialty canola varieties from their proprietary breeding programs. The Holly type of canola oil is significantly more stable for industrial frying. The specialty oil also finds use in cosmetic and pharmaceutical preparations.

SemBioSys Genetics Inc, - a plant biotechnology company spin-off from the Department of Biological Sciences at the University of Calgary, has developed an extensive patent estate involving genetic transformations and a novel aqueous process to obtain native and genetically modified oil bodies from oilseeds. These oil bodies have many unique properties which may find use in cosmetics, pharmaceuticals, food and feed preparations. SemBioSys has raised more than $30 million dollars of private investment, mainly of US origin, and recently commissioned a special purpose pilot plant in Calgary to develop commercial products from its oil body technology platform.

Canola meal is an economical feed protein that competes with imported soybean meal on the basis of protein and energy content and digestibility. During the late 1990s, Canbra Foods of Lethbridge launched a canola by-pass protein supplement for use in dairy feeds. The technology to manufacture this product was imported from Europe. In addition to this investment in new meal processing technology, Alberta investors in the past two to three years have reviewed at least three proprietary processes to extract high value protein from canola meal.

Grain Legumes and other crops – The past decade has seen a spectacular increase in the area planted to canola, field pea, triticale and potatoes in Alberta. Introduction and testing of foreign pea varieties was instrumental in allowing breeders and the seed trade to identify specific ideotypes better suited to Prairie conditions and with much higher yields. New chickpea varieties developed by the University of Saskatchewan plant breeders in the late 1990s are now being adopted by Alberta farmers. Some farmers have incorporated new marketing firms to directly export chickpea, food-grade field pea, lentils and other specialty crops to South Asia and other foreign destinations.

Figure 1.2
Acreage and Productivity Changes Over the Past Decade



Triticale - Triticale is a very interesting example of innovation by farmers. As a grain crop, triticale has been grown on a small area in Alberta for many years. As new higher yielding triticale varieties were released during the 1990s, farmers have increased the area sown to triticale. As farmers gained experience with these new varieties, they identified the potential of triticale as silage and green feed. A group of farmers organized the first silage and green feed trials with triticale through AARI's On-Farm Demonstration Program. More definitive research was subsequently undertaken by AAFRD crop researchers. Triticale now has a 20% share of the two million acres of cereal silage production in Alberta. All this was based on innovative observations by Alberta farmers.

Seed Potatoes - Potatoes are a high value-added crop which for some Alberta growers have become a well recognized product line. Alberta is a strong producing area, selling into the large U.S. market and elsewhere. Alberta targets the Pacific Northwest of the U.S. Potato producers generally target two market segments: table potato for home use, and processing potato for french fry and chip production. Alberta's frozen french fry potato industry in southern Alberta consists of three global players - Lamb Weston, Maple Leaf Foods and McCains, two of which only established in the area in the past five years. The track record of Alberta potato growers and provincial infrastructure in irrigation, transportation, R&D and extension were key elements in these firm's location decisions.

Functional Foods/Nutraceuticals - The new area of functional foods and nutraceuticals is an emerging Canadian industry. The University of Alberta has started a new Food for Health program to meet this new and important market. The University of Calgary also has health products from agriculture sources under research. ARC has recently started a new functional foods program to develop market ready products. AFRD is supporting these endeavours in appropriate areas.

Alberta companies working in this niche include Ceapro Inc., CV Technologies Inc. - a spin-off company from the University of Alberta, Kinnickinick Foods Inc. and New Era Nutrition Inc. Ceapro is located in the University of Alberta's Transition business incubator facility and utilizes the expertise and infrastructure at AAFRD's Leduc Food Processing Development Centre for process and product development of its oat beta-gluten products. It is a licensee of a patented oat extraction technology developed by Agriculture and Agri-Food Canada (AAFC).

CV Technologies is a herbal drug discovery company which has developed several products including Cold FX. Cold FX is a tablet which helps to prevent people from catching a cold by enhancing the immune system. The product is achieving some market acceptance (**www.herbtech.com).** CV Technologies employs research to define active components in their products to ensure consumers' needs are fully met.

Kinnikinnick Foods of Edmonton manufactures and sells non-allergenic bread products at a retail location and over the internet. The company has realized strong success in its approach (**http://www. kinnikinnickcom/**). The company sells gluten free products and has a broad product line from breads to muffins to bagels and mixes. This is an example of a functional food company which has grown from a small traditional bakery base into a highly specialized product niche. It delivers in North America within a two to three day time period and has found e-commerce to be very beneficial given their highly specialized functional food niche.

New Era Nutrition is an Edmonton based company which develops and sells nutrition food bars for clients in North America. It developed its product "platform" with the assistance of the University of Alberta hospital and the AAFRD's Leduc Food Processing Development Centre.

The benefits of applying science and nutrition to problems for disease prevention and management (such as type 2 diabetes, cholesterol prevention, anti-cancer) are both possible and highly probable. For example, the University of Illinois, in its Functional Foods for Health program, has identified soy meal as a preventive agent for heart disease, cancer, osteoporosis, menopausal symptoms, kidney disease, hypertension and gallstones. These new market applications illustrate an overlap of food, nutrition and health sciences. As biotechnology applications are being developed, the lines between these science disciplines will be reduced and an integrated approach will be needed. Alberta has strength in the universities in these required scientific disciplines but lacks management capacity, incubators, equipment

and a development process. More can be done if a strategy is developed and implemented.

Horticulture and medicinal herbs - These areas are potential growth markets. The province has a small but thriving greenhouse industry which will see biotechnology product applications. There also exists significant potential to extract specific ingredients from herbs, medicinal natural botanicals, grains and milling fractions with novel physical, chemical and nutraceutical properties. Currently, Alberta greenhouses produce cucumbers, lettuce, tomatoes, peppers, tree seedlings and cut flowers. Medicinal herbs for health products are an opportunity and will be needed as companies develop markets and require local sources of supply. Horticulture applications in landscaping and ornamentals are opportunities

Forestry - Tree seedlings are grown for reforestation in Alberta. Alberta forestry companies are buying seedlings from Alberta nurseries, but are also going outside the province for new genetics. A number of companies are investing in research carried out at the Hybrid Poplar Co-op research program at the University of Minnesota. Alberta has a small research effort in forestry. These types of seeds would be targeted at faster growing trees on private lots, as Alberta's wood supply is finite and generally already allocated. Public lands require seeds harvested from proximate lands to those that were logged. More agri-forestry opportunities can be developed in the future.

Alternate Livestock - Bison, elk, deer and several other livestock species are expanding businesses for many Alberta farmers. To achieve more value added, elk farmers are harvesting antlers and processing antler ingredients into consumer products e.g. Elk velvet antler pills.

Livestock/Crop Genetics and Related Services - The excellence in livestock genetics is well established in Alberta for livestock such as beef and dairy cattle, hogs, and horses. The development of a strong private sector has shown that specialist breeding and related service organizations such as Alta Genetics can survive and prosper given the large livestock market opportunity and Alberta's experience base.

In the case of crop genetics, a similar strong base of R&D capacity and genetic material exists which will help position the sector for further growth. Cereal and oilseed plant biotechnology are strengths in the province and have much potential for growth. By contrast, investment in forage improvement is remarkably small in the province given that forage has been identified as a critical limiting resource for the expansion of the cattle industry.

These "top end genetics producers" within the animal and crop industries will see greater growth in global markets as other jurisdictions seek out the best quality genetic material for their domestic industries. For these types of companies, genomics and agri-research will be useful in identifying and selecting for specific desirable traits. However, several cross-cutting consumer issues exist and will impact on the industry's ability to use certain biotechnology tools for crop and livestock improvement.

Processed foods and meats - Alberta has many companies of various sizes from multinational firms to local processors producing processed foods and meats. Product development research for the multinational firms is conducted outside the province. Smaller Alberta-based food processors utilize AAFRD's Leduc Food Processing Development Centre extensively.

Much potential exists for food processors to expand. Alberta also has great potential to develop its processing capability for specialty crop products, spices, herbs, and other food products. The AAFRD's Leduc Food Processing Development Centre and the Olds College Centre for Innovation are gearing up to serve entrepreneur's R&D needs in these areas. An expansion of the Leduc Centre is nearly complete and a small-scale pilot plant for botanicals and herbs is planned for the Olds College Centre for Innovation.

Bio-products – Bio-products are a significant growth and expansion area for Alberta and Canada. Extensive discussion is occurring by industry and government to establish a federal non-profit corporation to guide Canada's R&D and technology commercialization efforts across federal, provincial and industry organizations in bio-products over the next 20 years. Bio-products Canada Inc. was incorporated in 2001 and efforts are underway to build cross-government and cross-sectoral support and resources for its work.

Present thinking suggests that Canada's manufacturing capacity including food processing, pharmaceutical and forest products is about 10% bio-based. The target of having Canada's manufacturing industries become 30% bio-based by 2020 is being discussed. This quantum step could result in a $100

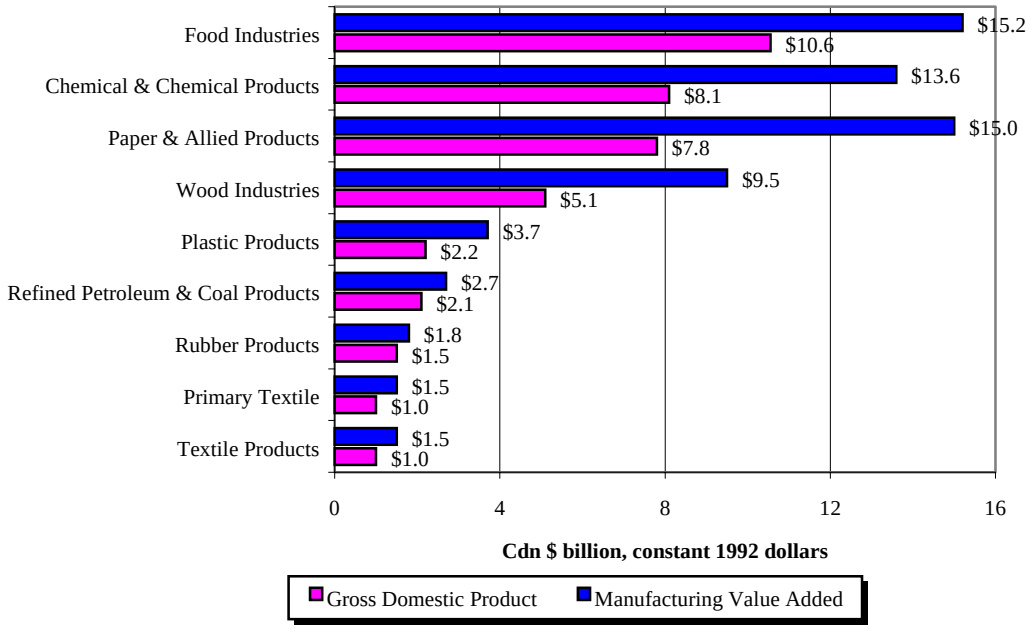
billion per year contribution of bio-products to Canada's GDP. Alberta certainly is well positioned to contribute R&D capacity that is resident in industry and government to build Alberta's and Canada's bio-based economy.

With further analysis and assessment, Alberta can likely specify and develop complete value chains for bio-chemicals, biomaterials, bio-energy and bio-health products from agricultural and forestry resources. Bio-products are strategic market areas involving great uncertainty in science and business. Although the risks are high, the returns to research investment could be huge relative to similar investment in traditional agricultural product segments.

Sustainable Agriculture Production and Value Systems - A major underpinning to the development of the food and industrial opportunities in the province based on its natural resources is the development and enhancement of sustainable and new production systems. The development of integrated crop and livestock production and management systems allows for new products and opportunities, and adaptive capability in the face of climate change. The potential to develop organic and natural products with reduced chemical inputs is part of this focus and direction. The development of new alternatives to chemical pesticides, herbicides, and fertilizers are potential huge areas for new research, investment, technology development, transfer, and commercialization.

The Alberta sector is well positioned to grow but faces a need to balance growth with other socio-economic forces impacting the sector. These are discussed in the next chapter.

Figure 1.3
Canadian Manufacturing Industry Statistics - 1995



2.0 THE ALBERTA RESEARCH AND DEVELOPMENT AND TECHNOLOGY TRANSFER SYSTEM

2.1 CLIENTS OF THE ALBERTA AGRI-FOOD R&D/TT SYSTEM

Clients of the Alberta agri-food research and development and technology transfer system entail primary producers and Alberta companies of various sizes. Clients are defined as producer-users of new technologies and practice change and companies which develop market ready products for specific end-markets.

Recent AAFC data indicates the Alberta farm sector is characterized by nine main farm types as noted in Table 2.1. The categories include retirement, lifestyle, small and commercial farms.

Some of the key findings are:

- the sector is rapidly becoming bi-modal in structure;
- part-time farmers and off-farm income are a major part of the industry;
- the investment levels required to farm are very high;
- a trend of consolidation in farm numbers appears; and,
- diversification is strongly evident in farm size and enterprise types.

It is noted that the top farm producers (all commercial segments above) account for 40% of all farms, 77% of sector sales and have net operating margins of 16% to 22%. Retirement farms account for 8% of sales, and Hutterite colonies account for 5% of sector sales. There is a large range of potential client types and needs, based on the financial profiles above.

In addition, the current agri-processing industries offer opportunities for the R&D/TT system. In Alberta over 400 agri-food companies are active and a number of new emerging companies are in early stages of development. Many of these companies are in meats, foods, dairy, bakery and niche foods.

The number of emerging rural based businesses offer potential for applied research and technology transfer. In addition, the main niche value added "types" appear to be:

- value added processing - from a primary product;
- entrepreneurial processors;
- agri-tourism (recent Alberta conference had 200 attendees);
- "clean and green"- horticulture, greenhouse and related products;
- services/small scale manufacturers; and,
- bed and breakfasts.

Table 2.1
Alberta Farm Profile

Farm Type	Number	Average Total Revenue	Operating Margin (%)	Farm Income per Family	Off-Farm Income
Retirement	6,670	87,200	17	15,000	28,000
Lifestyle	3,120	28,200	-31	-4700	85,300
Small	2,555	29,800	-20	-4100	11,800
Bus: small	3,585	28,600	13	4200	29,500
Bus: Medium	7,150	71,600	19	12,700	28,600
Bus: Small commercial	9,080	153,300	18	26,200	22,500
Bus-Med –com	3,640	334,800	22	68,500	21,600
Bus-Large commercial	2,085	1,567,100	16	129,000	72,800
Hutterite Colonies	165	2,252,700	12	-	
Totals	**38,045**	**222,100**	**11**	**24,732**	**32,414**

These value added niches are growing with clients who are attempting to secure market share in very "splintered" markets in the food and consumer products industries. A communication gap exists between the emerging processors and the very dynamic and fierce marketplace. There is a lack of information, poor data and generally a poor understanding of the real costs and difficulties in developing a product and a market.

2.1.1 Clients of the Future

Future clients should likely come from three main groups within the agriculture, agri-food system:

1. **Primary production sector clients** - This sector is under stress and needs infusion of new technology, new approaches and new ideas from "idea generators" for current clients to enhance productivity and innovation. These are generally the current clients of AARI and AFRD;
2. **Processing and value added clients** - These processors are looking to build a supply base to meet end-user markets, but require a science and technology solution. Examples include companies attempting new products and needing specific new varieties and agri-based micro components.
3. **New Life Science spin-off/ novel private company clients** - These clients require primary production input through a technology transfer linkage to industries and investors developing new technologies and products such as functional food/nutraceutical products, industrial bio-products, agri co-generation of energy, etc. These clients are "technology harvestors" seeking science and primary production partners for commercialization of new products and specific resources (contract manufacturing, identify preserved production of specific raw materials, etc.).

Table 2.2 summarizes the current and future clients of the R&D and TT system.

2.2 THE STRUCTURE, FUNCTION AND COMPETENCY OF THE SYSTEM

2.2.1 Agencies Involved in Agriculture and Food R&D and Technology Transfer

A large number of agencies, institutions, companies and groups are involved providing or funding research and technology transfer services within Alberta. The major groups are listed below and include:

Table 2.2
Clients – Current and Future

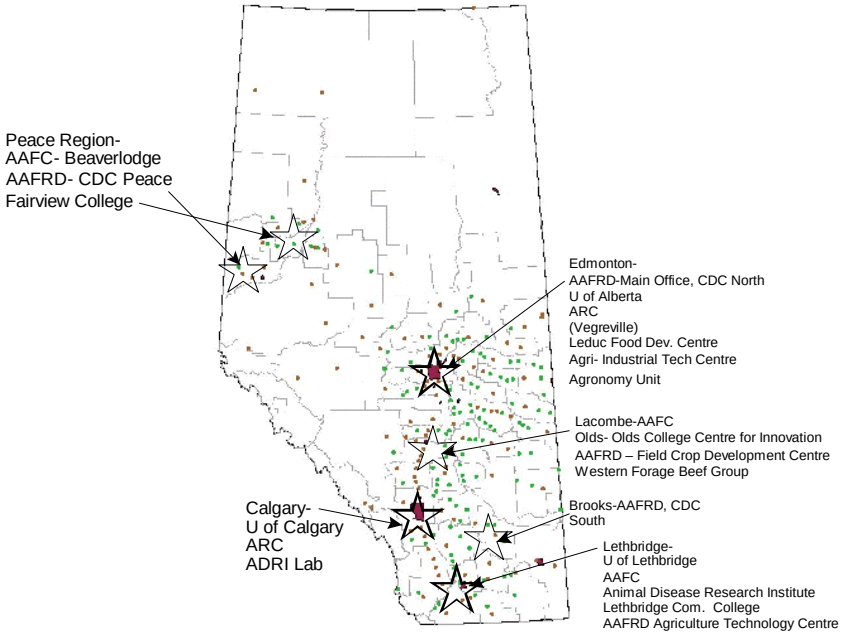
Client Group	Current R &D System Clients	Future Clients
Primary- likely 20,000 clients	Many of this group's needs are met with current approaches	Yes, more collaborative technology projects
Value added/processing, rural based businesses, likely 300-500 clients	Few are clients of the current system. Special crops and others have been serviced by system	Needs technology guidance, market linkages
Life science spin-off/novel companies	Universities have served some of these specialty companies	Will need specific supply base of agric. materials on new uses, and new cross discipline applications

- AARI/I&S - through research programs and On Farm Demonstration;
- AAFRD - through management, staff, resources, projects and programs (e.g. beef-forage, barley, environmental management, agri-food processing;
- Applied Research Associations and Forage Associations;
- Agriculture and Food Council - through projects and programs;
- AAFC - through staff and research station programs;
- Alberta Research Council (ARC) - through staff and research projects, and in particular, the Vegreville Sustainable Agriculture Program;
- AVAC Ltd. - through pre-commercialization project support; focus on wellness, new emerging products, industrial uses;
- Universities of Alberta, Calgary and Lethbridge - many focuses including human nutrition, dairy nutrition, genomics, functional foods, etc, As well, the Department of Rural Economy at the U of A has world class recognition in areas of resource economics (agriculture and forestry);
- Olds College Centre for Innovation - composting, by-products recycling, building a botanical processing capability;
- Federal sources - support programs such as IRAP;
- Producers and Private Industry;
- Industry Development Funds (Livestock, Crops, and Diversified Livestock); and,
- Commodity Organizations - such as the Alberta Pulse Growers. Alberta Pork Development Corporation, Alberta Barley Commission, Alberta Canola Producers Commission.

The agencies are plotted on the following figures. The map indicates the research and innovation system for the province and concentration of research and development resources in the corridor of the province.

One of the overview conclusions from the map is that the research performers are generally located in the Edmonton - Calgary - Lethbridge corridor, which means the approach of building a technology transfer network to clients outside the corridor is important. Second, developing a cluster of expertise in a particular discipline and focus area is important to ensure efficiency and impact within the agri-food system.

Figure 2.1
Alberta Agri-Food Research and Innovation Clusters



2.2.2 Description of Agriculture and Food R&D and TT System Performers

A comprehensive assessment of the focus, strategic direction, core competencies, clientele, and collaborative linkages of all the R&D and TT performers was completed. This was accomplished through consultation and help from the system participants. Immediately below, a general description of the function and purpose of each system participant is presented. Table 2.3 summaries these factors for each provider.

2.2.2.1 Alberta Agricultural Research Institute

Alberta Agricultural Research Institute (AARI) is a business unit of Alberta Innovation and Science headquartered in Edmonton. Its mission is:

"To enhance the economic contributions of the Alberta agricultural and food industry through support for research and technology transfer, with a strategic emphasis on life sciences".

AARI is committed to providing leadership to the R&D community, and to being a strategic funder of R&D and Technology Transfer. ARRI is not an R&D performer. It has a $10 million annual research program which is being refocused within strategic directions. The directions include basic research, primary production, value added, agri-health, bio-products, environmental sustainability, and collaborations. AARI also has a $700,000 per year On Farm Demonstration program (OFD) which focuses on technology transfer and knowledge building for practice change in primary production. The program was reviewed recently and shown to be a "bottoms-up" priority setting strategy with five regional committees and eight Applied Research Associations involved.

The current OFD technology transfer model is worth reviewing for the lessons learned. The model is based on all projects having a team comprised of an AAFRD staff specialist, a producer/ industry partner, a defined plan and objectives with leveraging of AARI funds by typically 2-3:1 (industry funds:AARI funds). The OFD program is located at the piloting and evaluation stage along the continuum towards broad commercial use and market exposure.

Decision-making is based on each region addressing local needs through a committee comprised of producers (users), AAFRD Directors, staff and others as needed. The structure is a way to allow direct program access to end users (producers) and has evolved to being an informal "primary producer network" of technology evaluation and transfer. (Note: AAFRD roles need to be considered carefully given the mutual client base and mutual strategic goals.)

A recent study (Toma & Bouma) shows the AARI model and role within the technology discovery and use process. The model is useful for building a more integrated technology transfer approach to the sector in view of the Life Sciences strategy for Alberta.

The model encourages technology and innovations at the producer level to be shared openly. The OFD model is a project-based approach which provides the key mechanism to bind various parties together through a common research project with science based questions.

Each project must follow general guidelines of the OFD program, which include involvement of a co-operator-producer, AAFRD staff specialist, a defined project plan with objectives, a budget and a timeline. Clients typically are innovators and early stage adopters. Current clients have been regional in nature to reflect regional needs and AAFRD client contacts as AAFRD is an integral delivery partner for AARI. AAFRD typically defines clients on both geographic (regions) and commodity criteria.

The OFD program has served a demonstration, extension and technology transfer function which can be enhanced in breadth and depth. The model works well for producers and Applied Research Associations in sharing technology and new innovations which need a seasonal approach. For new future clients like rural based processors, a modified and more dynamic approach will be needed to address market, proprietary technologies and confidentiality concerns. This issue is likely equally important for Life Science/ novel companies.

AARI has a value added Technology Transfer program sponsored by the Agriculture & Food Council for a total of $450,000, of which most funds are now spent.

The strategy of AARI in the past appears to be driven largely by industry needs and researchers who annually apply for funding. The annual cycle of AARI has deficiencies relative to a number of aspects: projects are small, sometimes opportunistic in nature; it requires a very time intensive proposal and review process; and, a decision cycle of nearly five months.

Overall AARI through its OFD program, which is a "bottoms-up" priority setting process and its research program, can be summarized as not being focused on any specific themes. AARI has developed new strategic directions (themes) but needs to communicate these more broadly (they are not understood) and encourage more focus to desired research goals.

2.2.2.2 Alberta Agriculture, Food and Rural Development

Alberta Agriculture Food and Rural Development (AAFRD) is focused on delivering the agri-food development and growth agenda for the province. The agri-food sector includes a primary production base of 51.4 million acres (30% of Canada's farm land) and 32 million acres of cultivated land. AAFRD has many business units which work in various parts of the research and development and technology commercialization continuum. (Note: research and applied research mean different things to different people. A description of the continuum is provided in Chapter 3.)

The core research business units of the department include:

- CDC South, North and Peace (Crop Diversification Centre) - which focus on new crops, specialty crops, vegetables, cereals breeding and agronomics;
- Lacombe – Field Crop Development Centre, barley, triticale, and winter wheat breeding and production practices, Western Forage/Beef Group;
- Agronomy unit - integrated soil, crop and water production practices;
- Leduc Food Processing Development Centre - processed foods, meats, functional foods, product development and sensory evaluation, concept analysis and development, prototype design, product packaging and labelling, quality control and assurance.
- Agri-Industrial Technology Centre - a new unit to focus on new uses (industrial) and engineering needs;
- Lethbridge Irrigation Branch - water management and irrigation technology, Agricultural Technology Centre;
- Economic Services - marketing and socio-economic research and analysis.

AAFRD is more likely to be involved in aspects of technology transfer and knowledge building than in research although basic and applied research is done or managed in many cases. AAFRD has a pervasive role throughout the province and has extensive industry contacts. The role definition may need to be examined in view of a new research strategy and private sector capabilities. Further, the department has spawned a number of new organizations to respond to industry needs and wants. The Agriculture and Food Council (AFC) discussed later is one such organization. The three new Industry Development Funds (IDFs) which have been set up are nearing implementation.

Given these organizations, AAFRD has a strong role in technology transfer and in strategic priority setting as it sponsors strategy reviews of emerging issues, trends and industry studies which do serve to influence commodity groups and agencies in certain directions. AAFRD has primary and processing clients.

Closely aligned with AAFRD are the Applied Research Associations (ARAs) which receive core funds from the Department and receive research funds from AARI. It is notable that AARI has historically relied heavily on AAFRD to implement its projects in a number of cases and the department is a key partner for the OFD program.

AAFRD has a research business plan which indicates an investment of $20.3 million invested in R&D in 2000/2001. In addition, the Department indicates an investment of an additional $13 million in related scientific activity. The four focus areas for the department include: value added processing, crop development, livestock development and environmental stewardship.

The department has a short term and long term focus for research. The short term focus is:

- stronger emphasis on food safety, global competitiveness and environment;
- profitability and environmental stewardship;
- importing research results for use in Alberta;
- encourage private sector involvement in research; and,
- foster research partnerships.

The long term directions are:

- analytical methods and technologies for value added products, functional foods, nutraceuticals and pharmaceuticals;
- knowledge and technology to enhance quality and safety;
- addressing unique Alberta problems;
- importing research results for use in Alberta; and,
- strengthen networks, alliances and joint projects.

AAFRD indicates they have seven divisions conducting research in the four focus areas of the department. The cereal feed grain breeding program at Lacombe is developing world class status and has been reviewed by external scientific experts every five years. Food processing research is carried out by the Processing Industry Division. Collaborations are noted with companies, University of Alberta, AAFC, University of Calgary, Alberta Research Council, and international organizations. A number of specific research project outputs are planned for the four focus areas. The Department indicates over 12 research locations in Alberta.

Some observations offered about the Department's research and development strategy are:

- some basic research efforts exist, with much more effort in applied research, technology development and knowledge transfer;
- the title of scientist within AAFRD is not always seen to be equal to the University title;
- AAFRD implements many industry solutions with partners (such as ARAs) and conducts a number of research projects through agreements;
- AAFRD has networks with many industry associations and organizations in the R&D system; and,
- AAFRD is very involved as a technology transfer/knowledge building agent with nearly $13 million budgeted for the activity.

The overall strategy for R&D/TT may be summed up as part of the growth plan for the industry given the need for sustainable production practices. Within the strategy, however, much room for interpretation exists.

AAFRD has developed a number of industry agencies to help implement strategies for development. Some of these include: Agriculture and Food Council, Agrivantage (from the Ag Summit 2000), AVAC Ltd. and the Applied Research Associations. One of the comments noted in the review process was the disconnect from the growth vision ($20 billion in processing/ $10 billion in primary production by 2010) with industry and staff buy-in. Many people do not see the implementation plan and process as being fully developed by AAFRD. This results in a gap and a limit to achieving the vision.

2.2.2.3 Agriculture and Agri-Food Canada Research Branch

Agriculture and Agri-Food Canada (AAFC) is a national organization with international R&D and technology linkages and networks. AAFC influences the strategies and directions of commodity organizations as it develops information products, programs and regulations which impact industry growth and development. (Note: the nutraceutical foods and functional foods niche offers promise for Alberta and others, yet it is still a developing regulatory interest area administered by AAFC and Health Canada). AAFC has primary and processing clients.

AAFC is in a change process and nationally moving to an agenda with four focus areas:

- environment;
- sustainable production systems;
- bio-products; and,
- food safety.

Each of these main themes will be coordinated from Ottawa and implemented by teams operating within the theme area. Research sites at Lethbridge, Lacombe, Beaverlodge and several sub-stations have certain strengths which match these focus areas.

The strategy for AAFC is changing to one of national delivery to the Canada's food system. This contrasts

with prior regional focuses on centres of excellence. This re-organization will take several years to design and implement.

AAFC has Research Centres in Alberta operating from Lethbridge, Lacombe, and Beaverlodge. Each centre has unique skill sets, R&D and technology transfer capacities, many of which are world class.

2.2.2.4 AAFC Lethbridge Research Centre

The Lethbridge Research Centre is the largest agricultural research establishment within the Research Branch of Agriculture and Agri-Food Canada. It is AAFC Research Branch's national Centre of Excellence in ruminants and has world class capacity in many areas of breeding, animal physiology, livestock, ruminant nutrition, crops and irrigation.

The Lethbridge Research Centre's scientific activities include studies to increase the efficiency and environmental sustainability of beef production and improve beef quality; enhance crop production sustainability and competitiveness by developing innovative technologies and cultivars; develop crop, soil, water and manure management strategies that protect the environment, maintain bio-diversity, reduce greenhouse gas emissions, improve soil, water and air quality, and make efficient use of water; and to develop integrated pest and disease management technologies and strategies that control weeds, crop and livestock pests.

Lethbridge Research Centre has an immediate land area of 500 hectares, a 17,000 hectare beef cattle ranch near Manyberries, a 400 hectare substation near Stavely in the foothills, and a 190-hectare irrigation substation at Vauxhall. The Centre also has a facility in Kamloops, BC. The total staff complement staff in all units is about 350 including 107 in the professional categories. The centre operates with a budget of $23.7 million with $15.4 million from federal A-base resources and $8.3 million from external sources

2.2.2.5 AAFC Lacombe Research Centre

The Lacombe Research Centre has 30 Full Time Equivalent (FTE) permanent scientists and technology transfer professionals that operate R&D facilities in Lacombe and Beaverlodge. The Centre develops integrated, sustainable crop and animal production systems and crop varieties for the short-season environments of the Parkland and northwestern Canada. It is also AAFC Research Branch's Centre of Excellence in meat research and has a national mandate to research the ante- and post-mortem factors that influence red meat: yield, quality, safety and preservation. Scientific activities include studies of food safety, red meat quality, carcass grading, cereal breeding and forage/beef research on a global scale.

AAFC Lacombe's research station in Beaverlodge, Alberta is uniquely positioned in the world for its northern locale and agroclimatic region. From this location, Lacombe manages a national research program in apiculture.

Concerning technology transfer, AAFC scientists are involved with producers, companies and other agencies. Thus transfer can mean publishing, field days and direct advice with producers, to contract research for a company, or licensing of AAFC technologies to receptor companies for commercialization. Technology transfer is a major activity of the Department and will likely continue to be even more important with the new national program theme approach.

As an example, the Lacombe Research Centre has licensed a number of technologies including *Computer Vision System* (CVS) software grading system to determine the grade and saleable lean yield of beef. The Canadian Cattlemen's Association describes CVS as "*the most exciting development the industry has seen in 25 years.*" The CVS grading system is being commercialized by Research Management Systems, Inc. of Calgary. The technology is used daily by Cargill Foods, High River, and in plants in the U.S. and Australia. Technology sales are projected to reach $50 million by 2005.
http://scitech.gc.ca/fptt/proceedings00/agbeef.html

2.2.2.6 Animal Disease Research Institute

The Animal Disease Research Institute (ADRI) in Lethbridge is one of 21 laboratories and science centres of the Canadian Food Inspection Agency as mandated by the federal Health of Animals Act. ADRI is CFIA's national Centre of Expertise for animal diseases.

ADRI reports 5.85 FTE of permanent scientists and technology transfer professionals. This staff complement is down from 12 FTE positions several years ago. The establishment maintains a 100 cow herd for research that is not vaccinated and operates a Level 3 bio-containment facility. ADRI works in collaboration with industry, Canada's three levels of veterinary infrastructure, AAFC Lacombe and Lethbridge, and with universities. ADRI and AAFC Lacombe recently conducted contract clinical level research for a U.S. firm where the two establishment's joint R&D expertise and infrastructure uniquely served the firm's needs.

ADRI's scientific activities include risk analysis, surveillance, risk assessments on animals and animal product importations according to the guidelines, technology development for program purposes, assistance in the accreditation of private laboratories, and scientific information and advice to the Animal Product Directorate. Current technology development includes work on bovine and equine indigenous viral diseases, detection of mammalian protein in feeds, production of monoclonal antibodies for incorporation of ELISA for improved accuracy and reporting time in the diagnosis of hog cholera, application of molecular-based techniques to aid in the diagnosis of *Bacillus anthracis*, and application of molecular techniques for the recovery of leptospires from swine.

2.2.2.7 Alberta Research Council

Alberta Research Council (ARC) develops and commercializes technologies to give its clients a competitive advantage. ARC performs applied research and development on a contract or fee basis, and co-ventures with other firms and organizations to develop new technologies.

The ARC's vision statement is *"working with and for Albertans, the ARC will be recognized around the world as Canada's leading knowledge organization in assessing, sourcing, developing and commercializing technologies"*. Its mission statement states *"in partnership with global leaders, the ARC helps advance the economy and well-being of Alberta by providing technology and innovation to meet current and emerging needs of industry and government"*.

ARC's scientific research capacity serving the agriculture and food industries is located in Vegreville and Edmonton. ARC reports a scientific complement of 46.8 FTE permanent scientists and technology transfer professionals working on agricultural issues. ARC's technology transfer activities are described in two parts: first, scientific reporting to clients and extension, and second, conducting partner led technology development and commercialization through joint ventures, contract research, licensing agreements and contract manufacturing in agricultural biologics and pharmaceuticals.

ARC operates under a corporate model with most clients being either companies or government departments seeking specific expertise and solutions to specific problems. One of ARC's performance indicators is the number of technology users, spin off companies or "deals" completed. These performance measures are more comparable to those of the Industry Liaison Offices at Universities, than to provincial departments such as AAFRD. ARC in 2000 completed about 10 agri-food related TT agreements with companies through its Technology Commercialization Office (TCO). Generally, ARC does not provide or appear to intend to provide much technology transfer activity for the agriculture and food sector unless these activities relate directly to contracted research or applied research from which it can derive a return on its R&D investment from the commercialization of new products and services.

2.2.2.8 University of Alberta Department of Agriculture Food and Nutrition Sciences

The University of Alberta's Department of Agricultural, Food and Nutritional Science (AFNS) is a major scientific resource for Alberta's agriculture and food industries. AFNS has 43.2 FTE permanent scientists with broad expertise in plant science, animal science, bio-resource engineering, food science and nutrition. It offers broad interdisciplinary interests and skills across crop, livestock, food, and human nutrition competencies.

AFNS's focuses are teaching and research into efficient and sustainable agricultural production, value-added processing, food safety, and the improvement in health and quality of life through nutrition. With its breadth of expertise, and collaborations with experts in other departments at the University, it can comprehensively study issues of food production, processing and utilization that cross disciplines, departments and industry sectors.

Research in grains, oilseeds, forage and horticultural crops focus on plant breeding, disease resistance, sustainable range management, and other factors affecting plant growth and crop yield is carried out. Dr. Temelli and colleagues have completed and continue with considerable new research into soluble fibres from barley and oats. Dr. Chandinin and his team focus on human nutrition issues. Many other research examples are evident. Utilization of Alberta feedstuffs for livestock concentrates on animal nutrition, utilization of protein and energy, metabolism and reproductive efficiency; the effects of management on the productivity, animal welfare, and the environment.

Research in food science and technology focuses on food safety, value-added processing, product development and food process engineering. AFNS's Food for Health program is building on these strengths to create functional foods and nutraceuticals from plant and animal resources. Technical focus areas include food chemistry, food physics, food microbiology, food safety, food processing, food process engineering involving extraction and fractionation, membrane processes, extrusion processing, emulsion technologies, modified atmosphere packaging and minimal processing, and in sensory and consumer science.

AFNS together with experts in other faculties have world class strengths to study the role of nutrition and diet including the role of dietary fibre, fats, proteins, vitamins and minerals in health and disease, dietary influences on the immune system, and the role of dietary components in the prevention and control of diabetes, heart disease, cancer, osteoporosis and other health conditions.

2.2.2.9 University of Alberta Department of Rural Economy

The Department of Rural Economy at the University of Alberta strives to lead in the discovery, application and dissemination of knowledge of economic, sociological, and business dimensions of agriculture, food, forestry and the environment. Areas of specialization include: the economics of agricultural markets and price behaviour; production economics and farm management, economics of agricultural and rural development, economics of policy intervention, environmental and natural resource economics, forest economics, rural sociology, environmental and resource sociology, resource policy analysis, and agroforestry.

In agriculture and food, Rural Economy has 8.5 FTE permanent professionals and 5.5 technology transfer professionals responsible for an extensive socio-economics library. The Department offers a dual degree of Master of Business Administration and Master of Agriculture in collaboration with the University's Business School. The Department is also the home of the Sustainable Forest Management Network, one of Canada's Network Centres of Excellence.

2.2.2.10 University of Alberta Department of Renewable Resources

The Department of Renewable Resources conducts research and technology transfer of knowledge about natural and managed ecosystems. The Department offers Bachelor and Graduate degree programs in Environmental and Conservation Sciences, Forestry, and Forest Business Management.

The department has 9.2 FTE permanent scientists conducting research activities in agroecosystem modeling, remote sensing, nutrient cycling, range management, conservation biology, protected area management, soil biology, soil chemistry, soil classification, soil fertility, soil genesis, soil physics, water resources, environmental economics and policy, land reclamation, and human dimensions of environmental management.

2.2.2.11 University of Alberta Department of Biological Sciences

The plant biology group of the Department of Biological Sciences has 16 academic staff whose research ranges from the study of the intracellular process to understanding the processes that govern the distributions and evolution of plants through ecological and geological time. Group members are also participants in a new Plant-Animal Interactions Working Group which facilitates collaboration in teaching and research in multi-disciplinary areas of plant-animal interactions.

Other research interests relevant to the agriculture industry include plant community ecology, productivity-competition relationships, grasslands, plant-insect interactions, plant-pathogen interactions,

plant structure, reproductive biology of flowering plants including in-vitro fertilization, embryogenesis and endosperm development in cereals grains, plant molecular biology, plant developmental biology; seed dormancy, germination, seedling growth, plant molecular genetics; plant adaptation to environmental stresses, molecular systematics of seed plants, plant physiology; physiology and biochemistry of metal tolerance in higher plants, and many others.

Research achievements include commercial contracts with Pioneer Hi-Bred International (USA) to develop an in-vitro fertilization system for corn, the Canadian Cold Buster nutritional bar, and $2.5 million in research contracts over the past five years to study bacterial degradation of petroleum pollutants and industrial waste products.

Dr. Good of the department is mapping genes in canola that confer resistance to fungi and insect pests in collaboration with Dr. Gary Stringam of the AFNS Department, and other researchers. The research team has identified DNA markers closely linked to a single dominant gene for blackleg resistance in canola which is present in Australian cultivars and is now in the process of cloning the gene based on its map location. The team is identifying and genetically characterizing pathogen and insect resistance genes in wild *Brassica* and has identified a number of *Brassica* hybrids with insect resistance. This work is supported by funding from NSERC, AAFRD, Zeneca Seeds and Agricore.

AgriGenomics Inc. is a new plant biotechnology company spun-off from the U of A to commercialize basic research discoveries patented by Dr. Good in the area of nitrogen efficient plants. Dr. Good determined that the introduction of a specific aminotransferase gene driven by a stress induced promoter into canola *(Brassica napus)* results in transformed canola plants outperforming control plants by up to 50 to 80% based on fresh weight or dry weight. Research is continuing with funding by an NSERC Strategic grant, Agrium Inc. and an NSERC/AAFC Matching grant. ARC is also an early stage investor and contributor of scientific resources to the venture. AgriGenomics' goal is to build a world-class agricultural biotechnology company committed to reducing chemical inputs into agriculture.

2.2.2.12 University of Calgary Department of Biological Sciences

The University of Calgary reports 15.4 FTE permanent scientists working in basic research in the Department of Biological Sciences with activities of agricultural importance concentrated in environmental sustainability, molecular and cell biology and genetic engineering. Research interests cover a wide field including immunopathogenesis of infectious diseases in livestock, bacterial bio-films in a wide range of situations including cattle rumen and plant diseases, bio-control, genetic engineering of oilseed species, genomics and stress, seed development, structure of proteins including milk and plant proteins, micropropagation of crops species and trees, hormonal control of flowering of cereals and trees, and plant-insect interactions in pollination and damage by insects.

Basic research by Dr. Moloney of the Department of Biological Sciences into "molecular farming" in the late 1980s and early 1990s led to the creation of the university spin-off company SemBioSys Genetics Inc. The Firm's technology platform is anchored on the functional properties and genetic transformation of an oilseed protein called oleosin, and the isolation and purification of native and transformed oil bodies bound by this oleosin. The platform is robust and can be exploited in many oilseed species including canola, flax and safflower. The technology has potential for use in manufacturing of novel ingredients for cosmetics, pharmaceuticals, food and feed. Since 1996, the firm has attracted more than $30 million of private capital to expand basic and applied research, technology development, process design engineering and product development. SemBioSys has a staff complement of 40 to 60 personnel and commissioned a new pilot plant in Calgary in 2001.

2.2.2.13 University of Lethbridge Departments of Biological Sciences and Chemistry & Biochemistry

The University of Lethbridge (U of L) is providing increased R&D services to Alberta's agriculture and food industry. U of L collaborates extensively with AAFC Lethbridge by providing specific basic research expertise, facilities and leadership in initiatives related to livestock, water management and forage management. Research scientists at AAFC

Lethbridge, ADRI and Defense Research in Suffield serve as adjunct professors in Biological Sciences, Chemistry and Biochemistry departments. From a small base of 7.0 FTE permanent scientists serving agriculture and food, U of L is developing recognition for basic research related to large-scale ecosystem interactions, carbon sequestering, climate change, plant physiology, plant hormones, natural products chemistry, genetic and molecular marker techniques, and lipid biosynthesis in oilseed and bovine tissues.

2.2.2.14 Olds College Centre for Innovation

Olds College Centre for Innovation was founded in 1999 to serve as a hub for rural agri-food technology and agribusiness innovation from concept to commercialization. As an agribusiness incubator, it is committed to nurturing value-added activity through applied research and innovation, pilot product testing, knowledge transfer, business development, consulting and network development. OCCI has established expertise and scientists working in composting technology, environmental microbiology, bio-fertilizers, plant physiology, horticulture, new crop development, farm equipment design and engineering, and value-added processing. It is constructing a small-scale extraction and bio-processing pilot plant. OCCI has 8.5 FTE permanent scientists and technology transfer professionals working in environmental sustainability, livestock production, special crops, horticulture, nutraceuticals, functional foods, technology transfer and venture creation.

2.2.2.15 Industry Development Funds

Recently, three Industry Development Funds (IFDs) were established by AFRD to address industry needs. The three funds are Crop, Livestock and Diversified Livestock.

The goals and programs are now being planned and in total involve about $23 million of new money. These funds need to be allocated within the R&D/ TT system to ensure a coordinated approach.

The Livestock Development Fund has four goals:

- develop and implement accredited initiatives to enhance food safety, animal welfare and environmental sustainability;
- increase marketing opportunities and value added developments;
- increase adoption and implementation of sustainable, food safety and animal welfare practices; and,
- strengthen and increase public confidence in Alberta meat and livestock products.

The Fund is directed by a five-person board of Directors and clients may include associations, government, educational organizations and the private sector. The role of the Fund will likely be within the areas of applied research and technology transfer activities, but as of yet is not well developed.

The Crop Industry Development Fund and Diversified Livestock Fund are also in start-up mode. Both will be funders to the R&D/TT system. The potential for overlap with the Agriculture and Food Council program and clients is high and AARI is attempting to develop a collaborative process for decision-making on new projects.

2.2.2.16 Agriculture and Food Council

The Agriculture and Food Council (AFC) has been operating since 1994 and has a number of industry programs to help increase the competitiveness of the sector.

Its role is focused with delivery of Growing Alberta, the CARD program (Canada Adaptation and Rural Development Fund) and a Value Chain Program. A new business management program is in the process of development.

The CARD program has involvement with applied research and technology transfer projects for industry partners. In 2000, AFC completed 26 projects for an investment of $3.4 million and a total of $10 million in other funding. Collaborations with other CARD agencies across Canada has occurred with outputs like the new Western Agri-Food Institute (WAFI), located in Winnipeg and to complete industry wide socio-economic research projects.

CARD has helped to lead the Community Riparian Program in Alberta and secured a new Agriculture Environmental Stewardship Initiative (AESI) of $990,000 over three years. The AFC has noted the success of its approach in the overall system to be a

catalyst for new actions, but has also indicated a potential conflict with the new Industry Development Funds without cooperation and coordination.

2.2.2.17 AVAC Ltd.

Alberta Value Added Corporation Ltd. (AVAC Ltd) has operated since 1997 and is actively involved in the pre-commercialization activities of new agri-value projects in Alberta. Its role is in the areas of applied research assistance, technology transfer and commercialization. The primary focus of AVAC is on the concept of creating "Agrivalue". This is a trademarked term by AVAC. Agrivalue is defined as wellness, industrial products, and new and emerging uses for agriculture products. AVAC is interested in pre-commercialization, venture creation and venture growth and has expanded its staff and intake process to develop more opportunities.

2.2.2.18 University Industry Liaison Office

The University of Alberta has an Industry Liaison Office which helps to encourage technology transfer of new discoveries. The University of Calgary has University Technologies International Inc. (UTI) which is a for profit entity. Each has a similar function - license new discoveries, complete patents and provide a contracting function for companies interested in a specific scientists' research.

These TT functions on behalf of the universities work well and have operated for a number of years. The capacity for more spin-off companies and technology licensing agreements in Alberta is significant, providing receptor companies can be located. This is a constraint to TT from these organizations.

As of 2000, the U of A ILO has created 49 spin-off companies, with eight being inactive. The companies have created 906 jobs and all companies are located in Alberta. Five of the companies are publicly traded with a capitalization of more than $1 billion. The sector breakdown is:

- 58% are life science companies;
- 25% are basic science companies; and,
- 17% are ICT companies.

Research at the University of Alberta totals about $214 million with $35 million from industry sources. The U of A is in the top five of Canadian universities in research investments. In 2000, the U of A received $122,000 in royalties, researchers disclosed 64 new inventions, 609 patents were filed and 15 patents were issued. From a comparison with other Canadian universities, Alberta is ahead in the approach and results of the technology transfer efforts.

2.2.2.19 University of Calgary: University Technologies International Inc.

University Technologies International Inc. is the University of Calgary's technology commercialization entity. It was established in 1989 to identify and help commercialize new technologies and ideas, primarily from the University, but also from outside and the private sector. UTI has a staff of 15 people. It is financially supported by Alberta Innovation and Science, but also generates an increasing portion of its revenues from clients. Over the past year, UTI has signed 135 disclosure agreements, of which 50% were from within the university, and the balance from the private sector and other institutions. Over the past year, it has done 30 deals for technology commercialization, and is currently working with 150 companies. It has promoted the establishment of the Alberta Technology Commercialization Net-work (ATCN).

UTI has generated a number of successful spin-off companies. SemBioSys is a principal example. SemBioSys received an investment from Dow AgroSciences Canada of $17 million in 1997 and has subsequently raised an additional $16 million in 2000 from a syndicate of US investors. This is an example of a potential global growth opportunity arising from basic research in a life science discipline where the commercial partner is introduced to the research discovery through the TT system.

It is estimated that 30 to 40% of all commercialization revenue has been generated between the ILO, and UTI in Canada over the past years. Only 1% of venture capital firms are resident in Alberta. Alberta receives only 3.5% of Canada's venture capital. Of this, the bulk goes to the oil and gas industry, and for later stage projects. Venture capital is an issue for the system.

Table 2.3 summarizes the scientific and technical focus of the key research and technology transfer providers in the province. In addition, the core competencies, clients, and collaborating partners are identified.

Table 2.3
Key Alberta R&D and TT System Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		UNIVERSITY OF ALBERTA		
Edmonton	➠ plant breeding (canola) ➠ sustainable range management ➠ animal digestion, metabolism and reproductive efficiency ➠ effects of management on the productivity and well-being of farm animals, and the environment ➠ food safety systems ➠ value-added processing ➠ product and process development ➠ functional foods and nutraceuticals ➠ use of dietary fibre, fats, proteins, vitamins and minerals in health and disease ➠ nutrients and diet influence on the immune system ➠ reproductive efficiency in meat/poultry ➠ production efficiency and economics	➠ food chemistry ➠ food physics ➠ food microbiology ➠ food process engineering ➠ sensory and consumer science ➠ botany ➠ canola breeding ➠ beef and pork production ➠ Poultry Research Centre ➠ Sinclair Swine Research Centre ➠ Metabolic Research Centre ➠ Crops Research Centre ➠ research labs	➠ private companies ➠ government agencies ➠ research scientists	➠ Cross faculties: physical education, pharmacology, medicine, chemistry, business ➠ Provincial and federal governments ➠ AAFC ➠ Producer groups ➠ Industry and other organizations ➠ Alberta Agriculture Research Institute ➠ Alberta Cattle Commission ➠ Alberta Barley Commission ➠ Alberta Milk Producers
Kinsella	➠ University Research Farm – beef and bison production (3200 ha)	➠ agronomic practices	➠ industry	➠ Industry
Ellerslie	➠ sustainable crop production ➠ rotation studies	➠ Ellerslie long-term crop rotation (1920's)	➠ industry ➠ government	➠ Alberta Research Council
Breton	➠ soil management ➠ zero till ➠ agronomics	➠ research plots (1929)	➠ government ➠ industry/producers	➠ National/international
Ministick Wildlife Field Station	➠ wild ruminants (260 ha for elk production)	➠ nutrition ➠ production	➠ industry	➠ Industry
U of A *Agricultural Food & Nutritional Science*	➠ production efficiency and sustainability ➠ agri-food technology ➠ nutrition and human health	➠ 170 staff in food for health initiative ➠ 3 professors have 3M teaching award ➠ production to nutrition	➠ research ➠ industry ➠ government	➠ Industry ➠ Medicine, physical education, dentistry, cross-faculty - AAFRD ➠ ASRA, CIHR ➠ AARI ➠ ARC/NRC

Table 2.3
Key Alberta R&D and TT System Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		UNIVERSITY OF ALBERTA		
Renewable Resources	➠ sustainable agriculture ➠ forest biotech, production ➠ reclamation ➠ soil research/quality ➠ landscape ecology ➠ manure management/client change	➠ Breton Plots (1929) ➠ soil science ➠ reclamation ➠ wildlife ➠ sustainable crop systems	➠ research ➠ industry	➠ AAFRD ➠ Industry ➠ ARC ➠ Adjunct Professor
Rural Economy	➠ agricultural economics ➠ forest economics ➠ resource economics ➠ marketing ➠ agri-business ➠ finance and risk management ➠ rural and environmental sociology	➠ forest and resource economics (WC) ➠ economics ➠ agro-forestry	➠ research ➠ government	➠ NCE ➠ AARI ➠ Prairie Genome
Human Ecology	➠ textiles ➠ consumer studies ➠ community studies	➠ textiles ➠ forestry health ➠ consumer behaviour	➠ research	
Faculty of Science	➠ transgenic plants	➠ agrigenomics ➠ research		➠ ARC
		UNIVERSITY OF CALGARY		
U of Calgary	➠ plant biotech and transgenics ➠ genomics	➠ biotech ➠ water quality ➠ genomics	➠ research	➠ U of A ➠ AAFC ➠ Private companies ➠ National
		UNIVERSITY OF LETHBRIDGE		
Lethbridge	➠ plant physiology ➠ enzyme additives for livestock production ➠ agricultural production economics ➠ molecular biology ➠ analysis of plant development ➠ plant phylogenetic relationships ➠ ecology and pest management ➠ weed bio-control ➠ water management	➠ biotechnology ➠ genomics ➠ transgenics	➠ public research	➠ AAFC ➠ ARC ➠ NSERC ➠ U of A ➠ U of C

Table 2.3
Key Alberta R&D and TT System Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
	ALBERTA AGRICULTURE, FOOD & RURAL DEVELOPMENT (AAFRD)			
Principal Agency	➠ livestock and crops ➠ forages ➠ foods ➠ new uses ➠ socio-economic/markets ➠ competitiveness issues	➠ applied research ➠ technology transfer ➠ production systems	➠ public ➠ producers ➠ companies ➠ associations/industry groups ➠ government	➠ Western Forage Beef Group ➠ U of A ➠ Industry ➠ AAFC ➠ ARC
CDC North (Edmonton)	➠ entomology (pest management, biological control agents) ➠ plant pathology (plant diseases) ➠ horticulture industry development (farmer's markets; fruit crops, greenhouse crops, nursery crops) ➠ seed potatoes, vegetables ➠ special/new crops (pulse crops, herbs/ spices)	➠ horticulture ➠ new crops ➠ special	➠ producers ➠ producer organizations ➠ processing companies	➠ AAFC ➠ ARC ➠ Producer organizations ➠ U of A ➠ OCCI ➠ ATO Netherlands ➠ Companies ➠ Europe/USA research facilities
CDC South (Brooks)	➠ processing of essential oil crops ➠ production techniques for greenhouse crops ➠ biological controls ➠ post-harvest technology	➠ horticulture production ➠ new crop development ➠ IPM	➠ producers ➠ producer organizations ➠ processing companies	➠ AAFC ➠ Producer organizations ➠ ARC ➠ Companies ➠ Research facilities: China, Pakistan, US ➠ U of S, horticulture
Lacombe	➠ breeding of barley, triticale, and winter wheat ➠ agronomy of oilseed crops ➠ forage production/utilization	➠ breeding/variety development ➠ grazing management ➠ forage	➠ public research ➠ associations ➠ companies – seed	➠ CIMMYT, ICARDA, AAFC ➠ Alberta Barley Commission ➠ Barley Development Council ➠ U of A ➠ Western Forage Beef Group ➠ ARC ➠ Companies
Agronomy Unit	➠ building and delivering integrated soil, crop and pest management systems ➠ primary competitiveness ➠ variety testing ➠ sustainable production systems ➠ manure management ➠ greenhouse gasses	➠ dryland and irrigation production systems	➠ producers ➠ AAFRD specialists ➠ industry associations	➠ AAFC ➠ ARC ➠ U of A ➠ TT with AAFRD ➠ Companies ➠ Producer organization

Table 2.3
Key Alberta R&D and TT System Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		ALBERTA AGRICULTURE, FOOD & RURAL DEVELOPMENT (AAFRD)		
Agri-Industrial Technology Centre (Edmonton)	➠ developing new equipment technologies ➠ equipment evaluation ➠ industrial uses (non-food)	➠ engineering (process, chemical, agri)	➠ producer associations ➠ companies	➠ Leduc F.P.D. Centre ➠ ARC ➠ U of A ➠ Industry
Leduc Food Processing Development Center	➠ foods – processed ➠ functional foods ➠ meats	➠ processed meats ➠ fractionation ➠ product development ➠ sensory evaluation	➠ companies (SME) ➠ entrepreneurs	➠ U of A ➠ ARC ➠ Industry Groups ➠ Netherlands/Japan ➠ Canadian Food Development Centres (5)
Lethbridge Irrigation Branch	➠ irrigation management ➠ water management practices	➠ water management ➠ irrigation system design and management	➠ producers ➠ Irrigation Districts ➠ government	➠ International projects ➠ CIDA ➠ Irrigation Districts (13)
Economic Services (Edmonton)	➠ international trade ➠ markets ➠ economics	➠ Cost of Production ➠ statistics	➠ producers ➠ public ➠ government	
Agricultural Technology Centre	➠ technology transfer	➠ test facilities and engineering expertise to evaluate, design and modify farm machinery and equipment	➠ farmers, innovators, small business and manufacturers	➠ Universities in USA and Canada, colleges, applied research associations, producer groups and associations, ACC, Alberta Pork, ARC, AAFC, Natural Resource Canada ➠ Canadian Wind Energy Association ➠ Prairie Implement Manufacturers Associations ➠ Dealers and AB Transportation.
Western Forage/Beef Group	➠ Reduce forage and beef production cost, maximize profit, develop beef production and sustainable forage/beef systems and maintain a forage/beef centre of excellence for research and transfer of information and knowledge	➠ forage physiology, mgmt., grazing mgmt., variety adaptation, weed physiology ➠ beef management and nutrition ➠ beef cattle and forage extension	➠ beef producers ➠ cow-calf operators ➠ small feedlots ➠ agri-businesses such as forage seed and herbicide companies	➠ AAFC Research Centres ➠ Universities ➠ Provincial research centres, in western Canada ➠ Extension personnel, producer groups ➠ Individual producers.

Table 2.3
Key Alberta R&D and TT System Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		AGRICULTURE AND AGRI-FOOD CANADA (AAFC)		
Lethbridge	➠ beef cattle genetics ➠ livestock physiology livestock pests ➠ nutritional and management ➠ feed microbiology biotechnology ➠ range management ➠ water and air quality ➠ manure management ➠ soil management ➠ new cultivars in wheat (winter and soft white wheat), ➠ beans, potatoes and forages ➠ disease resistance ➠ cropping systems ➠ weed bio-control	➠ livestock sciences ➠ land resource sciences ➠ crop sciences ➠ long-term crop rotations (76 yrs) ➠ cow herd (1961) ➠ manure management trials (25 yrs) ➠ plants- novel traits (12 yrs) ➠ National Beef Centre ➠ rumen microbiology world class (WC) ➠ livestock genomics and entomology (WC) ➠ cereal breeding (WC)	➠ private companies ➠ producer associations ➠ industry ➠ producers ➠ beef industry ➠ government ➠ international	➠ Canadian beef associations ➠ ARC ➠ U of A ➠ U of G ➠ U of L and U of C ➠ CIDA/International ➠ CFIA ➠ Private companies (biotech, animal health, seed) ➠ Veterinarians ➠ USDA ➠ NRC PBI ➠ Lethbridge region "Cluster" ➠ AAFRD
Lacombe	➠ food safety (HACCP – plant) ➠ red meat quality ➠ carcass grading ➠ cereal breeding ➠ forage/beef	➠ National Meat Centre ➠ meat research (WC) ➠ plant and soil	➠ meat plants ➠ producer associations ➠ industry associations ➠ CFIA	➠ AAFRD ➠ Producer groups ➠ Meat processing industry ➠ USDA ➠ Alberta Pulse Growers ➠ Alberta Canola Growers
Beaverlodge	➠ crop production systems ➠ honey bees and other pollinating insects ➠ grass seed production ➠ soil physics ➠ integrated crop systems ➠ canola breeding ➠ soil microbial ecology	➠ northern crop production (canola, forages, grass seed) ➠ new greenhouse facility (canola)	➠ seed companies ➠ producer associations ➠ industry associations ➠ honey industry ➠ producers	➠ Producer associations ➠ Private companies ➠ AAFRD ➠ ARC

Table 2.3
Key Alberta R&D and TT System Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		ALBERTA RESEARCH COUNCIL (ARC)		
Vegreville	➠ integrated pest (insects, disease & weeds) management ➠ integrated manure utilization ➠ development of diagnostic tools ➠ plant biochemistry, transgenics/molecular farming ➠ toxicology – livestock, oil industry interactions, animal health ➠ development of native plants ➠ biocontrol technologies ➠ nutrient control and abatement ➠ impact of air emissions on crops ➠ cropping systems ➠ composting technologies ➠ technology transfer ➠ sustainable agriculture ➠ agglomeration – waste product utilization ➠ climate change technologies ➠ industrial ecology – impact & sustainability, odour detection/control technologies ➠ sustainable range and repair in ecosystems ➠ predictive landform / soil mapping ➠ rural water supplies	➠ ecological pest management in crops ➠ pest bio-control ➠ toxicology-food safety ➠ native grasses and legumes ➠ industrial ecology ➠ geomatics ➠ remote sensing ➠ molecular biology ➠ specialized laboratories, greenhouse growth chamber and field facilities, animal pathology ➠ biochemical inhalation toxicology ➠ wildlife ➠ reclamation ➠ water quality and reuse ➠ soil science ➠ climate change mitigation and adaptation ➠ biofixation ➠ impace of ethylene ➠ ozone exposure ➠ analytical chemistry (organic and inorganic)	➠ private companies ➠ AAFRD ➠ AARI ➠ Climate Change Centre ➠ Alberta Environment ➠ Sustainable Resource Development ➠ producer associates ➠ Canadian Association of Petroleum Producers ➠ petrochemical companies ➠ Government of Alberta ➠ Alberta Cattle Commission ➠ Alberta Health	➠ Government of Alberta ➠ University of Alberta ➠ University of Calgary ➠ University of Lethbridge ➠ University of British Columbia ➠ Joint ventures with private companies (biotech, ag. chem., seed, oil/gas) ➠ Industry associations (CAPP, ACC) ➠ AAFC ➠ AARI ➠ Producer associations (canola, pulse growers, horticulture, potatoes) ➠ CASA, AESA ➠ Alberta Environment ➠ Andrews University ➠ Alberta Pork ➠ Prairie Swine Centre ➠ Plant Biotechnology Institute (Saskatoon) ➠ Olds College

Table 2.3
Key Alberta R&D and TT System Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		ALBERTA RESEARCH COUNCIL (ARC)		
Edmonton	➠ scale-up and manufacture of biotechnology-based products, including vaccines to improve animal health ➠ synthesis of novel carbohydrates for diagnostic and therapeutic applications ➠ improved processing and products for OSB engineered composite and pulp and paper industry ➠ new products for agri-fibres ➠ research to advance the practice of forestry and sustainability of its ecosystems ➠ value added processing	➠ environmental technologies - water ➠ fermentation-based products (vaccines) ➠ agri-fibre (straw) ➠ pulp processing technologies ➠ applied research ➠ contract vaccine manufacturer for biotech/ animal health ➠ climate change ➠ biotech fermentation plant (15,000 l) ➠ OSB pilot plant ➠ Technology Commercialization Office (TCO)	➠ private companies (biotech) ➠ forest company consortia ➠ government – federal & provincial ➠ producers	➠ VIDO ➠ Vetrepharm ➠ Philom Bio/MBR ➠ Alberta Technology Commercialization Network ➠ U of A ➠ U of C ➠ OSB industry, eg. Tolko, Weldwood, Weyerhauser, etc. ➠ Private companies (MBR-Saskatoon) ➠ Intervet – Belgium ➠ Saskatchewan Research Council ➠ Industry associations (Forintek, PAPRICAN, etc.) ➠ CONRAD ➠ Leduc Food Processing Development Centre ➠ P.O.S. – Saskatoon ➠ AAFRD ➠ AARI
Calgary	➠ data mining ➠ decision support through data analysis ➠ web-based systems architecture and software design	➠ ICT ➠ asset tracking (cattle and equipment)	➠ private companies	➠ Landview ➠ U of C ➠ Precarn
		COLLEGES		
Fairview	➠ primary production	➠ technology transfer ➠ agri-production ➠ golf course management ➠ silviculture	➠ producers	➠ Industry

Table 2.3
Key Alberta R&D and TT System Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		COLLEGES		
Olds College and Olds College Centre of Innovation	➠ horticulture ➠ applied research – agri-industry ➠ composting ➠ processing of new crops ➠ venture creation ➠ venture growth	➠ composting ➠ horticulture ➠ agriculture production ➠ technology transfer	➠ horticulture industry ➠ companies ➠ producers ➠ entrepreneurs	➠ Producers ➠ AVAC ➠ ARC ➠ Industry
Vermilion	➠ environmental technologies ➠ agricultural production	➠ technology transfer	➠ producers	➠ AAFRD
Lethbridge	➠ water quality improvement ➠ aquaculture technologies	➠ aquaculture ➠ technology transfer	➠ public research	➠ Eastern Irrigation District

Table 2.4
Applied Research/Technology Transfer/Commercialization Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		UNIVERSITIES		
U of Alberta	➠ life science spin-off and contracting	➠ technology transfer ➠ licensing ➠ patents ➠ contracting	➠ companies ➠ scientists	➠ Alberta Technology Commercialization network ➠ Westlink (Western Canada Universities) ➠ ARC
U of Calgary University Technologies Inc.	➠ life science spin-off and contracting	➠ technology transfer ➠ licensing ➠ patents ➠ contracting	➠ companies ➠ scientists ➠ private sector	➠ ATCN
U of Lethbridge	➠ work with AAFC and U of C	➠ N/A	➠ scientists	➠ AAFC ➠ ATCN

Table 2.4
Applied Research/Technology Transfer/Commercialization Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		ALBERTA RESEARCH COUNCIL		
ARC-Technology Commercialization Office (TCO)	➠ Life Science spin-off, joint venture & contracting ➠ technology development & commercialization	➠ technology evaluation ➠ technology transfer ➠ licensing ➠ patents ➠ contracting ➠ joint ventures	➠ companies/private sector ➠ scientists/engineers ➠ other research organizations	➠ ATCN ➠ NRC/IRAP ➠ U of A ➠ Westlink ➠ Inno-Centre Alberta ➠ Foragen Technology Ventures Inc. ➠ Innovation Centres ➠ Private sector
		ALBERTA APPLIED RESEARCH ASSOCIATIONS		
Battle River Research Group	➠ forage ➠ livestock ➠ direct seeding ➠ herbicide evaluation ➠ variety demonstrations ➠ special crops	➠ applied research ➠ regional priorities ➠ technology transfer	➠ producers ➠ AARI ➠ AAFRD	➠ Other agencies ➠ Private companies ➠ AFRD ➠ ARI
Chinook Applied Research Association	➠ transfer of technology ➠ crops ➠ livestock ➠ soil	➠ applied research ➠ technology transfer ➠ regional priorities	➠ producers ➠ AARI ➠ AAFRD	➠ AAFRD ➠ ARI
Gateway Research Organization	➠ conservation ➠ agricultural techniques ➠ crop production ➠ livestock production	➠ applied research ➠ technology transfer ➠ regional priorities	➠ producers ➠ AARI ➠ AAFRD	➠ AAFRD ➠ Agricore ➠ AAFC ➠ ACPC ➠ ARI
Lakeland Agricultural Research Association	➠ improving animal and plant performance ➠ promote environmental stewardship	➠ applied research ➠ technology transfer ➠ regional priorities	➠ producers ➠ AARI ➠ AAFRD	➠ ARI ➠ AAFRD

Table 2.4
Applied Research/Technology Transfer/Commercialization Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
ALBERTA APPLIED RESEARCH ASSOCIATIONS				
North Peace Applied Research Association	➠ soil and water conservation ➠ agriculture production ➠ technology transfer	➠ applied research ➠ technology transfer ➠ regional priorities	➠ producers ➠ AARI ➠ AAFRD	➠ Other agencies ➠ Private companies ➠ AAFRD ➠ ARI
Smokey Applied Research and Demonstration Association	➠ farm demonstrations ➠ agriculture production	➠ applied research ➠ technology transfer ➠ regional priorities	➠ producers ➠ AARI ➠ AAFRD	➠ ARI ➠ AAFRD
Fairview Applied Research Association	➠ crops ➠ forages ➠ weed control ➠ equipment	➠ applied research ➠ technology transfer ➠ regional priorities	➠ producers ➠ AARI ➠ AAFRD	➠ AAFRD ➠ Agricore ➠ ACPC ➠ ARI
Southern Alberta Applied Research Association	➠ farm demonstrations ➠ agriculture production	➠ applied research ➠ technology transfer ➠ regional priorities	➠ producers ➠ industry ➠ AARI ➠ AAFRD	➠ AAFRD ➠ ARI ➠ AAFC
CANADIAN FOOD INSPECTION AGENCY				
Animal Disease Research Institute, Lethbridge	➠ food safety ➠ animal health ➠ international standards and methods ➠ lab accreditation ➠ research	➠ animal disease diagnostics ➠ lab accreditation ➠ animal health testing ➠ import/quarantine	➠ AAFC ➠ companies ➠ international agencies	➠ AAFC – animal health program ➠ National lab system – 21 labs
Calgary	➠ food safety ➠ grading and inspection	➠ methodologies ➠ testing	➠ industry	➠ AAFC ➠ Canadian Grain Commission
COMMODITY GROUPS				
Alberta Canola Producers Commission	➠ improved canola varieties ➠ utilization of canola seed ➠ development of value-added canola products ➠ developing future uses of canola	➠ funding from industry ➠ producer priorities ➠ technology transfer ➠ production research centres	➠ producers ➠ processors ➠ government	➠ Canola Council of Canada ➠ AAFC ➠ ARA's ➠ AARI ➠ ARC ➠ AAFRD

Table 2.4
Applied Research/Technology Transfer/Commercialization Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		COMMODITY GROUPS		
Alberta Barley Commission	➠ competitiveness ➠ new uses ➠ fractionation processes ➠ production	➠ funding from industry ➠ producer priorities ➠ technology transfer	➠ producers ➠ processors ➠ government	➠ AARI ➠ U of A ➠ U of M ➠ Canada/Alberta Barley Development Agreement – Lacombe ➠ ARC ➠ AAFRD
Alberta Pork Develop. Corp.	➠ industry research programs ➠ nutrition and health ➠ reproductive physiology ➠ environment and housing ➠ infrastructure	➠ funding from industry ➠ producer priorities ➠ technology transfer	➠ producers ➠ processors ➠ government	➠ AARI ➠ Private companies ➠ U of A – new research center ➠ Prairie Swine ➠ VIDO ➠ Canadian Pork Council ➠ ARC ➠ AAFRD
Alberta Potato Growers Marketing Board	➠ production and management	➠ funding from industry ➠ producer priorities ➠ technology transfer	➠ producers ➠ processors ➠ government	➠ AAFRD ➠ AAFC – Lethbridge (five scientists) ➠ ARC
Alberta Pulse Growers Commission	➠ production and management – new varieties ➠ feed uses	➠ funding from industry ➠ producer priorities ➠ technology transfer	➠ producers ➠ government	➠ ARA's ➠ AARI ➠ ARC
Alberta Soft White Wheat Producers Commission	➠ wheat breeding ➠ production	➠ funding from industry ➠ producer priorities ➠ technology transfer	➠ producers ➠ government	➠ AAFC – Lethbridge
Alberta Sugar Beet Producers Marketing Board	➠ production and storage ➠ bio-controls	➠ plots – Burdett and Taber ➠ producer priority ➠ fund source ➠ technology transfer	➠ producer ➠ processors ➠ government	➠ AAFC – Lethbridge ➠ Rogers Sugar

Table 2.4
Applied Research/Technology Transfer/Commercialization Performers

Organization/ Location	Key Agri-Food Focus	Core Competencies	Clientele	Linkages / Collaborations
		COMMODITY GROUPS		
Alberta Sheep and Wool Commission	➠ grazing ➠ production/ID ➠ value chain ➠ disease and flock health	➠ producer priorities ➠ fund source	➠ producers ➠ processors (Canada West Foods)	➠ AAFC – Lethbridge ➠ AAFRD ➠ Canada West Foods - products
Alberta Turkey Board	➠ animal care ➠ production efficiency	➠ producer priorities ➠ fund source	➠ producers ➠ government	➠ AAFRD ➠ U of A Poultry Research Centre ➠ Alberta Research Council
Alberta Egg Producers Marketing Board	➠ national center for research ➠ animal care ➠ production	➠ producer priorities ➠ fund source	➠ producers ➠ government	➠ AAFRD – Dr. Hansen ➠ U of A
Alberta Hatching Egg Producers Marketing Board	➠ production ➠ keep Alberta research viable	➠ producer priorities ➠ fund source	➠ producer ➠ ACPB ➠ government	➠ U of A ➠ AAFRD
Alberta Chicken Producers Marketing Board	➠ keep Alberta research viable ➠ production ➠ value chain	➠ producer priorities ➠ fund source	➠ producer ➠ government	➠ U of A ➠ AAFRD
Alberta Cattle Commission	➠ beef demand ➠ animal care ➠ production ➠ animal identification	➠ producer priorities ➠ fund source	➠ producer ➠ government	➠ AAFC – Lethbridge ➠ U of C - $1 m program ➠ Beef Information Centre ➠ AAFRD ➠ CCA ➠ CCIA ➠ ARC- ABIDF

2.3 INDUSTRY SURVEY ANALYSIS

Over 18 meetings were held in Lethbridge, Calgary, Lacombe, and Edmonton with industry, government, R&D performers, and agencies and organizations involved in technology transfer and commercialization activities in Alberta. Over 60 professionals in the industry were interviewed on a one-on-one basis in this process. A conclusion expressed by virtually all individuals consulted was that there is a strong need for action and leadership at this time. The time for talk and analysis is coming to an end.

It was noted from the interviewees that Alberta is not ranked well compared to other regions of Canada. Ontario is a clear leader in research within the agriculture and agri-food sector in Canada. Quebec is considered second, and Saskatchewan third. Alberta and Manitoba are searching for the fourth and fifth place.

In total, 59 written surveys were submitted and analyzed. The sample was divided into two samples, one being the primary R&D providers and technology agents, such as the Universities and AAFC, and the other being industry, technology transfer, and commercialization agents. While there were not strong differences between the responses between the two groups, the results are reviewed and discussed separately.

Primary Results**:**

1. The first question analyzed was "*Who was viewed as the main research competitor to the Albertan research provider?"* The responses showed first that the U.S. is viewed most frequently as a key competitor. University providers were less likely to view the U.S. as a competitor. They were more likely to view AAFC, or other universities as their competitors.
2. The second question was "*How does Alberta rank itself relative to other research providers in other jurisdictions, as ahead, equal to, or behind other providers?"* Twenty-one percent of respondents ranked Alberta ahead of competitors, 27% behind, and the balance about the same. In general, Alberta ranks itself not significantly different compared to other provinces and jurisdictions in its capacity to provide research and development and technology transfer expertise.
3. A series of questions ranked various characteristics of Alberta R&D and TT system on a 1-5 ranking, in which 1 strongly disagree, 5 strongly agree, and 3 is a mid-point and do not agree or disagree. The ranking by question, and for each of the two respondent groups is presented in the table below.

Statement/Question	Primary Research Providers	Technology Transfer & Commercialization Agents
Alberta has a world class R&D system	**3.0**	2.9
Alberta has a world class TT system	2.6	2.7
Alberta has a clearly defined R& D strategy	2.8	2.7
Alberta has a clearly defined TT strategy	2.6	2.7
Alberta needs a stronger focus on R&D	4.1	4.0
Alberta needs a stronger focus on TT	4.1	3.8
The overall system needs more integration	4.2	3.9
We have world class R&D competency	3.3	3.6
We have world class TT Competency	2.8	3.1
We have a clearly defined R&D strategy	3.3	3.6
We have a clearly defined TT strategy	2.8	2.8
We need a stronger focus on R&D	3.4	3.5
We need a stronger focus on TT	3.3	3.4
We need more resources to become world class.	4.3	4.3

Source: Alberta Industry Survey, August, 2001, 59 completed surveys by industry.
Note: "We" refers to respondent.

The major conclusions drawn from the above table are:

- The respondents slightly disagreed with the statement that Alberta has a world class R&D or TT system, or a strategy for achieving world class status.

- There was a very strong indication and agreement that Alberta needs a much stronger focus on R&D and TT. The responses from the universities were marginally higher in this regard.
- There is strong agreement the system needs much more integration. In fact, this factor ranked about the highest, with the exception of the statement that the system needs more resources.
- It is interesting to note that where the institutions were asked to rank their competency, and strategy, invariably they ranked themselves higher than they ranked the balance of the Alberta R&D and TT system providers. They indicate that they are adequate, but the rest of the system has a problem.
- By a significant margin, all respondents indicated that the system needs more resources to become a world class.
- Respondents agreed over the need for a strong focus required within the R&D and TT system.
- There does not seem to be a significant difference between the two respondent groups.

4. Gaps In the System: An important question asked was with respect to what were the gaps in the Alberta R&D system. The respondents were asked to rank their perceived gaps in order of priority. An analysis was done on the respondents first and second choice gaps. The greatest gap identified was with respect to research funding, at 36% as indicated by the respondents. The second priority, equipment and infrastructure was identified as being a gap by 25% of the people. Having good researchers and better coordination were equally the third most important gap, at about 16% each.

   The related question was with respect to the gaps in the TT system. The respondents identified the lack of incubators as the greatest gap. Some 25% of the respondents identified this as the greatest gap. Lack of venture funds were identified as the second most important gap, with 24% of the respondents indicated this result. The lack of commercial partners was identified as the third most important gap with 21% indicating this.

5. Comments on System by Survey Respondents: The comments from the surveys were visually scanned, and an extraction of the most important and most repeated comments made were recorded. The list follows.

What are the Best Things about the Alberta R&D and TT System?

- Research infrastructure
- Critical mass
- Strong support among AAFRD specialists
- Strong animal industry research sector
- AARI – no other province has such an entity
- Cooperation among researchers
- Willingness of granting agencies to work with researchers
- People
- Quality of researchers
- Facilities and infrastructure at U of A
- Collaboration and cooperation of all segments of industry
- Availability of funding
- Good industry base
- Good vision
- Vaccine development for beef and pork
- Diversity
- Collaboration between scientists
- Scope of agriculture has been broadened to environmental issues
- New initiatives – IDF's
- Lots of new prospects, opportunities

What are the Worst Things about the Alberta R&D and TT system?

- No coherence
- No peer review at AARI
- Too focused on primary agriculture
- Funding for commercialization is scarce
- System in constant state of flux, and uncertainty of direction
- Focus on applied, means future innovation will be compromised
- Too many funding agencies, disjointed funding system

- Weak university agriculture systems
- No processing and marketing system
- Insufficient funding support
- Lack of emphasis on basic versus applied research
- Lack of infrastructure
- Bureaucracy
- Short term view
- Need for research to be goal oriented, and producer focused
- Lack of researchers for research positions.
- No money
- Old culture, old way of doing things
- All talk, no support from outside agriculture
- Decreasing government support
- Applied products
- Lack of clear long term strategy and will to implement it
- Fragmentation
- Funding bias to R&D i.e. heritage funds
- No strategic vision to address long term issues
- Lack of information for processing regulatory hurdles
- Lack of explicit definitions around current phases as value added
- Lack of implementation abilities at government level
- Lack of direction
- Failure to build an integrated network for adaptive/validation research and TT
- Failure to build on or maintain current infrastructure

What are the greatest competencies within the Alberta R&D and TT system?

- Primary industry is beef
- Agronomy
- Technology transfer
- Beef/ pork/ crops
- Meat quality
- Ruminant nutrition
- Swine reproduction
- Extrusion processing, meat processing
- Industrial products
- Facilities and staff at U of A, and pork and poultry
- Beef, barley, potatoes
- Our competitive advantage will be related to how quickly and effectively we can integrate new technologies and products into our production systems.
- Western forage/beef alliance

Where do we need to invest in the Alberta R&D and TT system?

- Natural health products
- New uses
- Functional foods
- Bio-products
- Sustainable livestock production systems.
- AAFRD needs to keep support of basic elements of production
- Bio-processing and bio-products
- Toxicology of oilfield substances in cattle
- Bio-controls
- Basic technologies

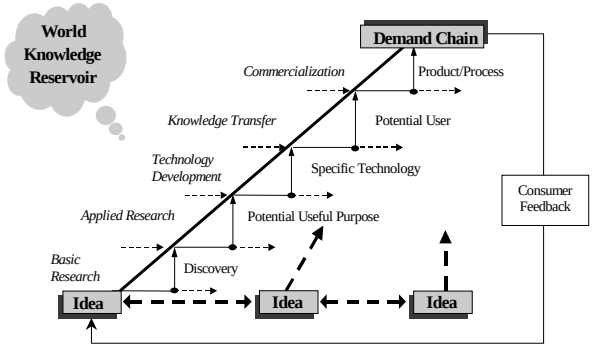
3.0 INVESTMENT IN ALBERTA AGRICULTURE AND FOOD R&D AND TECHNOLOGY TRANSFER SYSTEM

3.1 R&D AND TECHNOLOGY COMMERCIALIZATION CONTINUUM

AARI uses a six-category model to describe activities in research and technology commercialization. The R&D and Technology Commercialization Continuum includes the following:

- ***Basic research*** – understanding how things work.
- ***Applied research*** – application of basic findings to potentially useful purposes.
- ***Technology Development*** – using basic and applied knowledge to develop specific technology.
- ***Technology and Knowledge Transfer*** – process of moving new technology and knowledge to potential users.
- ***Commercialization and Utilization*** – process of making new technology and knowledge available for commercial or non-commercial production and distribution.
- ***Unallocated***

Figure 3.1
R&D and Technology Commercialization Continuum



The boundaries separating the six categories of the Technology Commercialization Continuum are far from clear and many interpretations exist. The continuum of knowledge generation and commercialization is a much more complex and synergistic than illustrated. Innovators feed off ideas generated in many different disciplines and industries. Knowledge and technology from the world reservoir of knowledge that might be useful to Alberta can be generated at any level of the continuum, imported to Alberta at any level, and also exported for use elsewhere. As Canada only produces 2 to 3% of the world knowledge, it is critical that Canada and Alberta be efficient harvestors and receptors of knowledge, as well as generators of new knowledge in areas that are of strategic importance.

The following descriptors were prepared by S. J. Campbell Investments Ltd. (1999) to provide examples and guidance to R&D Performers as to how they might allocate their R&D and TTC investment to the six categories in the R&D and Technology Commercialization Continuum.

Basic Research – *understanding how things work.* Examples include the discovery of a new disease resistance gene, report of a new composition of matter, or demonstration of a new mode of action. The work will normally become the subject of peer reviewed scientific publications or patent applications. These publications should most often represent the first disclosure of new knowledge, whether made public or not. The specific commercial or non-commercial use of the discovery may be uncertain and the benefit of the discovery uncertain.

Applied Research – *application of basic findings to potentially useful purposes*. Includes work to validate newly reported discoveries through independent study and report it in peer reviewed scientific or proprietary literature.

Includes work to characterize and extend a new discovery, including scientific work to support utility and process patents related to an earlier discovery. Includes research to demonstrate the food, feed and environmental safety of a new trait.

Technology Development *– using basic and applied knowledge to develop specific technology*. Examples are plant breeding to transfer traits to regionally adapted varieties with commercial potential. Variety registration trials. Research to demonstrate food, feed and environmental safety of a candidate variety or product. Pilot plant processing of new varieties and species that might be produced in Alberta.

Technology and Knowledge Transfer *– process of moving new technology and knowledge to potential users.* Examples include work to conduct variety recommendation trials or evaluate the utility of a new technology, process or product for commercial or non-commercial use. Includes proof of concept work to support an early-stage decision to attempt to commercialize a technology new to Alberta. Evaluation of technology developed elsewhere (outside Alberta or outside firms active in Alberta) for use in Alberta. Pilot plant work to establish and validate state-of-the-art process design parameters for new construction.

Commercialization and Utilization *– process of making new technology and knowledge available for commercial or non-commercial production and distribution.* Examples includes pilot plant work to reduce a new technology to practice; on-farm or in-plant demonstrations of new products or procedures; or work to establish technical requirements for seed multiplication and establish new identity preservation systems. Work to demonstrate the utility and social and economic benefits of a new technology, product or procedure to users and society.

Unallocated Work not elsewhere specified but pertaining to "new" technology or maintenance of an established technology subject to a current regulatory review. Work includes development of standard methodologies for regulatory or trade requirements and sample preparation at a pilot plant for customer or regulatory evaluation prior to commercial production.

In the Alberta context, the R&D and Technology Commercialization Continuum focuses on "new" technology – new to science, but also new to the Alberta agriculture and food industry, or new and improved in its use and benefits to Albertans.

Once a technology is introduced and demonstrated to be useful at various locations in Alberta or for specific segments of society, continued investment either by government or industry to demonstrate technology or products to more and more users and to society in general is viewed to be education, extension or marketing, depending on the circumstances.

Marketing, extension or education activities to promote proven technology or products are not considered to be part of the R&D and Technology Commercialization Continuum, even though they are important economic and social development activities that are critical to industry development and growth, and require science-trained individuals and scientific protocols for successful program delivery, decision making and industrial performance.

3.2 R&D AND TT INVESTMENT IN ALBERTA IN 2000/01

3.2.1 Total R&D and TT Investment Activity

For 2000/01, the total annual investment in operating costs in agriculture and food R&D/TT in Alberta at public R&D establishments and selected industries is estimated at $134.5 million. This includes costs for permanent scientists, term professionals, support staff, graduate students and technology transfer professionals, but does not include maintenance.

This R&D/TT activity was directed by 584.0 permanent scientists, technology transfer professionals and R&D/TT managers (in full time equivalents – FTE). Operating and facility costs of technology transfer officers working outside an R&D Performer such as a university technology commercialization office, or working for community-based business incubators, project developers, or seed and venture capital firms are not included in these estimates.

Table 3.1
R&D/TT Investment Activity

Alberta Agriculture & Food R&D and TTC Activity	Permanent Professionals		Location A-Base Funds	External Government Grants	External Industry Grants	Total	% of Total
	FTE	FTE % of Focus	million dollars				
Basic and Applied Research							
Environment	113.5	*19.4%*	$ 16.5	$ 4.3	$ 4.6	$ 25.4	*18.9%*
Plants & Plant Products	133.8	*22.9%*	$ 16.9	$ 4.5	$ 6.6	$ 28.1	*20.9%*
Livestock and Animal Products	145.8	*25.0%*	$ 23.3	$ 6.8	$ 7.8	$ 37.9	*28.2%*
Niche Processed Products	70.1	*12.0%*	$ 6.0	$ 1.9	$ 10.7	$ 18.6	*13.8%*
sub total	463.2	*79.3%*	$ 62.7	$ 17.6	$ 29.7	$ 110.0	*81.8%*
Technology Development	31.5	*5.4%*	$ 6.0	$ 0.2	$ 0.2	$ 6.3	*4.7%*
Knowledge and Technology Transfer	57.6	*9.9%*	$ 8.8	$ 0.2	$ 0.2	$ 9.1	*6.8%*
Commercialization	14.7	*2.5%*	$ 3.8	$ 0.1	$ 1.1	$ 4.9	*3.7%*
Other	17.0	*2.9%*	$ 3.4	$ 0.6	$ 0.2	$ 4.2	*3.1%*
sub total	120.8	*20.7%*	$ 21.9	$ 1.0	$ 1.6	$ 24.5	*18.2%*
Total $	584.0	*100.0%*	$ 84.6	$ 18.6	$ 31.3	$ 134.5	*100.0%*
% of Total			*62.9%*	*13.8%*	*23.3%*	*100.0%*	

These estimates were developed from data provided by R&D/TT managers at AAFC, AAFRD, ARC, Olds College Centre for Innovation, U of A, U of C, and U of L.

Industry's share of R&D/TT investment is very significant, but information on this activity is proprietary or never reported. The estimates also do not include industrial R&D/TT activities of national and international firms outside Alberta, which result in viable products that are useful to Alberta farmers and processors and are introduced via commercial market channels. Our estimates include R&D/TT activity by several public traded firms, principally in new uses, as well as an estimate of private plant breeding and animal genetics in Alberta.

Core (A-base) operating and capital funds at public institutions represent 62.9% of the total R&D/TT investment, external government grants 13.8%, and external industry grants and direct investment 23.3%. Industry's investment in R&D will be greater than indicated and government investment lower, given that many national and international agribusinesses conduct R&D/TT for application in Alberta, but information on this activity is proprietary. Our estimates include the activity by several public traded firms, principally in new uses, as well as an estimate of private plant breeding and animal genetics in Alberta.

We expect that the total R&D/TT investment reported underestimates the actual R&D/TT investment only to the extent of $5 to 8 million, and much of this would reflect industry investment.

R&D/TT expenditures by program area in 2000/01 were estimated to be: 18.9% in environmental issues, 20.9% in plants and plant products (not including forage which is included in beef), 28.2% in animal, animal products and forage, and 13.8% in niche processed products and new uses not included in the plants and animals focus areas. Taken together, technology development, technology and knowledge transfer, and commercialization activities were 18.2% of the total investment.

3.2.2 R&D and TT Activity by Sponsoring Organization

The share of R&D/TT conducted at federal, provincial, university and selected industry establishments is summarized in Table 3.2. About 29.8% of the province-wide R&D/TT in dollar value is conducted at federal establishments of the Research Branch of AAFC in Lethbridge, Lacombe and Beaverlodge and the Animal Disease Research Institute of CFIA near Lethbridge. The Alberta government conducts 37.6% of the R&D/TT at AAFRD locations across the province and at ARC in Vegreville and Edmonton. Universities and colleges

account for 20.2% of the agriculture and food R&D/TT with the greatest portion conducted at the U of A in Edmonton. Industry is estimated to conduct about 12.4% of the province-wide R&D/TT, in its own facilities.

Table 3.1 represents R&D/TT activity at these establishments and not the source of funding for R&D/TT. In all program areas, there are high levels of scientific and management collaboration between establishments with federal, provincial, university and/or industry scientists working together in teams at one establishment. Many examples exist where federal scientists work at provincial establishments and provincial scientists work in federal or university establishments. Industry scientists work in their own establishments and also at other establishments. Industry also funds research conducted at federal, provincial and university establishments.

3.2.3 Investment Across the R&D and Technology Transfer Commercialization Continuum

The number of permanent scientists and technology transfer professionals and the investment by organization across the R&D and Technology Commercialization Continuum is provided Table 3.2.

Table 3.2
R&D/TT Activity by Sponsoring Organization, 2000/01

Stage in R&D and TTC Continuum and Program Area	Federal	Provincial	University & Colleges	Industry	Total	% of Total
	million dollars					
Basic and Applied Research						
Environment	$ 9.2	$ 7.3	$ 7.5	$ 1.5	$ 25.4	*18.9%*
Plants & Plant Products	$ 8.7	$ 12.2	$ 5.7	$ 1.7	$ 28.1	*20.9%*
Livestock and Animal Products	$ 19.0	$ 8.6	$ 7.4	$ 2.8	$ 37.9	*28.2%*
Niche Processed Products	$ 0.9	$ 4.1	$ 4.1	$ 9.5	$ 18.6	*13.8%*
sub total	$ 37.8	$ 32.2	$ 24.6	$ 15.4	$ 110.0	*81.8%*
Technology Development	$ 0.2	$ 5.3	$ 0.7	$ 0.1	$ 6.3	*4.7%*
Knowledge and Technology Transfer	$ 0.3	$ 8.2	$ 0.4	$ 0.3	$ 9.1	*6.8%*
Commercialization	$ 0.6	$ 3.2	$ 0.4	$ 0.8	$ 4.9	*3.7%*
Other	$ 1.2	$ 1.7	$ 1.2	$ 0.1	$ 4.2	*3.1%*
sub total	$ 2.4	$ 18.3	$ 2.6	$ 1.3	$ 24.5	*18.2%*
Total $	$ 40.1	$ 50.5	$ 27.2	$ 16.7	$ 134.5	*100.0%*
% of Total	*29.8%*	*37.5%*	*20.2%*	*12.4%*	*100.0%*	

Table 3.3
Investment Across the R&D and Technology Commercialization Continuum in Alberta in 2000/01

Alberta Agriculture & Food R&D/TT Performer	Permanent Professionals		R&D, Technology Transfer and Commercialization Continuum $ million							
	Basic & Applied Research	TT & Mgnt	Total R&D/TT	Basic Research	Applied Research	Tech. Dev.	Knowledge & Technology Transfer	Commercial-ization	Other Including Mgmt	Total R&D and TTC
AAFC Lethbridge	103.1	3.0	$ 23.8	$ 5.9	$ 17.3	$ 0.2	$ 0.2	$ 0.3	$ -	$ 23.8
AAFC Lacombe/Beaverlodge	26.0	6.0	$ 12.0	$ 2.5	$ 7.8	$ -	$ 0.1	$ 0.3	$ 1.2	$ 12.0
CFIA ADRI Lethbridge	5.4	0.0	$ 4.3	$ -	$ 4.3	$ -	$ 0.0	$ -	$ -	$ 4.3
AAFRD	165.7	86.0	$ 36.7	$ 2.0	$ 20.9	$ 3.8	$ 8.1	$ 2.0	$ -	$ 36.7
ARC	28.2	18.6	$ 13.8	$ -	$ 8.0	$ 1.5	$ 0.1	$ 1.2	$ 3.0	$ 13.8
Olds College and OCCI	8.3	2.0	$ 2.4	$ -	$ 1.9	$ 0.1	$ -	$ 0.1	$ 0.3	$ 2.4
U of A AFNS	40.2	3.0	$ 12.7	$ 2.5	$ 8.6	$ 0.6	$ 0.2	$ -	$ 0.8	$ 12.7
U of A Renewable Resources	9.0	0.2	$ 1.2	$ 0.3	$ 0.5	$ 0.1	$ 0.2	$ 0.1	$ 0.0	$ 1.2
U of A Rural Economy	8.5	0.0	$ 3.8	$ 0.8	$ 3.0	$ -	$ -	$ -	$ -	$ 3.8
U of A BioSciences & Others	6.6	0.0	$ 2.1	$ 2.1	$ -	$ -	$ -	$ -	$ -	$ 2.1
U of C BioSciences & Others	14.4	1.0	$ 3.4	$ 3.1	$ -	$ -	$ -	$ 0.3	$ -	$ 3.4
U of L BioSciences & Others	7.0	0.0	$ 1.6	$ 1.5	$ -	$ 0.1	$ -	$ -	$ -	$ 1.6
Industry & NGO	40.8	1.0	$ 16.7	$ 4.5	$ 10.9	$ 0.1	$ 0.3	$ 0.8	$ 0.1	$ 16.7
Total	463.2	120.8	$ 134.5	$ 25.2	$ 83.1	$ 6.5	$ 9.2	$ 5.0	$ 5.5	$ 134.5

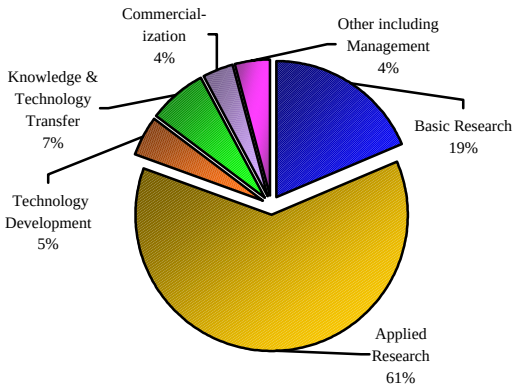
By far, the most significant performer is AAFRD with 251.7 professionals involved in R&D /TT, and an investment of $36.7 million annually. The second largest performer is AAFC, with 106.1 professionals and an investment of $23.8 million annually. Next is the ARC with 46.8 professionals involved in R&D/ TT, and invest $13.8 million annually. The U of A, AFNS closely follows with 43.2 professionals, and a $12.7 million annual investment, and AAFC Lacombe/ Beaverlodge with 32 professionals and $12 million annual investment.

In the table above, we have identified activity by Olds College and Olds College Centre for Innovation in R&D/TT. Other community colleges in Alberta include Grande Prairie Regional College, Fairview College, Northern Lights College, Lakeland College, Red Deer College and Lethbridge Community College. These institutions have educational programming in agriculture and food but only minor roles at present in R&D/TT.

3.2.4 Basic and Applied Research versus Technology Transfer & Commercialization

The distribution of total investment of $134.5 million by all performers across the R&D/TT continuum is illustrated in the figure below.

Figure 3.1
Total R&D/TT Investment in 2000/01 ($134.5 million)

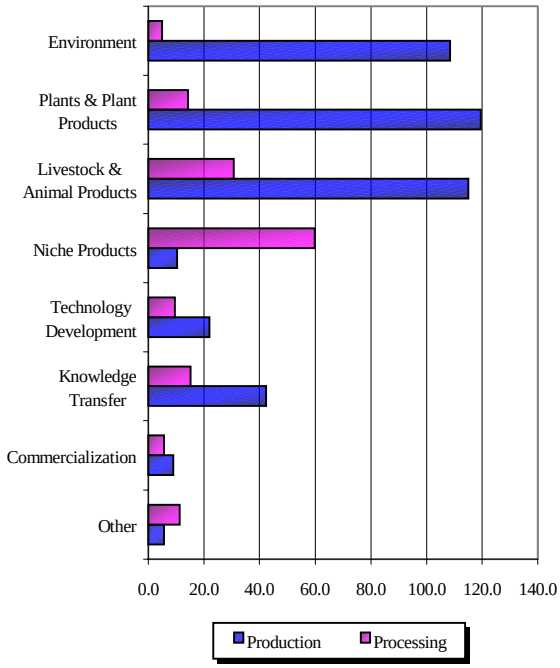


Investment in basic and applied research in 2000/01 amounted to $108.3 million or 80.5% of total R&D/ TT investment. We estimate there were 463.2 FTEs (permanent scientists) at public R&D establishments and in industry working in basic and applied R&D.

3.2.5 R&D Investments in Production versus Processing

An increase in value-added processing in Alberta is an important objective. The allocation of permanent scientists and TT professionals between production & processing R&D is an indicator of the R&D/TT system's response to this challenge. The allocation of permanent professionals between production and processing by program area in 2000/01 is estimated in the figure below.

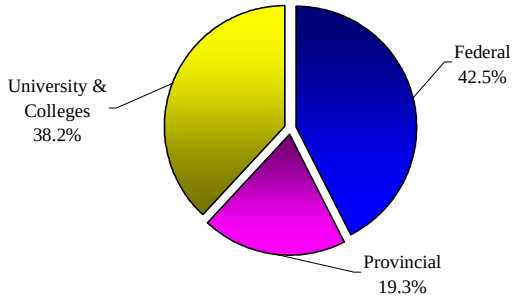
Figure 3.3
Permanent Professionals In Production and Processing R&D/TT



3.2.6 Capital Expenditures

R&D/TT performers spent about $5.7 million in 2000/01 to renew R&D/TT infrastructure. Major renewal projects included $2.2 million at AAFC Lacombe, about $2.0 million at the U of A, $1.0 million at ARC and $200,000 at Olds College Centre for Innovation. A very large capital program was initiated at AAFC Lethbridge but is not represented in the investment data. AAFRD had little in the way of capital expenditures in 2000/01.

Figure 3.4
Capital Expenditures in R&D/TT in 2000/01



Over the long term, we suggest that annual capital expenditures for equipment and infrastructure in public R&D facilities should represent about 10% of total annual investment in R&D/TT, including operating expenditures.

3.2.7 Detailed Information on R&D and TT Resources

The tables following provide detailed information on R&D and TT activities by program areas for each of the R&D Performers in the province.

Table 3.4
R&DTT Activities by Program Area

Alberta Agriculture & Food Focus & Performer	Permanent Scientists		R&D/TT Operating Funds				R&D/TT Capital Funds	
	FTE	FTE % of Focus	Location A-Base Funds	External Government Grants	External Industry Grants	Total Operating Funds	Location Funding	External Funding
BASIC AND APPLIED RESEARCH								
Environment								
AAFC Lethbridge	37.2	32.8%	$ 5,372,977	$ 1,302,800	$ 1,065,200	$ 7,740,977		
AAFC Lacombe/Beaverlodge	4.0	3.5%	$ 1,300,000	$ 90,000	$ 40,000	$ 1,430,000	$ 1,500,000	
CFIA ADRI Lethbridge	0.0	0.0%				$ -		
AAFRD	27.0	23.8%	$ 5,010,000			$ 5,010,000		
ARC	8.2	7.2%	$ 1,372,000	$ 758,000	$ 148,000	$ 2,278,000	$ 23,000	
OCCI	3.0	2.6%	$ 330,000	$ 90,000	$ 310,000	$ 730,000		
U of A AFNS	4.3	3.8%	$ 513,323	$ 515,225	$ 133,266	$ 1,161,814		
U of A Renewable Resources	8.5	7.5%	$ 527,700	$ 305,130	$ 281,880	$ 1,114,710	$ 38,782	$ 155,131
U of A Rural Economy	3.0	2.6%	$ 196,000	$ 371,000	$ 756,000	$ 1,323,000		
U of A BioSciences & Others	3.3	2.9%	$ 429,000	$ 462,000	$ 176,000	$ 1,067,000		
U of C BioSciences & Others	7.0	6.2%	$ 910,000	$ 320,000	$ 60,000	$ 1,290,000		
U of L BioSciences & Others	4.0	3.5%	$ 520,000	$ 118,000	$ 131,000	$ 769,000		
Industry & NGO	4.0	3.5%	$ -	$ -	$ 1,500,000	$ 1,500,000		
sub total	113.5	100.0%	$ 16,481,000	$ 4,332,155	$ 4,601,346	$ 25,414,501	$ 1,561,782	$ 155,131
Plants and Plant Products								
AAFC Lethbridge	30.7	22.9%	$ 3,971,247	$ 1,111,700	$ 1,360,200	$ 6,443,147		
AAFC Lacombe/Beaverlodge	5.0	3.7%	$ 1,280,000	$ 505,000	$ 422,000	$ 2,207,000	$ 700,000	
CFIA ADRI Lethbridge	0.0	0.0%				$ -		
AAFRD	63.4	47.4%	$ 7,114,000	$ 400,000	$ 1,622,000	$ 9,136,000		
ARC	8.8	6.6%	$ 2,122,000	$ 710,000	$ 186,000	$ 3,018,000		
OCCI	4.0	3.0%	$ 440,000	$ 100,000	$ 330,000	$ 870,000		
U of A AFNS	5.1	3.8%	$ 584,629	$ 543,344	$ 226,132	$ 1,354,105	$ 3,200	
U of A Renewable Resources	0.0	0.0%				$ -		
U of A Rural Economy	1.5	1.1%	$ 98,000	$ 186,000	$ 378,000	$ 662,000		
U of A BioSciences & Others	3.3	2.5%	$ 429,000	$ 462,000	$ 176,000	$ 1,067,000		
U of C BioSciences & Others	5.5	4.1%	$ 715,000	$ 370,000	$ 270,000	$ 1,355,000		
U of L BioSciences & Others	1.5	1.1%	$ 195,000	$ 138,000	$ 15,000	$ 348,000	$ 11,000	
Industry & NGO	5.0	3.7%	$ -	$ -	$ 1,650,000	$ 1,650,000		
sub total	133.8	100.0%	$ 16,948,876	$ 4,526,044	$ 6,635,332	$ 28,110,252	$ 714,200	$ -

Source: Industry Meeting of R&D Performers.

Table 3.5
R&D/TT Activities by Program Area

Alberta Agriculture & Food Focus & Performer	Permanent Scientists		R&D/TT Operating Funds				R&D/TT Capital Funds	
	FTE	FTE % of Focus	Location A-Base Funds	External Government Grants	External Industry Grants	Total Operating Funds	Location Funding	External Funding
BASIC AND APPLIED RESEARCH								
Livestock and Animal Products								
AAFC Lethbridge	33.7	23.1%	$ 5,445,171	$ 1,202,000	$ 1,812,226	$ 8,459,397		
AAFC Lacombe/Beaverlodge	16.0	11.0%	$ 3,800,000	$ 1,475,000	$ 1,005,000	$ 6,280,000		
CFIA ADRI Lethbridge	5.4	3.7%	$ 4,199,610	$ 74,300	$ 10,400	$ 4,284,310		
AAFRD	57.0	39.1%	$ 4,228,000	$ 150,000	$ 303,000	$ 4,681,000		
ARC	10.2	7.0%	$ 3,033,000	$ 820,000	$ 77,000	$ 3,930,000	$ 520,000	
OCCI	0.3	0.2%	$ 36,300		$ 20,000	$ 56,300		
U of A AFNS	14.8	10.2%	$ 1,624,785	$ 1,925,540	$ 1,888,457	$ 5,438,782	$ 55,519	$ 595,820
U of A Renewable Resources	0.5	0.3%	$ 26,070	$ 15,000	$ 13,860	$ 54,930	$ 1,907	$ 7,629
U of A Rural Economy	2.5	1.7%	$ 163,000	$ 309,000	$ 631,000	$ 1,103,000		
U of A BioSciences & Others	0.0	0.0%	$ -	$ -	$ -	$ -		
U of C BioSciences & Others	1.6	1.1%	$ 208,000	$ 155,000	$ 45,000	$ 408,000		
U of L BioSciences & Others	1.5	1.0%	$ 195,000	$ 60,000	$ 131,000	$ 386,000		
Industry & NGO	2.3	1.5%	$ 300,000	$ 600,000	$ 1,900,000	$ 2,800,000		
sub total	145.8	100.0%	$ 23,258,936	$ 6,785,840	$ 7,836,943	$ 37,881,719	$ 577,426	$ 603,449
Niche Processed Products								
AAFC Lethbridge	1.5	2.1%	$ 214,300	$ 167,300	$ 147,600	$ 529,200		
AAFC Lacombe/Beaverlodge	1.0	1.4%	$ 320,000		$ 80,000	$ 400,000		
CFIA ADRI Lethbridge	0.0	0.0%				$ -		
AAFRD	18.3	26.1%	$ 3,937,000		$ 100,000	$ 4,037,000		
ARC	1.0	1.4%	$ 86,000			$ 86,000		
OCCI	1.0	1.4%	$ 110,000	$ 110,000		$ 220,000		$ 175,000
U of A AFNS	16.0	22.8%	$ 1,192,778	$ 1,432,305	$ 500,111	$ 3,125,194	$ 54,010	$ 691,273
U of A Renewable Resources	0.0	0.0%				$ -		
U of A Rural Economy	1.5	2.1%	$ 98,000	$ 186,000	$ 378,000	$ 662,000		
U of A BioSciences & Others	0.0	0.0%	$ -	$ -	$ -	$ -		
U of C BioSciences & Others	0.3	0.4%	$ 39,000	$ 40,000		$ 79,000		
U of L BioSciences & Others	0.0	0.0%				$ -		
Industry & NGO	29.5	42.1%	$ -	$ -	$ 9,450,000	$ 9,450,000		
sub total	70.1	100.0%	$ 5,997,078	$ 1,935,605	$ 10,655,711	$ 18,588,394	$ 54,010	$ 866,273
Total Basic and Applied Research	**463.2**		**$ 62,685,890**	**$ 17,579,644**	**$ 29,729,332**	**$109,994,866**	**$ 2,907,418**	**$ 1,624,853**

Source: Industry Meeting of R&D Performers.

Table 3.6
R&D/TT Activities by Program Area

Alberta Agriculture & Food Focus & Performer	Permanent Scientists		R&D/TT Operating Funds				R&D/TT Capital Funds	
	FTE	FTE % of Focus	Location A-Base Funds	External Government Grants	External Industry Grants	Total Operating Funds	Location Funding	External Funding
TECHNOLOGY TRANSFER								
Technology Development								
AAFC Lethbridge	0.0	0.0%	$ 200,000			$ 200,000		
AAFC Lacombe/Beaverlodge	0.0	0.0%				$ -		
CFIA ADRI Lethbridge	0.0	0.0%				$ -		
AAFRD	26.0	82.5%	$ 3,780,000			$ 3,780,000		
ARC	5.0	15.9%	$ 1,295,000	$ 155,000	$ 61,000	$ 1,511,000	$ 550,000	
OCCI	0.5	1.6%			$ 100,000	$ 100,000		
U of A AFNS	0.0	0.0%	$ 558,151			$ 558,151		
U of A Renewable Resources	0.0	0.0%				$ -		
U of A Rural Economy	0.0	0.0%				$ -		
U of A BioSciences & Others	0.0	0.0%	$ -	$ -	$ -	$ -		
U of C BioSciences & Others	0.0	0.0%				$ -		
U of L BioSciences & Others	0.0	0.0%				$ -		
Industry & NGO	0.0	0.0%	$ 125,000	$ -	$ -	$ 125,000		
sub total	31.5	100.0%	$ 5,958,151	$ 155,000	$ 161,000	$ 6,274,151	$ 550,000	$ -
Knowledge and Technology Transfer								
AAFC Lethbridge	1.0	1.7%	$ 150,000			$ 150,000		
AAFC Lacombe/Beaverlodge	2.0	3.5%	$ 120,000			$ 120,000		
CFIA ADRI Lethbridge	0.0	0.0%	$ 31,800			$ 31,800		
AAFRD	53.8	93.4%	$ 8,087,000			$ 8,087,000		
ARC	0.8	1.4%	$ 57,000	$ 34,000	$ 1,000	$ 92,000		
OCCI	0.0	0.0%				$ -		
U of A AFNS	0.0	0.0%	$ 237,512			$ 237,512		
U of A Renewable Resources	0.0	0.0%				$ -		
U of A Rural Economy	0.0	0.0%	$ -			$ -	$ 20,000	$ 100,000
U of A BioSciences & Others	0.0	0.0%	$ -	$ -	$ -	$ -		
U of C BioSciences & Others	0.0	0.0%				$ -		
U of L BioSciences & Others	0.0	0.0%		$ 127,000		$ 127,000		
Industry & NGO	0.0	0.0%	$ 98,000	$ -	$ 156,000	$ 254,000		
sub total	57.6	100.0%	$ 8,781,312	$ 161,000	$ 157,000	$ 9,099,312	$ 20,000	$ 100,000

Source: Industry Meeting of R&D Performers.

Table 3.7
R&D/TT Activities by Program Area

Alberta Agriculture & Food Focus & Performer	Permanent Scientists		R&D/TT Operating Funds				R&D/TT Capital Funds	
	FTE	FTE % of Focus	Location A-Base Funds	External Government Grants	External Industry Grants	Total Operating Funds	Location Funding	External Funding
Commercialization								
AAFC Lethbridge	2.0	13.6%	$ 318,000			$ 318,000		
AAFC Lacombe/Beaverlodge	2.0	13.6%	$ 300,000			$ 300,000		
CFIA ADRI Lethbridge	0.0	0.0%				$ -		
AAFRD	6.2	42.2%	$ 1,114,000		$ 897,000	$ 2,011,000		
ARC	3.0	20.4%	$ 1,148,000	$ 12,000		$ 1,160,000		
OCCI	0.5	3.4%			$ 100,000	$ 100,000		
U of A AFNS	0.0	0.0%				$ -		
U of A Renewable Resources	0.0	0.0%				$ -		
U of A Rural Economy	0.0	0.0%				$ -		
U of A BioSciences & Others	0.0	0.0%	$ -	$ -	$ -	$ -		
U of C BioSciences & Others	1.0	6.8%	$ 190,000	$ 30,000	$ 60,000	$ 280,000		
U of L BioSciences & Others	0.0	0.0%				$ -		
Industry & NGO	0.0	0.0%	$ 690,650	$ 23,000	$ 52,200	$ 765,850		
sub total	14.7	100.0%	$ 3,760,650	$ 65,000	$ 1,109,200	$ 4,934,850	$ -	$ -
Total TT/Commercialization	103.8		$ 18,500,113	$ 381,000	$ 1,427,200	$ 20,308,313	$ 570,000	$ 100,000
OTHER R&D/TT (not above, generally senior management and overheads)								
AAFC Lethbridge	0.0	0.0%	$ -		$ -	$ -	$ 210,000	
AAFC Lacombe/Beaverlodge	2.0	11.8%	$ 760,000	$ 300,000	$ 180,000	$ 1,240,000		
CFIA ADRI Lethbridge	0.0	0.0%				$ -		
AAFRD	0.0	0.0%				$ -		
ARC	9.8	57.6%	$ 1,682,000			$ 1,682,000		
OCCI	1.0	5.9%		$ 300,000		$ 300,000	$ 200,000	
U of A AFNS	3.0	17.6%	$ 819,146			$ 819,146	$ 52,000	
U of A Renewable Resources	0.2	1.2%	$ 31,075			$ 31,075		
U of A Rural Economy	0.0	0.0%				$ -		
U of A BioSciences & Others	0.0	0.0%	$ -	$ -	$ -	$ -		
U of C BioSciences & Others	0.0	0.0%				$ -		
U of L BioSciences & Others	0.0	0.0%				$ -		
Industry & NGO	1.0	5.9%	$ 130,000	$ -	$ -	$ 130,000		
sub total	17.0	100.0%	$ 3,422,221	$ 600,000	$ 180,000	$ 4,202,221	$ 462,000	$ -
TOTAL R&D/TT	584.0		$ 84,608,224	$ 18,560,644	$ 31,336,532	$134,505,400	$ 3,939,418	$ 1,724,853

Source: Industry Meeting of R&D Performers.

It is significant to note that the industry and NGO investment is underestimated in the above table. It is anticipated that $5 to $8 million of investment could be added to this table is this respect. Current information collection systems do not adequately allow for their quantification and allocation.

As well, the information for the "Other" category is inconsistent as the different agencies provided information differently and it was not all verified. The industry performer factors are also not complete as the information gathered focused on the public sector.

4.0 SIGNIFICANT RESEARCH AND ECONOMIC TRENDS

The following sections identify some of the major trends which have been and are occurring in Alberta. These trends are grouped into economic and social trends, and technical/agronomic trends.

4.1 ECONOMIC AND SOCIAL TRENDS

1. *Global Competition and Trade is Increasing With Trade Agreements and New Markets:* The aggressive approach of NAFTA, FTAA, and other regional trade agreements has helped to open up agriculture trade. This is forcing nations to understand competitive and comparative advantages for their internal industries. Related to this is the rise of global communication through the internet, more travel, and development of virtual organizations which can respond quickly to market demands. Globalization is driving changes in many areas. The next round of the WTO negotiations will be held over the next few years and impacts will follow.

2. *Industry Consolidation/Industrialization of Agriculture:* One strong trend is the continuation of industry consolidation and the industrialization of agriculture. For example, in the Canadian agriculture sector, the grain industry now has three to four major companies collecting the grain, two to three major dairy processors, two to three major beef processors, two to three major hog processors and so on. Consolidation will continue in the sector and has implications for R&D and TT performers.

3. *Industrialization of Agriculture:* This means the farm sector is facing real structural changes. This is creating many classes of farms and farmers (e.g. full-time and part-time), more specialized production and a move away from commodity agriculture. Commodity agriculture is changing to "products", value chains and alliances with production centres. The new face of agriculture in North America is moving to more organized products which are directly tied to an end market. Information and use of technology is a key element in achieving these types of niche products (Industrialization of Heartland Agriculture, 1995).

4. *Risk and Government Role:* One of the outcomes of increased competition is pressure on the Canadian agri-food sector. Currently the farm sector is facing major survival challenges, especially in the grains and oilseeds industries. The lack of cash flow in the sector has compromised farm and agri-businesses viability and resulted in a pull-back of commercial extension related activities. In addition, the government extension activities and sources of technology and extension information have been reduced in past years due to budget cuts. Some new sources have emerged from the use of internet-based suppliers.

5. *Rise of Food Safety Concerns:* Consumers have food safety concerns for several reasons. With the increase in biotechnology applications and its image, the use of genetically modified organisms (GMOs) cause some consumers to fear biotech foods. Biotech companies have raised consumer fears, not expectations (Kerr, 1999). GMO products are being studied by three EU committees on possible food safety concerns. In Canada, consumers have not accepted Monsanto's BST (bovine somatatrophin) milk products, but in the U.S., BST is being used. GMOs may in fact become trade barriers, depending on the consumer reaction. Conversely, the rise of organic foods is the mirror industry rising in demand. There is a "distrust" of science and technology to its generators and advocates.

   Further, the outbreak of BSE in the UK led to a huge beef industry loss, and decline in per capita beef consumption, although consumption was already in decline. Hudson Meats was forced to close after a food poisoning event in a U.S. food restaurant. To counter this concern in North America and elsewhere, the introduction of HACCP (Hazard Analysis Critical Control

Point) and food quality programs has occurred. Recent Mad Cow and Foot and Mouth disease events in Europe pose further sector difficulty. Food safety risks to human and other organisms are a major concern, and are the policy thrust of many governments. Consumers continue to be concerned and many jurisdictions have invested in research programs to address it.

6. *Value Added Products are Increasing in Demand:* Consumers want value added products. They have less time, smaller families and cook less. The time from preparation to eating is now only 15 minutes, down from 1 hour in 1960 (SCI). Demographics and lifestyles are a bigger factor than ever before. Consumers can be described as:

   - ready and run - they have no time;
   - au naturale - they seek organic products;
   - meat avoiders and vegetarians - they have a particular taste; and,
   - income constrained - lack resources.

   The move from commodity sales to more value added product sales will continue. A related trend is the move to private label sales - in Canada about 25% of products are now private label. This compares to 20% in the U.S. and even higher in the UK. Some grocery chains have been very successful in their approach to creating a "brand" with quality attributes (e.g. Presidents Choice).

7. *Concerns About Environmental Effects:* In the U.S. and Canada, large concentrated populations of beef, dairy, poultry and hogs are causing concern. In North Carolina, the state actively recruited hog farms and as a result, also a new processor. The environmental problems which resulted from this has now created huge problems for the state. In western Canada, with reductions in feed grain transport subsidies, hog and beef industry intensive expansion is actively being pursued, but is facing questions on the limits to growth.

   All provinces and many states are seeing reactions by rural residents and neighbours on the issue. For example, development permits for new hog farms are being turned down because of concerned neighbours. The concerns tend to be: property value impacts, aesthetics, flies/rodents, soil contamination, dust, water quality, odour, traffic, noise. To overcome this development issue, people need to consult in advance, manage manure and odours, and have a good neighbour policy. More technology transfer is needed, in addition to other environmental solutions. Cereal and botanical producers have not been faced with as large an issue.

   A related environmental issue is the Kyoto Protocol (1997) on climate change and emissions. Using agriculture lands as carbon sinks to consume carbon dioxide can offer emitters of carbon dioxide positive benefits say some proponents. Consumers are concentrating in cities and urban habitats, creating the need for "balance" and demand for natural wild areas to visit for many non-market purposes. Agriculture can offer many non-market benefits - recreation, aesthetics, spiritual, cultural and historical- to many individuals and communities.

8. *Life Sciences, Biotechnology and Genomics:* These are emerging and create an uncertain question in many jurisdictions. Life sciences and biotechnology are being developed as a "new industry" in many regions and jurisdictions. The USA has over 27 state biotech associations. Biotechnology applications in agriculture, environmental, forest and health industries are used by many including researchers, farmers, manufacturers and companies. The latter will take biotech products into the market. Biotechnology tools and products may enter many new and emerging global market niches, including nutraceuticals, functional foods, animal and human health products, food, and forest applications.

   In the U.S., about 60% of the corn and 50% of the soybean crop is a GMO variety. Many food products use corn as an ingredient (or a component of corn) and possibly 60 to 70% of processed foods may contain a GMO ingredient (Dr. Gordon Surgenor, 1999). Bio (USA biotech association) reports there were 6 million acres of biotechnology crops in 1996. By 1997, U.S./Canada had 20-25 million acres, China 5 million acres, Australia 1 million acres, and the world 30 to 35 million acres of biotechnology crops. In 1998, the world acreage in biotechnology crops was 69.5 million acres.

Agriculture biotechnology applications are forecast to grow dramatically. The global market for transgenic crops is expected to be $6 billion by 2005. The use of BT (Bacillus thuringiensis) corn and other BT crops provide a $20 to $75 per acre advantage (NBAC, 1998).

9. *Technology, Competitiveness and Productivity are Global Market Drivers:* The rapidly changing role and impact of new manufacturing technologies and equipment on companies will continue to affect business productivity and overall competitiveness. The "technology treadmill" is a boon and a challenge as it offers immediate access to productivity gains. Borne out of this context of technology change will also emerge many new small businesses which are labelled as "gazelles" fast moving, flexible and mobile. Other "workhorses" in the economy such as agriculture will need to change direction with use of new technologies. Although Canada is rated as the best place to live, it is not yet rated as the top in productivity and competitiveness. This gap needs attention and is a major concern of other governments. Technology, knowledge and human resources are central topics to productivity issues. Consequently, effective technology transfer is a very important feature for a competitive agriculture sector.

10. *Global Communication and E-Commerce:* Facilitated by the internet, and e-commerce, information and technology transfer will increase tremendously. The role of the internet is only starting to become understood by manufacturers and the rise of global marketing approaches with "virtual" organizations and alliances to deliver a "value" (product and services) to consumers will be an engine of growth.

    E-commerce means the ability to create "virtual markets" involving business to business, or consumers to business. E-commerce is a second hot area for manufacturers in the U.S. and elsewhere and needs to become part of the business marketing and sales strategy. Currently the e-commerce industry is new and rapidly expanding and it will become a new way to sell products into global market channels via the internet. Thus small businesses will be able to reach new customers they could never connect with previously. This trend will have many, as yet unknown, impacts. This links to better manufacturing and production practices.

11. *Manufacturing Best Practices:* Competitiveness research in Canada, the U.S. and Europe on best practices of agencies assisting manufacturers indicates that manufacturers and farm businesses can create internal efficiencies through new approaches. Some of the best practices include:

    - incorporating "lean manufacturing"- ways to eliminate waste;
    - incorporating an e-commerce strategy;
    - having a customer focus; and,
    - moving to "next generation manufacturing" and in-plant rejuvenation.

    Customer focus is an important concept to keep businesses relevant and innovative. Next generation manufacturing approaches are processes to improve manufacturing and increase their global competitiveness. These global trends directly impact on agri-food markets and the current/future research needs of the sector.

4.2 TECHNICAL AND AGRONOMIC TRENDS

1. *Equipment "Scale-Up":* The gradual "giantism" - many basic mechanical/hydraulic machines sometimes goes almost un-noticed but it has probably had the largest single impact (albeit gradual) on Alberta agriculture in the last half of the 20th century. In the past 50 years, industry changed from four tonne single axle trucks without hydraulic hoists to 43 tonne 8-axle B-trains; 50 hp tractors to 350 hp tractors; 12 ft. cultivators to 48 ft. zero-till drills; front-end loaders which would lift 1/2 tonne to loaders which will lift 10 tonne, combines which would harvest 30 acres/day to combines which harvest 300 acres per day, 25 ft. sprayers to 125 ft. sprayers; and so on. This is clearly reflected in operational farm sizes: about 320 acres in the 1950s; 640 acres in the 1970s and 1,280 acres in the 1990s. The substitution of capital for labour is very dramatic.

2. *Bulk Materials Management Technologies:* This has similarly changed along with the scale increases. Increasing size required quicker and easier materials handling. Thus, industry now

has bulk fertilizer, high-capacity bulk delivery trucks, high throughput grain elevators, barrels of chemicals, pellets, hopper cars, etc. Again, this is the substitution effect noted above.

3. *The Communication/Information "Revolution":* This has profoundly impacted agriculture just as it has the rest of society. Only 20 years ago, fax and computer technology was in its infancy. Today, probably over 60% of all farms own a computer (at least for e-mail) and an estimated 28% now use the computer for farm business management activities. Having the opportunity to down-load information from AAFRDs Ropin the Web, Agri-Ville, AAFCs web-site, and hundreds of other information sites at the farmers discretion (space and time) is a very important capacity-building farm management tool. The proposed Alberta Supernet will further drive this revolution.

4. *GMO (Genetically Modified Organisms):* Applications – GMO's had a limited but high-profile evolution in the 1990s. In crop production, this has largely been limited to the development of both a GMO and non-GMO based herbicide-tolerant canola system which, together, are now estimated to account for 70% of all canola grown in the province. The Clearfield (previously Smart) technology is a non-GMO imidazolinone-tolerant technology which does not generally require country registration and raises little consumer opposition. However, the acceptance by consumers to GMO foods and traceability is a continuing concern.

5. *Broad-Spectrum Pest Control:* This process further enhances quick-and-easy pest management, as well as improving farm safety. This approach employs one pass, no mixing, and less operator exposure. Probably over 70% of the cropland now uses a one-pass spray application. An integral part of this evolution has been the parallel development of a complete spectrum chemical weed control (Roundup and similar products). This enhanced chemical fallowing and crop dissecation was a pre-requisite to the zero-till seeding technology which was perfected during the 1990s. IPM (Integrated Pest Management), while still in its infancy, also makes eventual development of more natural, non-chemical pest management techniques increasingly probable.

6. *Electronic Monitoring and Control of Production Activities:* This activity has become widespread. Seeding, spraying, and harvesting equipment now monitors virtually every aspect of machine operation and performance. As well, finger-tip adjustments (both electronic and hydraulic) can now re-set application rates, threshing speeds, and so on. Similar technologies are now equally commonplace in the mixing and application of feed rations to poultry and livestock. Satellite-based Global Positioning Systems (GPS) and "precision farming" also gained headlines but has so far seen limited practical application.

7. *Variety and Breeding Improvements:* These factors continue but generally with much less promotion or public awareness. Varietal yield improvements have been particularly pronounced in canola production. Twenty years ago the provincial average was perhaps 20 bushels per acre and now is about 35 bushels per acre. In animal production, breeds are, increasingly, now also being customized to satisfy consumer demand (beef cross-breeding). In the long-term, crop yields have typically climbed about 2.0% per year while livestock yields have typically increased about 1% per year). In 10 years, that amounts to an overall increase of about 16%. These productivity improvements have helped the sector compete, but contributes to over supply issues.

8. *Tillage Practice Changes:* Movement to zero till/ minimum till is the most far-reaching change in crop production practices during the 1990s. Instead of 4 to 5 or more cultivation/seeding passes per year, farmers now do 1 or 2; often just a heavy harrow in the fall for residue management and direct seeding in the spring. This was made possible by powerful tractors, floating hitch and multi-frame tillage assembly, novel seeding shovels (called "boots"), and a pre-seed weed "burn-off" capability (e.g. using Roundup). Starting at almost zero in 1990, about 65% of all farmers have now adopted this technology while, at the same time, the summer fallow acreage has continued to decline. The most far-reaching change in animal production was in animal environmental management: slats, crates, boxes, etc., developments which also accelerated the standardization of production.

9. *Sustainable Resource Management Practices:* These became a more conscious management consideration during the 1990s. This approach (aside from zero till) includes the development of more by-product re-cycling as reflected by less fall stubble burning, more manure management/ use, and heavy harrow straw management. Equally important was the adoption of pasture management (such as the "Savory System") and more crop rotations with a nitrogen and/or fibre-enhancement capability (e.g. more peas and a three or four year canola rotation). The shift to the production of more specialty crops is a part of this awareness. The multi-functionality of the agricultural resource base highlights this holistic perspective.
10. *Product Differentiation:* Inputs and end products also became a reality during the 1990s. This was prompted by two developments: identification of consumer niches and proprietary agri-industrial capabilities (supported by proprietary variety legislation). Traceability and identity preservation are key aspects. Agri-business began to develop and market their own "brands" (examples include Cargill's Intermountain Canola to Japan and Certified Angus Beef). The 1990s also saw the emergence of a rapidly growing market for differentiated and carefully segregated organic products. Some of this growth is related to an increasingly health-conscious consumer. There are now about 300 organic farmers in Alberta and the number is growing.
11. *Standardized Production and Management Processes:* This is another hallmark of the 1990s. Large standardized units, easily replicated, now dominate the commercial production of broilers, eggs, turkey, pork, and milk products. This has paralleled related developments to make, for example, 1200 sow hog units and (with robotics) 500 cow dairy barns a growing reality. This development has helped reduce risks, share management practices among a "peer group", and create a new production business model.
12. *Animal Feeding Technology Changes:* These technologies occurred during the 1990s which focused on animal feeding: rations, widespread pre-mixing of feeds and supplements (including micro-nutrients, hormones, stimulants, etc.) improved feed preparation techniques and improved processing (pelleting, rolling).

4.3 FUTURE TECHNOLOGY DRIVERS

More widespread adoption of these technologies (and variations thereof) during the first decade of the 21st century is almost assured from three over-arching drivers:

- increasing standardization and vertical integration/ coordination of agriculture commodity production systems. The "artisan factor" in primary production may become less important;
- increasingly integrated resource management (both rural-urban and inter-sectoral) which is both socially and environmentally sustainable; and
- an increasingly seamless value-added and consumer-driven marketing system.

Agriculture will see different approaches - large-scale, sophisticated (i.e. information-based), and proprietary networks/production alliances develop to meet consumer needs. The large-scale systems will provide "seemless" knowledge, financial/managerial capacity, and market access to actually exploit these emerging technologies. In addition, an emergence of small-scale production of niche products will also emerge to respond to market opportunities which are being created globally.

4.4 EMERGING TECHNOLOGY DRIVERS

1. *Energy Substitution:* Rural Alberta presently requires about 70% of all fuel consumed by the provincial economy, plus extensive use of other hydro-carbon derivatives, particularly nitrogen fertilizer, chemicals, and plastics. In the international marketplace, the use of alternative energy sources and increased energy efficiencies will likely become imperative. This is where the potential for bio-energy is immense. Sustainable agriculture can perpetually "grow" ethanol and hydrogen for fuel cells. (See for example, API Grain Processors LP in Red Deer and Poundmaker Feedlot in Saskatchewan). The Hypercar, powered by an engine that takes oxygen from the air and hydrogen from its tank

to create a chemical reaction that produces electricity and water (and with an entirely electronic transmission and steering system, as well as no other emissions) - is already awaiting commercial production.

2. *New Bio-Material Uses:* This includes the potential for enhanced fibre development of agricultural materials, new bio-based polymers which can substitute for plastics, and new bio-based enzymes which can be used for oil spills, etc. This has tremendous potential as annual world bio-mass production is perhaps five times as large as existing hydrocarbon energy consumption.

   Strawboard plants are just a rudimentary beginning of the new uses for products from agriculture. For example, the U.S. Cargill-Dow's polylactic acid is the first polymer produced from renewable resources that competes with high volume products such as nylon, PET and polyethylene in a multitude of product applications. DuPont recently announced a new polyester trademarked Sorona which is similar to Lycra but with higher elasticity and shrink. The building block is 1,3 propanediol (3G) which previously was produced by chemical synthesis, but will be produced by DuPont using a genetically enhanced *E. coli* fermentation system. (Note: the USA has recently completed a research strategy called "*Technology Roadmap for Plant/Crop Based Renewable Resources 2020*" which features using genomics, production, processing, and utilization links to develop new materials from crops (energy, bio-materials, etc.).

3. *Genomics:* This involves, in particular, the customization of plants to produce particular traits. GMO and IT (Clearfield) herbicide-tolerant canola is an emerging science. Beyond tolerance to herbicides and predators, genetic modification could eventually lead to an increased tolerance to drought, high salt, high aluminum, cold and hot temperatures, and other stress factors. Improvements in micro-nutrient levels amino acid replacement, or removal of anti-nutritional substances will also directly benefit consumers. This can also involve improvements in feed quality by, for example, increasing the lipid content in feed barley. Even processing characteristics (e.g. by starch modification) can be enhanced. And this is already happening. The World Health Organization is already promoting a Vitamin A and iron-enhanced rice to improve the nutritional standards of people in developing countries (Golden Rice). And in Canada, as well, (government-approved) herbicide-tolerant Clearfield wheat is entering the marketplace in the spring of 2001. The potential introduction of GMO Roundup Ready wheat however is meeting resistance by trade and consumer groups.

4. *Electronics/Robotics/GPS:* A quantum leap forward for electronic-based automation, robotics, and GPS-based monitoring and control systems could also encourage major structural change in the immediate years ahead. Robotic milking parlours, for example, could make 500 head dairy operations commonplace. GPS-based controls for field operations, with compatible and accurate information software for all field passes, could make 25,000 acre grain farms equally commonplace. Again, this will allow for a capital substitution for scarce labour and management.

5. *Bio-Controls and Organic Production Systems:* Driven by health and environmental concerns, plus agricultures present dependence on hydrocarbon-based fuels, chemicals, and fertilizer, more bio-control of pests and more organic practices can also be expected in the immediate years ahead. Integrated Pest Management (IPM) and Sustainable Farming Systems that do not depend so heavily on pesticides and chemical fertilizers have been heavily promoted in developing countries for at least a decade (World Bank, Asian Development Bank, etc.) Largely driven by consumers and the production economics of a "high-tech." cheap food policy, this is gaining more rural-urban support particularly with affluent North American and European consumers. Austria is already "ultra-organic" and organic food is expected to capture 20% of the entire German market (up from a current 2.5%) within a decade. The perceived danger of an increasingly international food system, accompanied by outbreaks of BSE and foot-and-mouth disease in Europe, have only accelerated this on-going shift to organic foods (perceived safe foods) in affluent consumer attitudes.

6. *Sustainable Multiple-Use of Resources:* Finally, there are a number of environmental and related resource-use issues which will, inevitably, also strongly impact on the future structure of Alberta agriculture. Resource use is becoming increasingly regulated (e.g. water withdrawals) and increasingly multi-functional. Technological, economic, and social/ institutional constructs must increasingly be developed to accommodate and facilitate this process during the coming decade. Alberta faces challenges within air, water and soil demands by many sectors.

Technologies for the next ten year period will be developed through many new approaches which will involve more collaborations of the public-private sector, more interdisciplinary approaches and likely more inter-industry transfer of technology.

Further, these varied technology platforms will very likely cause several sectors (e.g. health, agriculture, forestry, environment) to become linked as common problems (such as energy sources from crops, disease management products from specialty botanicals) are jointly identified and researched. This "integrated problem solving" approach will present new joint opportunities, new technology applications and lead to new technologies which are employed locally in the province, with potential global reach.

5.0 COMPARATIVE RESEARCH AND DEVELOPMENT AND TECHNOLOGY TRANSFER MODELS

This section provides a summary of a number of models internationally, and within Canada which potentially have relevance for the design of the Alberta R & D and TT system. A summary of these models and their respective focuses is presented in Table 5.1 below. Table 5.2 provides a summary description, and best practices identified within these external models. A detailed description of these external models is presented in the Appendix to this benchmark document.

Table 5.1
Summary Focus and Description of External R&D and TT Models

Model	Basic Research	Applied Research	Technology Transfer Commercialization	Comments
International				
Manufacturing Extension Partnership (USA)	Minor	Yes	Yes	$250 million per year, integrated, well focused, strong service, human resource development, and consulting orientation
Kansas Technology Enterprise Corporation (USA)	Minor	Yes	Yes	Strong linkages between Universities, incubators, venture capital, education, and business support services
Australia: Rural Research & Development Corporations	Minor	Yes	Yes	Independent, 5 year plans, stable funding, focused, driven by industry and government, outcome based
Australia: Cooperative Research Centres	Yes	Yes	Yes	Seven year agreements, defined R&D plans, jointly funded, strong management plan, in addition to research plan.
Denmark	Yes	Yes	Yes	Ministry of Food & Agriculture center of research system, system has six centres, undertake five year issues and programs. Priorities established by sector experts.
Netherlands	Yes	Yes	Yes	MOA provider of funds, but private sector dominates, strong commercial involvement, five organization carry out research and TT
United States Agriculture Research Service	Yes	Yes	Yes	Ten year plans, strength is land grant system, use Cooperative Research and Development Agreement for commercialization, strong international collaborations
United Kingdom	Yes	Yes	Yes	Strong orientation to commercialization and Privatization
Canada				
Ontario	Yes	Yes	Yes	Strongest system in Canada, well coordinated, due to realignment due to budget constraints, duplication reduced
Quebec	Yes	Yes	Yes	Entrepreneurial, dynamic, well integrated with venture capital system
Saskatchewan	Yes	Yes	Yes	Has focused, and developed recognition in biotechnology, veterinary medicine college, and VIDO, relatively well coordinated.

5.1 MODEL DESCRIPTION AND BEST PRACTICES

Table 5.2 Best Practices of External R & D and TT Models

Model	Description	Key/best Practices
Manufacturing Extension Partnership (USA)	➠ US model, Based on Rogers Extension Model $250 million per year. The MEP model is a world class technology transfer model which has been studied by many countries as a best practice model. It creates very strong linkages of basic research, applied research and technology transfer with SMEs and large companies. ➠ The role of the MEP network is to provide technical and business consulting services and solutions to client companies. This is accomplished via the provision of direct consulting services, referrals to outside consultants and other service providers, and by providing continuing education seminars and training programs. Services offered by the MEP include: field technical experts providing in-plant, hands-on, technology transfer/ problem solving services for clients. The EU and others have documented this as the best transfer model. Changes in the MEP system include a new emphasis on revenue generation and business development	➠ Coordinated set of extension services identified as key resource to achieve transfer of technology, and commercialization. ➠ Close to a consulting model ➠ Problem solving orientation ➠ Main deliverables are providing information, decision support, and implementation assistance. ➠ Emphasis on best business practices adaptation.
Kansas Technology Enterprise Corporation	➠ Clearly focused on seven strategic areas such as advanced materials, energy, manufacturing, biotech, and value added. ➠ Formed strong and sustainable linkages between the universities' five centres of excellence, five incubator centres, three venture capital firms, education and consulting through a MEP, and a market research group	➠ They have found a way to connect all players in the chain from universities to markets, incubators, venture capital, and support services. ➠ Have clear long term focuses.
Australia (Rural Research and Development Corporation model)	➠ Currently some 13 RDC's in Australia ➠ Independent boards ➠ Board has wide range of expertise ➠ Planning based on five year plan, and provide annual plans ➠ Mandated to achieve objectives both of industry, and the public ➠ Operate within agriculture, fisheries and forestry portfolio. ➠ Funded on matching basis, each of 0.5% of industry gross value ➠ Several RDC receive additional funds from government for issues of broad public interest. ➠ Studies show 25% of funds used to promote industry competitiveness, 24% sustainability, 21% processing, 8% market oriented R&D, 7% commercialization and TT activities ➠ Funds by type is 19% in basic, 38% applied, 14% experimental development, 13 % demonstration and extension, 9% commercialization, and 7% in Human resource development. ➠ Grain Research Development Corporation recently completed an international study "Impact of Global Trends in Chain Management on Grain R&D".	➠ Success based on all parties having ownership in outcomes ➠ Commitment to change and innovation ➠ Shows that inputs and actions of the participants and uses of the new technology are equal to, or more important than the new knowledge gained. ➠ Has been argued that the RDC model is the most efficient and effective in the world ➠ Non-linear approach indicated as one of the secrets to success. ➠ Antiquated models are the linear models used in other countries, such as U.S. ➠ Targets on industry and government needs, not researchers needs. ➠ Change from in the past where researchers directed R&D. Projects must have clear objectives.

Model	Description	Key/best Practices
New Zealand (Crown Research Institute)	➠ Clear focus on servicing technology and innovation needs ➠ Focus on small, medium and large organizations. ➠ Undertake public good research for government. ➠ Can borrow funds, form joint ventures, and subsidiary companies.	
Australia (Commonwealth Scientific and Industrial Research Organization-CSIRO)	➠ 30% of resources from non-government sources ➠ Increasingly applied research ➠ Primary functions are applied research, and use of research ➠ Secondary functions are international liaison, training of research workers, publication & dissemination of information	➠ Most countries are moving toward a structure, whereby the research is focused through a centre, council, or institutional structure, and focused on a relevant issue and need. ➠ Collaboration and partnerships are supported by firm written agreements and authority structures. ➠ Research centres generally have a fixed life of five to seven years. ➠ The separation and distinction between basic, applied and developmental research is increasingly blurred, and structures ensure they are integrated. ➠ Increasing focus toward food quality and safely, sustainability, health and welfare, and new food and non-food products ➠ In most countries, agriculture research is directed or controlled by the Ministries of Agriculture. ➠ Trend toward more private sector involvement and financial contributions.
Australia: Cooperative Research Centres (CRC's)	➠ Bring together researchers from Universities, CSIRO, private industry and government. ➠ Binding agreement between all participants ➠ Agreements include a management plan, key personnel, and contribution of participants. ➠ Have defined R&D plan ➠ Education program ➠ Commercialization, application strategy ➠ Seven years agreements ➠ Are over 60 CRC's, of which 15 in environment, 3 in agriculture, etc. ➠ 30% funding from government ($2.2 million), 23% from universities, 17% private, CSIRO 14% federal government 5%, state government agencies the balance.	
Denmark	➠ After criticism from OEDC, now have developed a national research strategy. ➠ Research delivery and management are through councils, research institutes, and research centres. ➠ Sector-orientated research model. Sectors "agree" on national strategy ➠ Have established Research Centres; typically undertake five year issue or topical research work. ➠ Focus more on primary research, adopt an umbrella approach ➠ Six centres devoted to food and agriculture issues ➠ Focus has shifted away from plants, to veterinarian and food science. Increased emphasis on food quality and safety, health and welfare research in livestock husbandry, and landscaping. ➠ Focus not on distinction between primary, applied and strategic research, but on developing high quality research activities with priorities established by sector experts ➠ Ministry of Food and Agriculture is the engine of the sectors research. ➠ Centres research not tied to agendas of universities and institutes.	
Netherlands	➠ Public sector research carried out by five organization. ➠ MOA greater provider of public funds. ➠ Private sector funding dominates. ➠ Strong commercial involvement.	

Model	Description	Key/best Practices
United States	➠ US agriculture research is provided by the Agri Research Service (ARS) ➠ Current focus is human health, crop and livestock improvement, industrial uses, and solving agricultural problems. ➠ Use of research partnerships with USDA, other federal agencies ➠ Use of CRDA's (Cooperative Research and Development Agreements) ➠ 10 year strategic plan ➠ Large international focus ➠ Land grant system, based on federal appropriation to state research, experimental stations, based on state farm population.	
United Kingdom	➠ Strong move toward commercialization and privatization ➠ Government still maintains control ➠ Increased accountability and cost effectiveness ➠ Government funds research institutes.	
Ontario	➠ All research activities governed under the Ontario Agriculture Services coordinating committee ➠ Higher emphasis on economic and market analysis ➠ Research community and activity directed by a series of service committees	➠ Food Processing clusters
Saskatchewan	➠ With limited resources, has had to focus. Recognized in the area of biotechnology, and made progress in areas in functional foods and nutraceuticals, Coordinated, and recognized with VIDO, and vet college.	➠ Biotechnology clusters
Quebec	➠ Quebec Ministry of Agriculture (MAPAQ) is the central governance figure. ➠ MAPAQ has partnered with number of non-profit research corporations, called Research Centres ➠ MAPAQ partners extensively with AAFC to meet its research needs. ➠ Very well linked with venture capital sector ➠ Entrepreneurial	➠ Is a model of coordinated teaching, research, extension and public service. ➠ The federal funding provides the glue for harmonization

Sources:
1) Internal documents, research reports, Internet research, consultants experiences
2) Agricultural Research Organization Models, Competitive Intelligence Unit, AAFRD June, 2000.
3) Governance Applications for Alberta's Emerging Agri-Food Research Community, A look at Australia, Denmark, and the Netherlands Competitive Intelligence Unit, AAFRD June, 2000.

6.0 RESULTS AND MAJOR CONCLUSIONS

The Alberta agriculture and agri-food R&D/TT system through which research, innovations and technologies are developed, transferred and commercialized is under-performing and inadequate as now structured, funded and managed. The difficulties within the system, which have been identified in the course of this situation analysis, are preventing Alberta from taking a leadership role in agriculture and agri-food research and development in Canada. Alberta lags behind Ontario, Quebec, and likely even Saskatchewan in focusing and distinguishing itself in unique areas of agriculture and agri-food research, technology transfer or commercialization.

The results and major findings from the review process (which included over 60 stakeholder consultations, a written survey of stakeholders, and an external review of research and development systems and models in other jurisdictions), which supports and elaborates on the Alberta system, are summarized below.

6.1 AGRI-FOOD R&D/TT SYSTEM FRAGMENTATION

The Alberta agriculture and food R&D/TT system is fragmented. The major R&D players are the University of Alberta, AAFRD, and AAFC with other performers including ARC, University of Calgary and Lethbridge and the private sector. Technology transfer is carried out by AAFRD and AAFC (primary production/processing) and for new discoveries, by the ILO offices at the universities, and the private sector. Each has a separate and independent strategy. Good research and development activities are being carried out independently by each institution and organization, but without adequate collaboration and integration. Collaboration is weakest at the institutional level, with relatively good collaboration at the researcher level. Each institution and organization establishes direction and focus largely independently of each other, based on their relative expertise, and in anticipation of funding priorities. The fragmentation is a consequence also of the relative degree of mistrust, and in some cases the lack of respect between institutions. Institutions and research disciplines operate as "silos", and are often destructively competitively with each other. A major deficiency within the system is the lack of a systems approach and systems thinking within the agriculture and food sector through which basic research, applied research, technology transfer, and commercialization should be integrated and seamless. This includes developing early stage supports, financing and venture capital partners who can provide much needed management expertise to new high-risk ventures.

6.2 LACKING LEADERSHIP AND DIRECTION

The Alberta system lacks clear leadership and direction, which contributes to its current level of sub-optimal performance. Paradoxically, the province has invested considerable resources over the past year to consult with stakeholders to identify needs, priorities, and focus. The weakness appears to be the lack of the translation of these activities into actions. The current consultations with respect to the Alberta Life Sciences strategy is creating uncertainty in the minds of part of the industry, and creating a further perception that actions will be delayed. Life Sciences as a theme offers huge global opportunities; the Alberta agriculture and food sector R&D/TT system should be among the very first sectors to provide results because it is a core Life Science pillar of scientific depth and breadth.

Clear leadership and actions, backed by a funding strategy, has not yet been established or exhibited. The changes and policies within AARI over the past year have contributed to the uncertainty and questions about the provincial agriculture R&D/TT strategy. The current actions of AARI are beginning to re-establish the structure and directions for leadership.

The sector has not yet established a clear focus as to the outcomes it desires. The discussion is currently

too broad, vague and hence lacks specifics. From two to four major achievable strategic R&D directions for the industry needs to be identified and agreed upon, so all parties can support and direct their resources. The system needs to be driven by government and industry, versus led by the research providers. A lack of a strategy for utilizing Alberta's competence and capacity means researchers, industry and government do not have a common ground for meaningful discussions.

6.3 UNTAPPED R&D/TT CAPACITY AND COMPETENCE

The Alberta agriculture and food system has significant depth and breath of capacity and competence in many scientific and technical disciplines. These include, but are not limited to crop science and plant breeding, economics, marketing, human and livestock nutrition, biotechnology, breeding, toxicology and food safety, environmental sustainability, sustainable resources management and integrated pest management. One major factor limiting the scientific and technical capacity, is fragmentation and dispersion of the research effort being performed independently (and sometimes competitively) in the different institutions. For example, there are upwards to 115 personnel who are engaged in crop and pest management in Alberta, located at ARC Vegreville, at AAFC Lacombe and Lethbridge, the University of Alberta and Lethbridge, and at AAFRD. The extent of this capacity, if focused, networked, or otherwise collaborated, could represent a world class or leading capability within Canada in the area of sustainable crop bio-systems management. It does not currently exhibit this capacity, given the system fragmentation. The Alberta system, if better focused, integrated, and managed, could achieve significant gains in outputs and outcomes. It would also be able to attract new global investments if it were truly integrated for research outcomes. Otherwise, global investment may prefer jurisdictions with a stronger integrated R&D/TT system.

6.4 INADEQUATE FUNDING

The funding system in Alberta within the agriculture and agri-food system is misaligned, fragmented, exhibits overlapping mandates, and is not user friendly. There is a misalignment of funding need and funding supply. The livestock sectors are well funded, but as a more established and mature industry, they have less R&D and TT needs. The new and emerging sectors, bio-products, functional foods, and nutraceuticals, are less well funded, yet have the greatest need, and arguably, have the potential for the greatest future payoffs. These future growth industries suffer from a lack of investment, champions and hence successes.

The addition of the recent new Industry Development Funds (IDF's) are examples of new funds which need to fit within and collaborate within the funding process. The IDF's are working to establish their niche focus, and clients. There is potential overlap between these and other existing funders' mandates. The many different funders, and the involvement of multiple financial intermediaries and agencies within the system, creates barriers to clients and users, and adds to system administration costs. Within the current processes transaction costs are very high. A comment received was "*we spend too much time writing proposals for small projects*". In addition, there is a lack of communication and collaboration between funders which clearly needs to be enhanced.

This review process has also identified that the research infrastructure within the Alberta system has significantly depreciated and deteriorated over the past 10 years. There is accumulated economic depreciation and obsolescence now built into the research infrastructure that will continue to undermine the capacity to develop excellence and capacity. The recent investment levels of about 1% of gross industry revenue, has not been adequate to maintain the infrastructure, and is low compared to other countries and jurisdictions where the investment level is closer to 2% or more of revenue. If Alberta wishes to harness its research capacity on a global stage, it cannot limit the potential by insisting on researchers using old tools.

6.5 AGRI-FOOD R&D/TT SYSTEM HAS GAPS

In view of competitor R&D/TT systems, major gaps and needs identified within the current agriculture

and agri-food R&D, TT, and commercialization system in Alberta include:

- A need to enhance and integrate business incubators within which industry, in partnership with research and technology providers can adapt, test, and pilot new products and business opportunities
- Business commercialization, marketing, and management skills are deficient for small business and entrepreneurs to originate, develop, finance, and commercialize new technologies and opportunities.
- A "systems" approach needs to be introduced, in which research, development, incubation, technology transfer, early stage funding support, and venture capital financing, and commercialization are all linked.
- Better linkages to the rural communities, and to the opportunities, capacities, needs and benefits of rural development are necessary.
- Providing incentives and tools that will attract private sector investment into the R&D and TT system. These could include tax credits, agri-food discoveries database, intellectual properties service capability, regulatory approval support services, new policies, and others.
- Communication between funders' priorities, clients, review process and the research and technology providers in the industry.
- Need to look at industry wide problems, using an integrated systems approach (eg: integrated environmental management, adaptation to climate change, Manure and odour management, water quality issues, urban-rural development)
- Further evaluation of venture capital, and pre-commercialization funding deficiencies and needs in province are required.

6.6 Focus And Action Is Needed To Remain Globally Competitive

The cross cutting themes and key conclusions are:

- The time for action is now - much frustration is seen in the system participants who are contemplating their roles in attempting to satisfy the sustainable growth agenda.
- The structure and incentives to increase the coordination within the system, and to make the system collaborative, responsive, and transparent, must be developed and applied.
- The province must focus on a selected number of strategic and concrete directions, in which it has scientific excellence, and is a fit with its production and human resource capabilities. A rifle approach versus the current shot-gun approach.
- The funding system needs consolidation and focus. It is a paradox that Alberta has provided excellent financial capacity for the sector, but it is spread among many funding agencies with poorly stated outcomes, performance measures, linkages and role definitions.
- The overall system needs strong leadership to develop the shared vision, and change our mental models through strong management to made it happen.
- Overall, the agenda for action is well recognized. To grow to $20 billion by 2010, major themes for research include: environment sustainability, primary production competitiveness, value added agri-products, new uses - functional foods, nutraceuticals, bio-products and enhanced market access and marketing.
- Therefore a new way of collaborating in research, development, technology transfer and commercialization is needed. The current approach is not working.
- Two actions present themselves. First, to increase the resource investment in the agri-food R&D/TT system for operating programs and for infrastructure, and second, to develop and implement a new Alberta strategy for agri-food R&D/TT to ensure global opportunities are not missed.
- From the review, R&D/TT performers and funders are very concerned and interested to see action being taken to overcome the gaps, provide integration methods and define a clear Alberta strategy.

APPENDIX

CONTACTS WITHIN INDUSTRY CONSULTATION PROCESS

Universities

Dr. Dennis Fitzpatrick, VP Research, U of L
Mr. Olie Hnatiuk, U of C, UTI
Dr. John Kennelly, U of A
Dr. Stephen Moore, U of A
Dr. Ian Morrison, Dean, U of A
Dr. Erasumus Okine, U of A
Dr. David Reid, Chair, Department of Biological Sciences, U of C
Dr. Peter Sporns, U of A
Mr. Neil Taylor, Coordinator Research Services, AFNS, U of A
Dr. Thavar Vasanthan, U of L
Dr. Michele Veeman, U of A

ARC

Ms. Nancy Cranston, ARC
Mr. Paul Lait, ARC
Mr. Peter Matthewman, ARC
Dr. David McNabb, ARC

AAFRD

Dr. Stan Blade, AAFRD
Mr. Bob Gibson, LFPDC
Mr. Alan Hall, AAFRD
Dr. Cornelia Kreplin, AAFRD
Mr. Doug Milligan, AAFRD
Mr. Ron Pettit, LFPDC
Ms. Connie Phillips, AAFRD, AITC
Mr. Brian Rhiness, AAFRD
Mr. Fred Schuld, AAFRD
Dr. Scott Wright, AAFRD
Dr. Rong-Cai Yang, AAFRD

AAFC

Dr. Peter Burnett, AAFC
Mr. Colin Campbell, AAFC
Dr. Glenn Coulter, AFFC
Dr. Steve Morgan-Jones, AAFC

Other Government Departments

Mr. Ray Basset, I & S
Dr. Ron Dyck, ASRA
Dr. Bill Yates, ADRI

Industry

Mr. Nigel Bowles, CIDF
Mr. Ross Bricker, AVAC
Mr. Les Brost, Chair, Agrivantage
Mr. Bert Bystrom, Alberta Canola Producers Commission
Mr. Darcy Fitzgerald, LIDF
Mr. Clif Foster, Alberta Barley Commission
Mr. Ross Gould, Alberta Cattle Commission
Mr. Cameron Klapstein, CIDF
Ms. Heather Loepky, Beef -forage Agreement
Mr. Tom Machacek, CIDF
Mr. Mark MacNaughton, CIDF
Mr. Jacob Middelkamp, Alberta Chicken Producers
Mr. Marvin Nakonechny, CIDF
Mr. John Oliver, Maple Leaf Bioconcepts
Mr. Jerry Stepnisky, AFC
Mr. Paul Stewart, Manager, Global Business Development, Elanco Animal Health
Mr. Al Stuart, ex Cdn Meat Council, AB Potato Growers, private vegetable processing companies
Mr. Darryl Vandenberg, Alberta Pork
Mr. Doug Walkey, CIDF
Mr. Dle Engstrom, LIDF
Mr. Ed Oosterhof, LIDF

DETAILED EXTERNAL R&D AND TT MODEL DESCRIPTIONS

A: Canada

Ontario: Ontario Agriculture, Food and Rural Affairs (OAFRA)

The research activities within (OAFRA) is governed by the Ontario Agricultural Services Coordinating Committee (OASCC) by which the priorities of research funding are set. The structure of the (OASCC) consists of the following committees:

1. Ontario Agricultural Economics and Business Research and Services Committee (OAE & BRSC);
2. Ontario Agriculture and Food Engineering Research and Services Committee (OAFERSC);
3. Ontario Animal Research and Services Committee (OARSC);
4. Ontario Field Crops Research and Services Committee(OFCRSC);
5. Ontario Horticultural Crops Research and Services Committee (OHCRSC);
6. Ontario Food Processing Research and Services Committee (OFPRSC);
7. Ontario Pest Management Research and Services Committee (OPMRSC);
8. Ontario Rural Research and Services Committee (ORRSC); and,
9. Ontario Soil, Water and Air Research and Services Committee (OSWARSC).

Ontario Agricultural Economics and Business Research and Services Committee (OAE & BRSC)

The OAE & BRSC's mandate is to identify and prioritize future agricultural economics and business research and service needs of Ontario's agri-food industry stakeholders. The OAE & BRSC's research priorities areas, in priority order are:

- risk management;
- environment;
- competitiveness of the agri-food industry;
- economic data and benchmarking;
- marketing; and,
- trade.

Ontario Agriculture and Food Engineering Research and Services Committee (OAFERSC)

The OAFRERSC is composed of four committees covering the areas of crop, livestock, rural environment and food engineering.

The crops engineering committee identified development of non compacting field equipment, manure and bio-solids application, grain and forage drying and rural roads and equipment transport safety as priorities for research and service.

Livestock engineering priorities were identified as development of standards for manure storages and structures, air quality in livestock buildings and corrosion and deterioration of agricultural building components.

The focus of the Rural Environment sub-committee continues to be manure handling and the impact of livestock operations on the environment. The need to investigate and adapt treatment processes used in urban environments for handling livestock manure was added to the list of research priorities from previous years.

The food engineering committee identified one new research and one new service priorities in addition to the list of priorities from last year's report. By-product utilization and waste management research added to the list.

The committee also indicated that there was a continuing need for research at public institutes on process and product development suited to small scale processors who have limited capital to invest in short term R&D and long term high risk research. Lack of research support may make the long term survival of these processors questionable.

Ontario Animal Research and Services Committee (OARSC)

OARSC is composed of 12 sub-committees (aquaculture, broilers, dairy, deer and elk, egg layers, equine, fur-bearing, goats, pork, sheep and turkeys) their strategic research requirements for the future.

In general, the market for products of animal origin is strong. Identified trends included:

- the established major commodity groups (beef, dairy, poultry and pork) continue towards greater consolidation. The loss of genetic diversity is of concern; and,
- increased producer numbers in the smaller production sectors reflect niche market development opportunities (e.g. goat milk, velvet antler and sheep cheese).

The sub-committees identified seven common research themes for the future: public health and safety, food safety, environmental quality, product quality/development of new products, animal health, profitable production for the smaller production sectors, and animal welfare.

Ontario Field Crops Research and Services Committee (OFCRSC)

The mandate of the OFCRSC is to review and direct research and services leading to improvements in crop production efficiencies and competitiveness of Ontario agriculture in world markets. OFCRSC has six subcommittees which focus on corn, cereals, forages, oil and protein seed crops, pulses and tobacco. The 2000 report identified four core strategic directions. These are listed in priority order as follows:

- field crop breeding and biotechnology;
- agronomic technologies;
- plant and crop physiology; and,
- variety/pesticide testing.

Ontario Horticultural Crops Research and Services Committee (OHCRSC)

The OHCRSC considers a wide range of horticultural crops with 16 subcommittees covering fruits, vegetables, greenhouse crops, nursery, landscape and turf. Agroforestry and apiculture are also considered under the OHCRSC umbrella. Research priorities are identified separately by each subcommittee. While these priorities vary greatly from group to group the following major issues crossed over many of the crops:

- integrated pest management;
- nutrient management planning;
- water quality and management;
- minor use pesticide registrations through PMRA;
- pesticide harmonization with United States/Food Quality Protection Act; and,
- requirement for research stations to be GLP (Good Lab Practices) certified for Minor Use Residue Testing studies and the cost for this certification.

Ontario Food Processing Research and Services Committee (OFPRSC)

The Ontario Food Processing Research priority, include:

Food Quality and Safety:

- methods for the early detection, and reduction/ elimination of food safety hazards/contaminants;
- "Farm to fork" processes for ensuring food safety;
- methods to improve the quality and consumer acceptance of Ontario products; and,
- on-line methods for monitoring and predicting quality during processing.

Value-added Products and Innovative Technologies:

- methods to enhance the value of Ontario products; and,
- development and evaluation of processing technologies that will limit the impact of the processing industry on the environment without unduly affecting cost and competitiveness.

A new research recommendation was added to the *value-added products and innovative technologies* category in 2000:

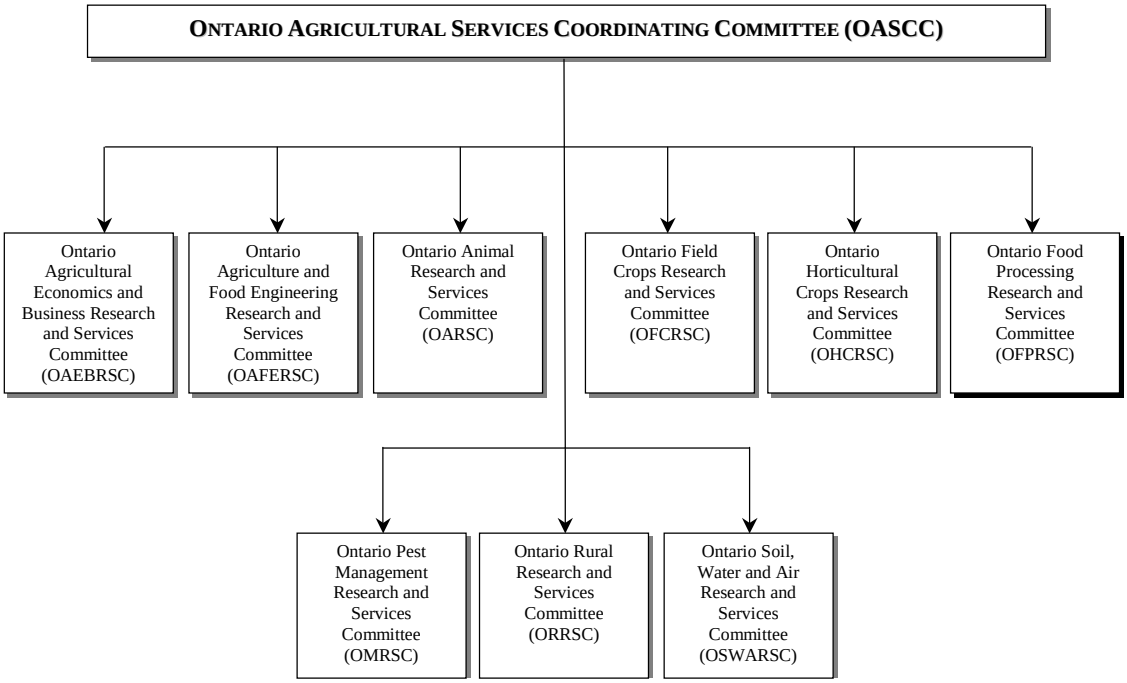
- development of innovative technologies to improve the manufacturing effectiveness of existing food products or to facilitate the production of new food products.

As in 2000, the issue of consumer acceptance of new technologies, especially genetically modified foods, was regarded as an important non-research and development priority.

Ontario Pest Management Research and Services Committee (OPMRSC)

The OPMRSC's mandate is to review and consider pest management and crop protection issues that may

affect several different commodities within Ontario plant agriculture.



The committee also reviews reports from the Ontario's Weed Committee and the Technical Working Groups who review and update OMAFRA's crop production publications.

OPMRSC identified the following issues for 2000:

- increasing cost of Minor Use registration process and decreased funding from AAFC for Minor Use trials;
- availability of non-biased, crop information and pest management programs throughout the province, including field diagnosis of crop problems;
- consolidation of the crop protection industry;
- maintenance of research teams and succession planning for research programs;
- the up-coming Supreme Court judgement to ban pesticide use by municipalities may impact the agricultural community if the ban is imposed; and,
- the on-going need for improved accessibility of Ontario growers to crop protection materials, including IPM friendly materials and biologicals and biorational products.

Ontario Rural Research and Services Committee (ORRSC)

The ORRSC's mandate is to identify and prioritize future research and service needs that affect the sustainability of the economic, social and environmental conditions of rural Ontario as determined by Ontario rural stakeholders.
The four main priority areas are:

- Economic Development - strengthen economic growth, entrepreneurship and business development in rural Ontario;
- Response to Change and Restructuring - understand, facilitate and assist rural communities as they plan for and act in response to change and restructuring;
- Capacity Building - understand community capacity building and enhance rural leadership, organization and community management; and,
- Information Technology - understand the roles of and promote the availability and use of information technology in rural Ontario.

Ontario Soil, Water and Air Research and Services Committee (OSWARSC)

The main research issues identified by the committee are:

- manure management;
- nutrient use efficiency;
- water management;
- soil and crop management;
- identification/validation of Best Management Practices;
- biosolid/waste application and treatment; and,
- greenhouse gas emissions.

New research priorities have been added and existing ones modified to increase emphasis on nutrient management, transport of bacteria, nutrient and chemical contaminants within the soil, the farm water cycle and development of models for integrated pest management, crop growth and irrigation management.

Saskatchewan Agriculture and Food

Key Focuses

The Department supports research and development to promote the development and diversification of the agriculture and food sectors in Saskatchewan, add value to agricultural products, and develop improved and environmentally sustainable practices.

Approach

The Department uses a number of mechanisms including proposal-based funding through the Agriculture Development Fund, administration support to industry funds such as the Saskatchewan Beef Development Fund, Horned Cattle Trust Fund, and the Cattle Marketing Deductions Fund.

Funding to identified strategic programs is provided through the Canada-Saskatchewan Agri-Food Innovation Fund. The Department also supports the Prairie Agriculture Machine Institute(PAMI) and Ag-West Biotech Inc. through operating grants.

Manitoba

Agriculture Research and Development

Agri-Food Research and Development Initiative (7a): The objective of the Agri-Food Research and Development Initiative (ARDI) is to provide funding for research and development which will enable the successful and progressive growth and adaptation of Manitoba's agriculture and agri-food industry within the changing global marketing environment.

The Province of Manitoba contributed $1.7 million to ARDI in 1999/2000 for a total Federal/Provincial contribution to agricultural research and development of $21.5 million since the establishment of the program in 1998. ARDI has the objective to provide, on average, 50 percent of total funding for research and development projects, with matching dollars contributed by industry. This will translate into new investments in research and development totalling $43.0 million in Manitoba.

ARDI provides project-by-project financial support to commodity groups, individuals, industry and institutions based upon expected potential for return on investment dollars.

This program focuses on value-added, processing, enhanced production and exporting of higher value products.

There are three major partners involved in the management of the ARDI program. The ARDI Program Council is responsible for developing ARDI program objectives, policies and project assessment criteria. The Council also prioritizes ARDI funding and approves eligible project proposals. The ARDI Program Council is an independent committee with representatives from the agriculture and agri-food sector, along with federal and provincial non-voting members.

The Manitoba Association of Agricultural Societies (MAAS) carries out the day-to-day administration of ARDI. MAAS accepts and coordinates funding proposals and administers the disbursement of funds. Manitoba Agriculture Program Advisors provide advisory assistance to MAAS and the ARDI Program Council, by facilitating assessments of eligible project proposals on behalf of the Council.

In 1999/2000, ARDI helped to fund many diverse projects in the following eligible categories:

- commodities that are well-established and present additional growth or development opportunities;
- commodities that are new or alternative and present opportunities for development in Manitoba;
- innovative development of machinery or equipment for production or processing enhancement;
- biotechnology;
- sustainability of the resource base and the environment; and,
- other innovative proposals.

Agricultural Sustainability Initiative – Covering New Ground (7b): The former Federal-Provincial Canada-Manitoba Agreement on Agricultural Sustainability (CMAAS) terminated December 31, 1998.

On June 16, 1998 Treasury Board approved the Covering New Ground Program at $1.2 million annually with the opportunity of funding for five years.

Covering New Ground funds activities in three specific areas: sustainable crop management; sustainable forage/livestock management; and integrated pest management with a goal of developing on-farm management activities to address environmental challenges. Delivery of programming occurs through: local producer groups on a four-region basis; provincial based commodity and agricultural organizations; and two regional crop diversification centres – the Parkland Crop Diversification Foundation and the Souris Valley Irrigation Centre.

In 1999/2000 the four regions delivered programming totalling approximately $560,000.

The Southwest Region, through 15 local delivery groups, undertook 31 projects. Areas targeted for activity included: crop silage production; forage production involving demonstration plots, native grazing management, rotational grazing, and forage burn off; leafy spurge management; crop agronomics/economics involving small scale demonstration; pea and bean production extension; benefits of hog manure demonstration; and development of beef supplementation strategies.

Six local groups delivered 90 projects in the Northwest Region. A large number of the projects dealt with pasture management, including rotational, swath and complementary grazing, pasture renovation practices, hay testing and management for quality. Other projects included: new crop demonstrations; pest management field days; fly tunnels for livestock pest control; and herbicide resistance surveys.

Approximately 56 Central Region projects were undertaken by 15 local delivery groups. The main focus of these projects was the establishment of producer directed demonstration and diagnostic sites such as Checkstrips, Forages for the Future, and New Crop Adaptation. A study of agricultural land use impacts on water quality and quantity was also undertaken. Other regional activities included forage tours and field days, the manure management tour, manure watershed run-off study, deep nitrate remediation trials, feed testing, leafy spurge biocontrol releases, and bean information days.

The Eastern/Interlake Region, through nine local delivery groups, undertook and coordinated 66 projects. Activities included: examining new crops and fall seeded crops, fertilizer value of manure on forages and annual crops, deep soil nitrate investigations, drainage schools, grazing management, field days addressing haying, tillage and combine equipment, livestock production, forage marketing, and alfalfa sampling.

Twenty provincial organizations, with the support of Manitoba Agriculture staff, carried out a wide range of activities funded at $320,000. Projects addressed areas such as potato late blight forecasting, irrigation water management, pest management of corn, berry and new special crops, agronomic practices for production of new crops including hemp and a range of medicinal crops including native species, manure management, zero and reduced tillage practices including winter wheat, forage crop management including disease control, pasture production, and high quality hay production.

Grant to University of Manitoba (7c): The objective of the University of Manitoba grant is to support Faculty of Agricultural & Food Sciences research, with projects primarily aimed at enhancing the productivity and growth of Manitoba's agriculture and food sector. The grant financially assists the Glenlea Research Station and research projects conducted by the Faculty.

Manitoba Agriculture and Food funding represents a significant proportion of total government and corporate contributions for research activities of the Faculty. Various departments within the Faculty received grant monies to assist in their research activities. The Department's grant is important in supporting the Faculty's research aimed at diversifying and sustaining the agri-food industry.

The Department's grant is a valuable resource to the Faculty in assisting it to attract additional outside funding for agricultural research. More specifically, the Department grant serves as a valuable leverage factor in attracting additional resource commitments from other organizations.

Grant to the Prairie Agricultural Machinery Institute (7d): The Department provides financial support to the Prairie Agricultural Machinery Institute (PAMI) for conducting agricultural research, development and testing of farm equipment and technology aimed at enhancing the productivity and income of Manitoba's agricultural producers. PAMI operates out of Portage la Prairie, Manitoba and Humboldt, Saskatchewan. It is financially supported through an agreement between the Province of Manitoba and the Province of Saskatchewan.

PAMI applies technology as a tool for economic development through client-driven activities. These activities support the province's priorities for international competition, diversification and value-added processing, livestock production, risk management, environment production, environment protection and farm safety.

Through its practical research and development, PAMI plays an important role in technology transfer to assist producers and the industry to improve their operations.

Canadian Industrial Research Assistance Program (IRAP)

IRAP is a national program that assists companies in technology matters. IRAP (Industrial Research Assistance Program) is a well-established federal program offered by NRC (National Research Council) to help companies in research and development problem solving on a short-term basis. It has operated since 1962. The program has 260 ITAs (ITA- Industrial Technology Advisors) located in 190 technical institutions across Canada. ITAs offer one on one advice to companies free of charge, but not in the same in plant process as in the USA. The program also offers companies an opportunity to cost-share research, in the order of from $15,000 to $350,000 per project. The total budget is about $66 million annually for projects. Alberta has an agri-food IRAP officer working with AFPA and an officer working with University of Alberta staff and emerging functional food companies to assist in technology transfer and commercialization

B: International Models

Australia

Rural Research & Development Corporation Model

Governments worldwide provide support for rural R&D on the basis of two key considerations. The first relates to market failure associated with the lack of incentives and difficulty in organizing the many rural producers to fund and pursue R&D, and the general inability of individual producers to fully appropriate the benefits of any research that they may fund. In the absence of Government intervention such market failure leads to significant under-investment in R&D.

The other major consideration for Government is the need to fund R&D that addresses national needs and priorities, for example the fostering of value-adding industries, and delivers public goods and benefits such as those related to improved natural resource management and general management of the nation's food supply.

Government financial involvement in R&D takes various forms, but for Australia's rural industries the R&D Corporation (RDC) Model is the major delivery system.

The policy basis of the RDC Model was described by the Minister for Primary Industries and Energy and

the Minister for Resources in the Research, Innovation and Competitiveness, statement of May 1989. The legislative basis of the Model is the Primary Industries and Energy Research and Development Act 1989 (PIERD Act) and mirror legislation that applies in the meat, wool and horticultural industries.

The legislated objectives for the Model focus on expanding Australia's rural R&D effort, improving its efficiency and effectiveness by investing in high priority areas, and enhancing industry's international competitiveness through more effective uptake of research results. Central to the Model is an alliance between industry and Government to pursue R&D to advance the interests of industry as well as those of the wider public.

The key elements in the Model are the independent board that is charged with taking a strategic approach to rural R&D, a rational and integrated approach to R&D priority setting, strong involvement of industry throughout the whole process, the broad scope of rural research activities that may be funded, a strong focus on outcomes, and a dual accountability to both industry and the Parliament. There has been some evolutionary change to the Model in recent years, most notably in the meat and wool industries where the R&D program has been merged with promotion and marketing activities, however the key elements outlined above are still present and the Government contribution to their R&D activities continues.

Board Composition

The members of RDC Boards bring a wide range of skills to bear on research and development issues and form an extensive and effective R&D network. They are chosen through an independent selection process which gives consideration to their expertise in areas specified in legislation including commodity production and processing, conservation and management of natural resources, R&D management, and economics.

Accountability

The RDCs are accountable to both industry and the Government. Parliamentary accountability is achieved through the relevant Minister's approval of RDC plans and agreement to table annual reports. Accountability to industry occurs through close consultation with representative industry organizations in preparing R&D plans, formal annual reporting arrangements involving industry organizations, and indirectly through industry involvement in the selection of RDC Boards.

RDC Planning

Strategic plans are prepared by each RDC that sets out objectives and priorities for a five year period, and outline the strategies which will be adopted in order to meet those objectives. These plans are prepared through a process of consultation with research providers, industry and Government. Regarding the latter, the Government provides the RDCs with regular statements outlining its priorities for rural R&D (see below for more detail).

The Dairy RDC provides a good example of the processes involved in R&D planning. Mechanisms employed include meetings with peak industry bodies; visits to State industry bodies; visits to farmers and processors; establishment of a set of regional R&D programs; conduct of search workshops on particular topics; establishment of reference panels for particular topic areas; and sponsorship of industry benchmarking projects.

RDCs are also required to prepare an annual operating plan for each financial year that is consistent with the strategic plan and provides details of the programs that will be funded in pursuit of the objectives of the strategic plan. Such rigorous planning has a number of benefits including:

Providing researchers, industry and government with a clear indication of the RDC's future direction; and allowing the evaluation of funding applications and the outcomes of R&D against the strategies and priorities identified in the plans.

Funding of the RDCs

Twelve rural-industry based RDCs operate within the Agriculture, Fisheries and Forestry Portfolio and are generally funded on the basis of the Government matching, dollar-for-dollar, industry R&D levies up to a maximum of 0.5% of the industry's gross value of production (GVP). Two other RDCs, the Land and Water Resources RDC, and Rural Industries RDC receive substantial Government funding in recognition of the broad public interest in energy and environmental issues, and the need to pursue generic

rural R&D and support new and emerging rural industries.

The Government's dollar-for-dollar matching contribution is designed to provide an incentive for the primary sector to increase its R&D funding and to become more involved in R&D priority setting and the adoption of outcomes, and also recognizes that activities funded by the RDC generate a mix of public and private benefits. Overall in 1997-98 industry contributed $149 million in R&D levies and the Commonwealth Government provided $148 million in the way of matching dollars and appropriation funds; total RDC expenditure for that year was over $300 million.

Range of RDC Investments

Under their enabling legislation the RDCs are empowered to invest in R&D across the production, processing, storage, transport and marketing chain of the primary industries. Recent surveys by AFFA have found that in recent years approximately 25% of the funds were invested in the area of promoting industry competitiveness, 24% in sustainability R&D, 21% in processing, 3% in distribution, storage and transport R&D, 8% in market oriented R&D, 7% in commercialization and technology transfer activities, 5% in human resource development, with the remaining 6% directed to other R&D, which includes such things as the routine collection of data and some funding of post-graduate scholarships. It is notable that many of the Corporations place more than 50% of their R&D investments in the off-farm area.

The category of R&D invested in is also quite broad: 19% being directed at basic research, 38% on applied research, 14% directed at experimental development, 13% towards demonstration and extension and 9% for commercialization; the remaining 7% of funds was invested in human resources or other R&D. The contrast with the business/manufacturing sector is quite stark. Australian Bureau of Statistics surveys have revealed that only 6% of their R&D effort is directed towards basic and strategic R&D, with the great bulk of their funds being invested in applied R&D.

The broad spread of RDC investments flows from their commitment to a whole of industry approach best demonstrated by the fact that the dairy, grains, horticulture, meat and wool industries individual primary producers pay the R&D levy, yet are prepared to approve R&D investments in off-farm, downstream activities. In effect the producers pay the R&D levy, but downstream industries are the main beneficiaries, producers only receiving indirect benefits through increased demand for their products.

RDC investments are spread across a range of institutions. RDC funds are spread across CSIRO projects 19%, State Government projects 35%, universities 18%, private sector 18%, and 11% in other institutions.

Delivery of Public Goods and Benefits

As noted above, Governments fund rural R&D in order to address national needs and priorities and deliver public goods and benefits. Public goods are a common property that benefits societal groups but do not provide direct and exclusive economic returns to private individuals or firms. Examples of public goods in the rural R&D setting include fundamental knowledge flowing from basic research; research to improve the management of natural resources and enhance environmental quality; improved knowledge about food and product safety risks and protection from such risks; improved nutrition and health; protection against national food security risks such as that associated with the breaching of Australian quarantine barriers; and knowledge essential to the accomplishment of public goals such as social equity, economic efficiency, and informed public policy making such as that associated with international trade.

Since 1994 the relevant Minister(s) have provided the RDCs with regular statements outlining the Government's priorities for rural R&D. In general these statements have focused on issues relating to trade and market access; improved industry productivity; investment in Australian products; the development of a value adding and export-oriented industry; and improved management of the natural resource base. As a general rule there has been a significant congruence between Government and industry R&D priorities.

While the Government may appear to be funding and promoting R&D that will deliver private benefits, it does so in the knowledge that there are significant positive externalities associated with R&D. Externalities (also called spillovers) are the indirect consequences of economic activity that are not fully

accounted for in the prices/costs of a free market system; they can be either positive or negative. It is widely accepted (by the Industry Commission, amongst others) that the public goods and positive spillovers flowing from rural R&D are generally larger than those associated with other industry R&D programs.

Spillovers associated with rural R&D encompass contributions to regional development and employment; improved occupational health and safety; maintenance of the scientific infrastructure; the development of a pool of trained researchers; stability in production and the provision of food/commodities to consumers at a lower price and/or with enhanced quality; and the development of an innovation culture within rural industries and the industries that provide support to that sector and/or process its produce.

RDC's Role in Rural Innovation

It is widely recognized that effective adoption of research outcomes is greatest where all parties are committed to change and industry has a sense of involvement and ownership of the process.

The RDC experience is consistent with that view, and confirms that successful R&D alone does not lead to improved industry competitiveness and broad and sustained economic growth. What matters most is innovation - the translation of scientific discovery into applied solutions. Innovation's contribution to economic growth is essentially an information process in which R&D is only one, albeit important, factor. Inputs and actions from the participants in the process, particularly the users of new technology, are just as vital as the new knowledge derived from R&D.

In the case of the RDCs, determination of industry research priorities requires information from the industry, including industry marketing performance and opportunities, production constraints, cost structure, management practices, the cost savings from any new techniques and the likely rate and extent of its adoption. Scientific knowledge is also required, including information on the appropriate research methods, an estimate of the cost of the research program, its duration and the likelihood of achieving the scientific and technical objectives.

The RDCs have confirmed that the chance of successful implementation of R&D outcomes is greater if all interested parties co-create the change. It is interesting to note, too, that these arrangements also appear to be having success in building industry appreciation of, and commitment to, R&D as a key driver of their prosperity. The success of this approach is evident in a recent Grains RDC survey that found that over the past five years more than two-thirds of Australia's 60,000 grain growers have adopted new technologies flowing from GRDC-funded R&D. It has also been estimated that in recent years rural R&D - largely funded through the Corporations - has provided an average annual 1% increase in the productivity of Australia's broad-acre enterprises.

Formal evaluations, most notably the 1995 Industry Commission Inquiry into R&D, and several internal Government reviews of the RDC Model, have also confirmed that the program is delivering rural R&D investments in an effective and efficient manner.

RDC Diversity and Cooperation

Implicit in the RDC Model is that individual rural industries differ markedly in their strengths and weaknesses, their problems and potential. Fostering close links with each industry was viewed as essential in identifying and servicing the relevant industry's R&D needs.

In practice each RDC adapts and responds to the prevailing culture and ethos of the relevant industry; as a consequence there are significant differences between RDCs in the way they invest in R&D and deliver its outcomes. In recent years the advantage of such diversity has been recognized by the RDCs and regular meetings of RDC Chairs, Executive Directors, Business Managers and Communication Managers are used as forums to explore best practice, and develop coordinated approaches to RDC issues; for example the Business Managers recently negotiated general insurance cover for all RDC Board members which provided savings for individual RDCs of up to 40% of what they were once paying for Board insurance. Currently the RDC Executive Directors are pursuing a benchmarking exercise in an attempt to identify best practice in key RDC processes.

The RDCs also engage in significant collaboration in their R&D investments. Collaboration is driven by industry need and the economics of conducting the R&D; once priority issues are identified in each industry, budget limitations provide real incentive to share the costs with others.

A good example is pastures R&D where five RDCs - Grains, Meat, Dairy, Wool and Rural Industries - work together to ensure national coordination, lack of duplication as well as attention to gaps that might otherwise remain through lack of funds. At last count, there were 162 projects involving collaboration among at least two RDCs.

In short, the RDC Model ensures the efficient delivery of well-targeted R&D investments and successful outcomes to our agricultural industries. Indeed, the absence of such a model in competitor nations indicates Australia has a comparative advantage in rural R&D arrangements.

The Current RDC Model is World Best Practice

It can be argued that the current RDC Model, and particularly its involvement of industry in the R&D process, represents world best practice. There are several pieces of evidence to support such a contention.

In 1995 New Zealand's Foundation for Research, Science and Technology commissioned the PA Consulting Group to evaluate best practice in R&D management; the project involving a benchmarking exercise across 23 R&D funders in Australia, Singapore, UK, Netherlands, Canada, USA and NZ. While many of their proposed best practices, for example those relating to the funding of pure research, are not relevant to the RDCs, the best practices identified during the course of this exercise show that the RDCs are operating at an internationally high level of efficiency and effectiveness. Dr John Stocker, in his recent Priority Matters report, also commented favourably on R&D coordination and priority setting in the Primary Industries and Energy portfolio, suggesting that they were close to best practice.

The report of a 1996 study tour by Mr. Eion Wallis (Executive Director of the Sugar RDC) of R&D funding in Europe, USA and New Zealand confirms that industry-oriented R&D funding bodies in those countries are still employing antiquated notions of linear technology transfer (research->extension->user). Linear technology transfer, with the industry user at the end of the production line, is markedly inferior to the more systematic approach employed by the RDCs which engages and commits industry to the full R&D process.

Conclusion

The RDC Model represents a radical change from the early 1980s when rural industry R&D was essentially directed by the science providers, with very little formal recognition of industry needs or accountability to those who were funding the research. In this earlier system funding arrangements were lax with researchers paid 6 months in advance of beginning any project, and thus having little incentive to perform. Today industry and Government needs are paramount in setting the research agenda, and researchers must commit themselves to projects with well-defined objectives, and with project payments contingent on meeting agreed milestones, and final payment only being made after an acceptable report has been submitted.

Industry is intimately involved in the whole R&D process and it is clear that the RDC Model is efficiently meeting industry and Government R&D needs, providing a strong return on the public and industry funds invested in R&D, and employing world best practice in the process. Rural industries are, in large part, internationally competitive because of the strong role of the RDCs in leading and promoting innovation right across the production, processing and marketing chain, with the Model providing a significant international comparative advantage for the rural and downstream industries.

Current AFFA RDC's

- Cotton Research and Development Corporation
- Dairy Research and Development Corporation
- Dried Fruits Research and Development Council
- Fisheries Research and Development Corporation
- Forest and Wood Products Research and Development Corporation
- Grains Research and Development Corporation
- Grape and Wine Research and Development Corporation

- Land and Water Resources Research and Development Corporation
- Pig Research and Development Corporation
- Rural Industries Research and Development Corporation
- Sugar Research and Development Corporation
- Tobacco Research and Development Corporation

United States

USDA Agricultural Research Service (ARS)

The Agricultural Research Service (ARS) was established on November 2, 1953, pursuant to authority vested in the Secretary of Agriculture by 5 U.S.C. 301 and Reorganization Plan No. 2 of 1953, and other authorities.

ARS is the principal in-house research agency of the U.S. Department of Agriculture (USDA). Congress first authorized federally supported agricultural research in the Organic Act of 1862, which established what is now USDA. That statute directed the Commissioner of Agriculture '... To acquire and preserve in his Department all information he can obtain by means of books and correspondence, and by practical and scientific experiments...' The scope of USDA's agricultural research programs has been expanded and extended more than 60 times in the 135 years since the Department was created.

The research currently performed by ARS is authorized by the Department of Agriculture Organic Act of 1862 (7 U.S.C. 2201, 2204), Research and Marketing Act of 1946, amended (7 U.S.C. 427, 1621), Food and Agriculture Act of 1977, as amended (7 U.S.C. 1281 note), Food Security Act of 1985 (7 U.S.C. 3101 note), Food, Agriculture, Conservation, and Trade Act of 1990 (7 U.S.C. 1421 note), Federal Agriculture Improvement and Reform Act of 1996 (FAIR Act), and the Agricultural Research, Extension, and Education Reform Act of 1998 (PL. 105-185).

The ARS mission is to conduct research to develop and transfer solutions to agricultural problems of high national priority and provide information access and dissemination to: ensure high-quality, safe food, and other agricultural products; assess the nutritional needs of Americans; sustain a competitive agricultural economy; enhance the natural resource base and the environment; and provide economic opportunities for rural citizens, communities, and society as a whole.

Verification, Validation, and Program Evaluation

ARS currently conducts a series of review processes designed to ensure the relevance and quality of its research work and maintain the highest possible standards for its scientists. This process involves customer input to help keep the research focused on the technical needs of the American food and agricultural system. Each of the approximately 1,100 research projects undergoes a thorough merit review before new or renewed activities are begun. All ARS employees, including the scientific workforce, are subject to annual performance reviews, and the senior scientists undergo a rigorous peer review (Research Position Evaluation System--RPES) on a three- to five-year cycle. These processes ensure the continuing high quality of the ARS scientific workforce.

ARS is in the process of restructuring the way it organizes and manages its national research programs. As part of this process, ARS has aggregated its 1,100 research projects into 23 national programs managed by multi-disciplinary teams of National Program Leaders (NPLs). The national programs will focus the work of the Agency on achieving the goals defined in the ARS Strategic Plan. In FY 2000, ARS will begin a series of program and program component reviews that will supplement current merit, and RPES reviews to ensure the quality, relevancy, effectiveness, and productivity of the work being done in each national program. The annual performance plans will also serve to keep the work of the Agency focused on achieving the goals established in the ARS Strategic Plan. The aggregate effect of these changes will be a strengthened research program and an accountability system that will measure more effectively the progress made towards established goals and outcomes.

Additional information describing the key external factors affecting the ability of ARS to achieve the goals and objectives described in this report and a description of the Agency's partnerships with other Federal agencies can be found in the introduction to the ARS Annual Performance Plan. The Annual Performance Plan and Report are available on the ARS home page – www.ars.usda.gov.

In January 1998, ARS requested permission from the Office of Management and Budget (OMB) 'to describe specific and tangible products, steps, intermediate goals, and/or accomplishments that will demonstrate that the Agency has successfully met each Performance Measure/Goal in a given fiscal year.' With OMB's concurrence, the ARS has employed narrative descriptions of intermediate outcomes and indicators of progress instead of numerical metrics as specified in GPRA. The indicators listed in this Annual Performance Report represent intermediate outcomes, significant products or anticipated impacts of the Agency's work, which will serve to measure progress during FY 1999. The research and technology transfer activities listed in this report are not all inclusive of the Agency's work. The indicators reflect, but do not adequately capture the broad range of basic research that underpins much of the Agency's work. Because of the unique nature of research, as recognized by the OMB waiver, ARS accomplishments are described using a nonnumeric narrative approach that may differ from the style and format used by most other USDA Agencies.

Establishing Priorities

The deputy administrator is responsible for establishing priorities in the ARS Strategic Plan and the agency's annual budget proposals (or submissions). The Administrator ensures that the priorities are consistent with the Department's goals.

The priorities established form the basis for determining program content, for operational planning, and for resource allocations in ARS in three major ways. Priorities will be the foundation for updating the ARS Strategic Plan and National Program statements for planning annual allocations and budget requests. Priorities will guide allocation of resources to research projects and among competing operational needs. An evaluation of progress in, and the plans of, each (CRIS) research project will form the basis for allocations.

NPS is responsible for guiding National Program development and establishing project scope and direction; line managers are responsible for ensuring project statement development and review, based on the general guidance from NPS and consistent with National Programs; and research leaders and individual scientists are responsible for determining which experimental approaches and specific lines of research to pursue within the overall mission of their laboratories.

Priority setting is complex and dynamic. It is an interactive process among staff and line scientists and includes considerations of both the scientific community and research users. Decisions by the Secretary of Agriculture, Office of Management and Budget, and Congress will determine the ARS appropriation and can affect the allocation of funds to specific locations and areas of research. Within ARS, individual scientists, along with area directors and their staffs, will significantly influence priorities based on their analyses of research and approach needs for equipment, facilities, and personnel for exploiting scientific opportunities. Outside of ARS, the REE advisory boards, commodity organizations, leaders of farm organizations, industrial groups, and professional societies influence priorities.

The USDA action and regulatory agencies that depend on ARS for research—agencies such as the Animal and Plant Health Inspection Service; Natural Resources Conservation Service; Cooperative State Research, Education, and Extension Service; Forest Service; Food Safety and Inspection Service; Food and Nutrition Service; Agricultural Marketing Service; and Foreign Agricultural Service—will also influence priorities. At times, the research needs of agencies such as the Food and Drug Administration, Environmental Protection Agency, Agency for International Development, Department of Defense, National Aeronautics and Space Administration, and Bureau of Land Management will enter the process. Analyses and projections by USDA's Economic Research Service and other agencies will also be considered.

For setting of priorities, the Administrator will rely on the deputy administrator, NPS, and NPS to plan, articulate, and evaluate National Programs.

NPS identifies research opportunities, research that is conducted by other organizations, and research needs that are expressed by user and advisory groups. NPS develops recommendations for program redirections and budget requests. As the direct recipient of the information described above, the deputy administrator, NPS, will establish and articulate ARS priorities and allocate resources accordingly. NPS

will update the ARS Strategic Plan and the National Program statements and, with the ARS Budget and Program Management Staff, develop the agency budgets.
The main criteria for setting priorities and allocating resources will be:

1. Consistency with the objectives and goals of Congress, the Department, and ARS.
2. Need for the research as expressed by ARS scientists, USDA action agencies and other Federal agencies, stakeholders, clientele, and the general scientific community.
3. Potential benefits from achieving the stated goals and objectives.
4. Research capabilities and capacity of the scientists, laboratory, or program.
5. Probability of success.
6. Cost of conducting the research.
7. Amount and kind of research effort conducted by other research organizations.

Several factors may limit the allocation of resources and kinds of research that ARS conducts and its flexibility in use of resources. The following factors, which include major limitations, must be considered:

- Availability of scientific expertise. Successful research depends on the training and experience of individual scientists and on the teamwork that evolves within and among laboratories. For both individuals and groups, many years are required to reach peak productivity.
- Geography, climate, and soil. For valid results, certain types of research, especially field research, must be conducted at problem sites and over extended periods.
- Nature of the problem. Much ARS research requires costly facilities and equipment that are problem-specific. Quarantine facilities and special equipment for work on recombinant DNA and foreign animal diseases are examples.
- Sequential nature of research. Often, one phase of research must be completed before the next phase can be started.
- Continuous adaptation of biological systems. Examples are the resistance of crop pests to chemical controls and the genetic improvement of crops that may introduce new vulnerabilities. Goals and priorities must be revised to meet new problems as they arise.
- Germplasm availability.

No totally objective formula is possible for setting priorities and allocating resources for research. Priority setting for research is the exercise of informed judgment. It is based on the criteria and limitations listed above; all the factors are important at some level of decision-making. At the project level, scientific criteria and experience will predominate. At the national level, scientific criteria must be balanced with Federal policies and with the needs of action agencies and other users of research. It is the task of the Administrator, deputy administrator, NPS, and the area directors, working as a team, to achieve such a balance so that ARS may provide its scientists with the long-term stability and the firm commitments that are needed for creative research.

Vision

Leading America towards a better future through agricultural research and information.

Mission

ARS conducts research to develop and transfer solutions to agricultural problems of high national priority and provides information access and dissemination to

- ensure high-quality, safe food and other agricultural products,
- assess the nutritional needs of Americans,
- sustain a competitive agricultural economy,
- enhance the natural resource base and the environment, and,
- provide economic opportunities for rural citizens, communities, and society as a whole.

Guiding Principles

- Provide leadership for the national agricultural research agenda.
- Carry out and support excellent, relevant science.
- Support long-term research to provide a foundation for problem solving.

- Apply the science base to address critical emerging problems.
- Provide the science base for informed policymaking.
- Strengthen relationships with ARS partners.
- Educate and relate to consumers and other constituents.
- Respond to societal, consumer, and environmental concerns.
- Promote interdisciplinary team and systems approaches.
- Develop and strengthen institutional and human resources.
- Develop and transfer information systems and technology

Five major areas of research define the scope of ERS activity. These research areas derive from strategic planning in USDA for its research, economics, and education mission.

Each research area encompasses a body of ERS work—presented in Briefing Rooms, publications, data, and other products and services—addressing one of the following strategic goals:

- A competitive agricultural system
- A safe food supply
- A healthy, well-nourished population
- Harmony between agriculture and the environment
- An enhanced quality of life for rural Americans

New Zealand

Crown Research Institutes

New Zealand's Crown Research Institutes (CRIs) were set up in 1992 as government-owned companies with a clear focus on servicing the technology and innovation needs of important sectors of the economy.

The new organizations are based on the skills of staff from a wide range of backgrounds in Department of Scientific and Industrial Research (DSIR), Ministry of Agriculture and Fisheries (MAF), the Forest Research Institute (FRI) and other government research organizations.

These skills, together with the freedom to operate as commercial organizations, have resulted in close and productive relationships with the sectors the CRIs serve.

The CRIs offer a rich and flexible resource for providing large, medium and small organizations with technology and innovation services. The CRIs undertake a wide range of research, technology development and consulting for private companies within New Zealand and overseas. The CRIs also undertake strategic public good science for government; work that complements the more applied research undertaken for the private sector.

The company structure allows the CRIs to borrow funds, form joint ventures and subsidiary companies so that they can fully exploit the commercial potential of new developments for the benefit of New Zealand.

The nine CRIs are based around four productive sectors of the economy:

- ESR works in the human resource and environmental health sector.
- Industrial Research supports a range of technology development in the industrial sector.
- Landcare Research, NIWA and the Institute for Geological and Nuclear Sciences undertake environmental and resource management research.
- AgResearch, Crop & Food Research, HortResearch and Forest Research support the land based industries.

US Land-Grant System

A land-grant college or university is an institution that has been designated by its state legislature or Congress to receive the benefits of the Morrill Acts of 1862 and 1890. The original mission of these institutions, as set forth in the first Morrill Act, was to teach agriculture, military tactics, and the mechanic arts as well as classical studies so that members of the working classes could obtain a liberal, practical education.

Over the years, land-grant status has implied several types of federal support. The first Morrill Act

provided grants in the form of federal lands to each state for the establishment of a public institution to fulfill the act's provisions. At different times money was appropriated through legislation such as the second Morrill Act and the Bankhead-Jones Act, although the funding provisions of these acts are no longer in effect. Today, the Nelson Amendment to the Morrill Act provides a permanent annual appropriation of $50,000 per state and territory.

A key component of the land-grant system is the agricultural experiment station program created by the Hatch Act of 1887. The Hatch Act authorized direct payment of federal grant funds to each state to establish an agricultural experiment station in connection with the land-grant institution there. The amount of this appropriation varies from year to year and is determined for each state through a formula based on the number of small farmers there. A major portion of the federal funds must be matched by the state.

To disseminate information gleaned from the experiment stations' research, the Smith-Lever Act of 1914 created a Cooperative Extension Service associated with each U.S. land-grant institution. This act authorized ongoing federal support for extension services, using a formula similar to the Hatch Act's to determine the amount of the appropriation. This act also requires that the states provide matching funds in order to receive the federal monies.

The Land-Grant College:

There is now at least one land-grant institution in every state and territory of the United States, as well as the District of Columbia. Certain Southern states have two land-grant institutions as a result of the Second Morrill Act, and some western and plains states have several of the 1994 land-grant tribal colleges.

The United States Department of Agriculture plays a large role in the administration of federal land-grant funds and the coordination of agricultural land-grant activities at the national level. The USDA's Cooperative State Research Service (CSRS), for example, administers both Hatch Act and Morril1-Nelson funds. A portion of the Hatch Act funding supports regional research, enabling scientists to collaborate and coordinate activities and thus avoid duplication of research efforts. The Extension Service of the USDA administers Smith-Lever funding, cooperating with state governments (which also provide funding for extension programs) to set priorities and facilitate the sharing of information within the entire Cooperative Extension System.

Special programs have been created to help finance agricultural research and extension at these institutions. The Evans-Allen program supports agricultural research with funds equal to at least 15% of Hatch Act appropriations. Another program funds extension activities at the 1890 land-grants with an emphasis on reaching socially and economically disadvantaged people.

Today, America's land-grant universities continue to fulfill their democratic mandate for openness, accessibility, and service to people, and many of these institutions have joined the ranks of the nation's most distinguished public research universities. Through the land-grant university heritage, millions of students are able to study every academic discipline and explore fields of inquiry far beyond the scope envisioned in the original land-grant mission.

Since their establishment, the land-grant colleges and universities have grown to represent to the world a unique system of widely accessible higher education.

Funding

Now, in addition to the income from the original land-grants, the appropriations of federal funds to aid the states in the maintenance of land-grant institutions amount to more than $550 million annually.

These funds are distributed to the states on several different bases. Some funds go in equal amounts to all states; some go to the states on the basis of their farm population, or on their total population in relation to the total population of the United States.

The United States Department of Agriculture (USDA) plays a key role in the administration of federal land-grant funds and the coordination of land-grant activities at the national level. The USDA's Cooperative State Research Service (CSRS), for example, administers both Hatch Act and Morrill-Nelson funds. The Extension Service of the USDA administers Smith-Lever funding, though it cooperates with state governments--which provide

additional funding for extension--in setting, matching state funds, and fees for service

MEP Funding

The 2000 national program budget is $105 million from federal sources, with matching state and fee structures totalling $250 million per year. The role of the MEP network is to provide technical and business consulting services and solutions to client companies. This is accomplished via the provision of direct consulting services, referrals to outside consultants and other service providers, and by providing continuing education seminars and training programs. Services offered by the MEP include: ·Quality management systems Materials engineering Business management systems Plant layout Human resource Product development Environmental studies Financial planning Electronic commerce/EDI Market development