ALBERTA'S AGRICULTURE, FOOD AND BIO-PRODUCTS RESEARCH & DEVELOPMENT AND TECHNOLOGY TRANSFER SYSTEM

MILLENNIUM STRATEGY (2002 BLUEPRINT)

PREPARED FOR

ALBERTA AGRICULTURAL RESEARCH INSTITUTE

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"CATALYST TO THE NEW AGRICULTURE, FOOD, AND BIO-PRODUCTS ECONOMY IN ALBERTA"

PREPARED FOR
ALBERTA AGRICULTURAL RESEARCH INSTITUTE

PREPARED BY
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EXECUTIVE SUMMARY

THE CURRENT SITUATION

A review of Alberta's agriculture, food and bio-products Research and Development and Technology Transfer (R&D/TT) system was conducted by a consortium of three Alberta agribusiness consulting firms in 2001.

This review included extensive private consultations, a written survey completed by over 60 stakeholders, and a review of R&D/TT systems and models in other jurisdictions. Major findings are as follows:

- *Alberta's agriculture, food and bio-products R&D/TT system, through which research, innovations and technologies are developed, transferred and commercialized to farmers and industry, is under-performing and misaligned as now structured, funded and managed.*
- *The difficulties within the system are preventing Alberta from taking a leadership role in agriculture, food, and bio-products R&D/TT in Canada.*
- *Alberta lags behind Ontario, Quebec, and Saskatchewan in focusing and distinguishing itself in unique areas of agriculture, food, and bio-products R&D/TT or commercialization.*
- *While agriculture already exploits life sciences extensively, Alberta has yet to embrace the potential for agriculture to contribute to an industrial bio-products economy.*

THE PLAYERS

The major Research and Development players in Alberta are Alberta Agriculture, Food and Rural Development (AAFRD), Agriculture and Agri-Food Canada (AAFC), and the University of Alberta with other performers including the Alberta Research Council (ARC), the Universities of Calgary and Lethbridge, Olds College Centre for Innovation (OCCI), and a significant private sector. Technology Transfer is carried out by AAFRD, AAFC and industry for primary production, and by commercialization offices of the universities, industry and venture capital firms for new discoveries.

It is important to realize that there have been significant achievements within the agriculture and agri-food sector. For example in the first six months of 2001, Alberta for the first time has exceeded all other provinces in the level of farm cash receipts. Further, the level of food and manufacturing shipments in 2000 was $9.2 billion. More importantly, the annual rate of growth in these shipments is now exceeding 14%, an historic high.

SYSTEM FRAGMENTATION AND NON-PRODUCTIVE BEHAVIOUR

Each R&D/TT player has a separate and independent strategy with most R&D/TT activity conducted independently and without adequate collaboration and integration. Collaboration is weakest at the institutional level, but is relatively good among many researchers. R&D/TT performers establish research project direction based on their expertise and anticipation of funding.

Major deficiencies are the lack of a systems approach and systems thinking and lack of coordination and collaboration to funding and executing basic research, applied research, technology transfer, and commercialization.

LACKING LEADERSHIP AND DIRECTION

The Alberta R&D/TT system lacks leadership and direction to achieve performance.

Parallel consultations of the Alberta Life Sciences strategy are creating uncertainty in the industry and a further perception that actions will be delayed. The sector appreciates and is ready to exploit further contributions from the life sciences.

Changes within AARI over the past year contribute to uncertainty and questions about the provincial R&D/TT system. AARI is seeking to establish a structure and direction for system leadership. The R&D/TT system needs to be driven by government and industry, versus opportunistically led by the research providers. The lack of an agreed strategy for utilizing Alberta's competence and capacity means researchers, industry and government do not have a common ground for meaningful discussions.

UNTAPPED R&D/TT CAPACITY AND COMPETENCE

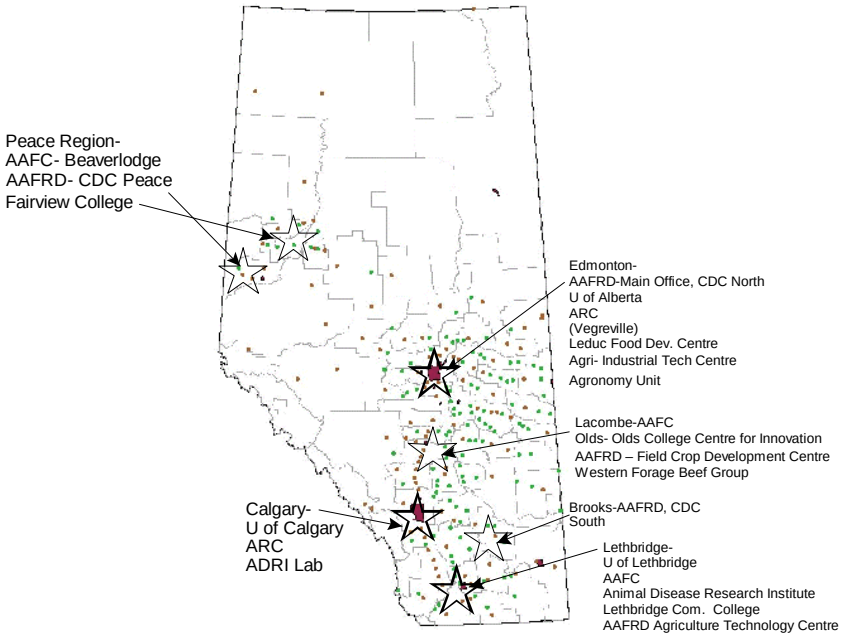
The Alberta R&D/TT system has significant depth and breath of capacity and competence. It can achieve significant efficiency gains in outputs and outcomes for the money invested in R&D/TT. It has potential to attract new global investments if it is truly integrated for research outcomes. Otherwise, global business opportunities for the sector will go elsewhere and opportunities will be missed.

MISALIGNED FUNDING

The funding system in Alberta for agriculture, food and bio-products R&D/TT is misaligned, fragmented, exhibits overlapping mandates, and is not user friendly. The new and emerging sectors of bio-products, functional foods and nutraceuticals are much less funded compared to the mature livestock and crops sectors, but have a greater need, and a greater potential for future payoffs.

Secondly, the review also identified that the R&D/TT infrastructure in Alberta is significantly depreciated. There is accumulated economic obsolescence built into the research infrastructure that is undermining the capacity of researchers to develop excellence. Recent investment in R&D/TT of about 1% of gross industry revenue is inadequate to maintain the infrastructure and operating capacity. Thus, more funds are needed. It is also noted that full cost accounting of research is difficult to complete and data needs to be tracked over time for funders use.

Alberta Agri-Food Research and Innovation Clusters



MILLENNIUM STRATEGY TO DEVELOP THE SYSTEM

RESEARCH THEMES

Overall, the industry's action agenda is recognized – to grow the value-added industry to $20 billion and the primary industry to $10 billion by 2010 utilizing opportunities identified from life sciences and global markets. Major themes for research include:

- Agri-health and value added food research.
- Primary production research.
- Bio-products research.
- Environmental sustainability research.

It is evident that Alberta must develop a "systems approach" that links all components of the R&D/TT continuum. Successful international models offer lessons to designing the new systems approach.

THE THRUST

- Provide AARI with the authority and resources to implement the Millennium Strategy
- Encourage Networks, Teams, and Collaborations.
- Build focus areas for Alberta.
- Build and replace R&D capacity.
- Increase Alberta's competence to harvest science and technology from around the world.
- Develop new commercial opportunities and enhanced technology transfer.
- Integrate research funders, performers and commercialization opportunities.
- Develop human resources and entrepreneurial capacity.

KEY ELEMENTS

- Recognition that excellence in basic research is vital to industry growth and attracting global investment.
- A move from technology push to market pull in R&D/TT must be strongly encouraged and include industry and private sector investors.
- Technology transfer (TT) is critical and needs to be improved based on a new TT network.
- Priority setting and projects selected within the research focus area.
- Target a portfolio balance among funders.
- New skills and development and retention of human resources are critical and must receive appropriate funding.
- Creating an open attitude to collaborations and building new relationships among organizations and researchers are vital.
- Alberta's global competitors are changing their R&D systems to reflect the demands of the new global marketplace and Alberta must quickly adapt.
- The systems need to be monitored and evaluated, performance measured, and reported on regularly.
- New investment of $40 million is needed, along with a larger annual AARI budget.

IMPLEMENTATION PLAN

- Secure buy-in to Millennium R&D/TT system approach and strategy.
- Encourage organizational change where appropriate.
- Establish network/teams for implementation.
- Coordinate/align funders within the system.
- Enhancements of incubators in the system.
- Increase technology transfer, and commercialization capacity and relationships.
- Augment scientific human resource capacity.
- Establish technology transfer network in agri-food and across other sectors.
- Develop monitoring and evaluating system for annual reporting.

RECOMMENDED AARI NEW BUDGET PLAN

The budget projections for AARI are based on its assumed leadership role in the development of the networks, teams, incubators, and new skills on behalf of the Alberta R&D/TT and commercialization system. This budget plan follows from the strategies indicated above.

The budget targets expenditures that will be a catalyst to bring changes to the structure and performance of the system.

AARI New Strategic Budget Plan

	No.	Year One	Year Eight
1 Networks	4	$ 3m	$ 12m
2 Teams	4	$ 3m	$ 12m
3 TT Network	1	$ .5m	$ 1.5m
4 Incubators	2	$ .6m	$ 1.2m
5 New Skills	12	$4.2m	$12.6m
Total		**$11.3m**	**$39.9m**

Three recommendations have been made. These recommendations provide for the important research themes, implementation steps, and the desired research portfolio balance. These are elaborated on in the Millennium Strategy document following.

THE MILLENNIUM STRATEGY (2002 BLUEPRINT)

THE CURRENT SYSTEM

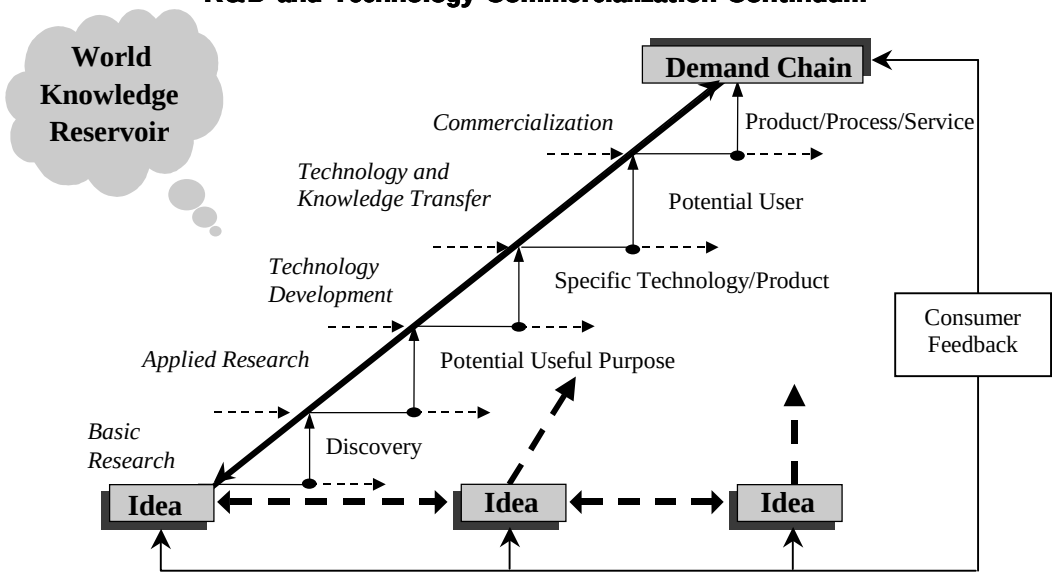
The current public sector component of the research and development and technology transfer system in Alberta employs some 584 permanent professionals. Of these, 79.3% or 463.2 are engaged in basic and applied research, and 20.7% or 120.8 are involved in technology transfer and commercial-ization activities. There was in 2000/2001 an estimated total investment in the system of $134.5 million. Of this amount, 81.8% or $110 million was invested in basic and applied research, and 18.26% or $24.5 million was invested in technology transfer and commercialization.

The R&D/TT is viewed as a continuum from the basic researcher, through to the end users "consumers" of the products of this continuum. This is illustrated in the figure below. The continuum should be viewed as non-linear. A critical loop within this continuum, is the necessary feedback of technical and applied information from the consumer or user of the research and technology transfer system, which guides and influences the origination of new basic and applied research.

The major providers within the system, are ranked below in order of their respective levels of investment.

- Alberta Agriculture, Food and Rural Development
- Agriculture and Agri-Food Canada, Lethbridge
- Industry and NGO's
- Alberta Research Council, Vegreville and Edmonton
- U of A, Agri-Food and Nutritional Science
- Agriculture and Agri-Food Canada, Lacombe/ Beaverlodge
- CFIA ADRI Lethbridge
- U of A, Rural Economy
- U of C Bio-Sciences
- Olds College Centre for Innovation
- U of A Bio-Sciences
- U of L Bio-Sciences
- U of A Renewable Resources

R&D and Technology Commercialization Continuum



For the purpose of this Strategy document, the various R&D, technology transfer, and commercialization activities are defined as follows:

- ***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.

THE SITUATION ANALYSIS

The Alberta agriculture, food and bio-products Research and Development and Technology Transfer process, through which research, innovations and technologies are developed, transferred and commercialized to farmers and industry, is under-performing and inadequate as now structured, funded and managed. Alberta lacks a coordinated and collaborating "system" for effective Research and Development, and Technology Transfer.

The difficulties within the current process are preventing Alberta from taking a leadership role in agriculture, food, and bio-products Research and Development and Technology Transfer in Canada.

Alberta lags behind Ontario, Quebec, and Saskatchewan in focusing and distinguishing itself in unique areas of agriculture, food Research and Development, Technology Transfer and Commercialization. While agriculture already exploits life sciences extensively, Alberta has yet to embrace the potential for agriculture to contribute to an industrial bio-products economy.

A review of Alberta's agriculture, food and bio-products Research and Development and Technology Transfer (R&D/TT) system shows significant deficiencies which will limit Alberta's growth and potential in responding to the goals of a $10 billion primary agriculture industry, and a $20 billion agri-food industry by 2010.

It is important to realize that there have been significant achievements within the agriculture and food sector. For example in the first six months of 2001, Alberta for the first time has exceeded all other provinces in the level of farm cash receipts. Further, the level of food and manufacturing shipments in 2000 was $9.2 billion. More importantly, the annual rate of growth in these shipments is now exceeding 14%, a historic high.

The results and major findings from the study on the Alberta R&D/TT system are summarized below. The review included over 60 stakeholder consultations, a written survey completed by over 60 stakeholders, and an external review of research and development systems and models in other jurisdictions.

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 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 1
R&D/TT Investment Activity

Stage in R&D/TT Continuum	Permanent Professionals		Funding				% of Total
	FTE p.y.	FTE % of Focus	Location A-Base Funds	External Government Grants	External Industry Grants	Total	
			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%
Technology Knowledge and 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 publicly 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 publicly 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.

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 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 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 at 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.

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 2.

Table 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
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

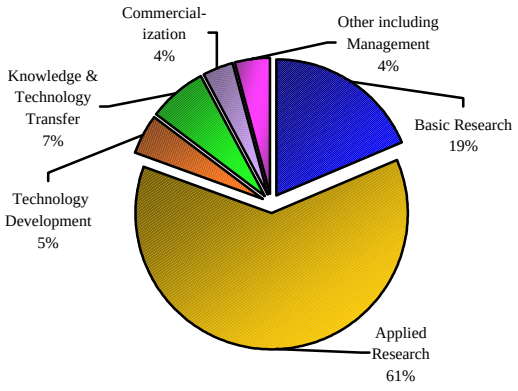
By far, the most significant performer is AAFRD with 251.7 professionals involved in R&D /TT, and an investment of $36.7 million annually. The second largest performer is AAFC, with 106.1 professionals and an investment of $23.8 million. ARC follows with 46.8 professionals involved in R&D/TT, and an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

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 1
Total R&D/TT Investment in 2000/01
($134.5 million)

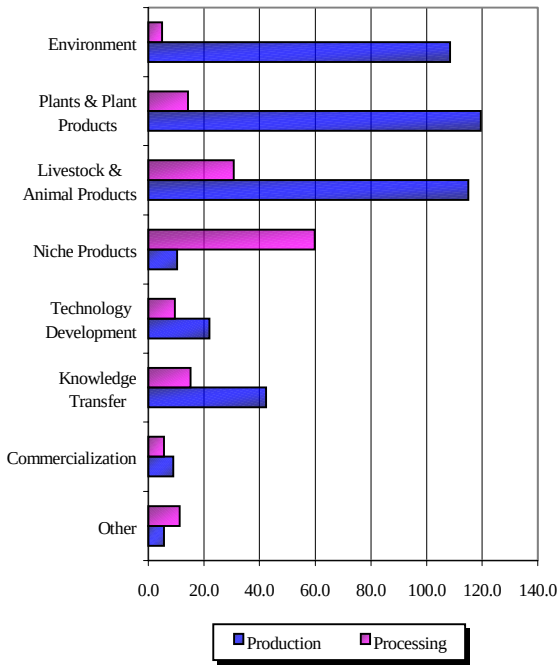


Investment in basic and applied research in 2000/01 amounted to $108.3m or 80.5% of total R&D/TT investment. We estimate there were 463.2 FTEs (permanent scientists) at public R&D establishments and in industry working in basic and applied R&D.

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 and 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. We estimate that production received support for 432.5 FTEs while processing received support for 151.5 FTEs. Plant production received the highest level of support with 119.6 FTEs or 27.6% of production R&D/TT professionals. Processing is weighted in favour of niche processed products (59.8 FTE), with animal products receiving support for 30.8 FTE and plants products 14.3 permanent FTE professionals.

Figure 2
Permanent Professionals In Production and Processing R&D/TT

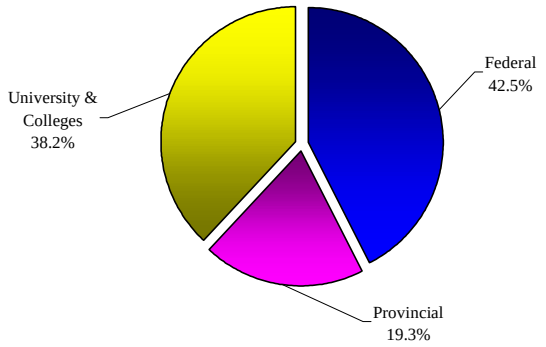


Capital Expenditures

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
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.

R&D/TT System Fragmentation

The Alberta agriculture and food R&D/TT system is fragmented. The major R&D players are Alberta Agriculture Food and Rural Development (AAFRD), Agriculture and Agri-Food Canada (AAFC), and University of Alberta with other performers including the Alberta Research Council (ARC), the Universities of Calgary and Lethbridge, Olds College Centre for Innovation/Olds College, and the private sector.

TT is carried out by AAFRD and AAFC (primary production/processing) and for new discoveries, by the Industry Liaison Office (ILO) and University Technologies International (UTI) offices, and the private sector. Each has a separate and independent strategy.

Sound 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, but with relatively good collaboration among many researchers.

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 a lack of respect and understanding between institutions. Institutions and research disciplines operate as "silos", and are often destructively competitive with each other.

A major deficiency within the current system is the lack of a systems approach and systems thinking through which basic research, applied research, technology transfer, and commercialization are integrated and made seamless. This includes developing early stage supports, financing and venture capital partners who can provide much needed management expertise to new high-risk ventures.

Lacking Leadership And Direction

The current 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 an inability to translate these activities into actions.

The current consultations with respect to the Alberta Life Sciences strategy are creating uncertainty in the minds of the industry, and creating a further perception that actions will be delayed. (Note: Life Sciences as a theme offers huge global opportunities.) The Alberta agriculture and food sector is already providing results from the use of basic life sciences such as animal and plant genetics, cell biology, molecular biology, genetic markers, genetic transformation, etc., and appreciates the significance and potential for further contribution of life sciences to the sector.

Clear leadership and actions, backed by a funding strategy, have 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

strategy. The current actions of AARI are seeking methods to develop a 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 and vague, and hence lacks specifics. From two to four major achievable strategic R&D directions for the industry need to be identified and agreed upon from which all parties can support and direct their resources. The system needs to be driven by government and industry, versus led by the research providers. The lack of a strategy for the utilizing of Alberta competence and capacity means researchers, industry and government do not have a common ground for meaningful discussions.

UNTAPPED R&D/TT CAPACITY AND COMPETENCE

The agriculture, food and bio-products 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, fermentation, livestock genetics, toxicology, food quality and 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 currently being performed independently (and sometimes competitively) in different institutions. For example, there are upwards of 80 personnel engaged in crop and pest management in Alberta at AAFC Lacombe and Lethbridge, AAFRD, ARC, and the Universities of Alberta, Calgary and Lethbridge, etc. The extent of this capacity, if focused, networked, or otherwise collaborated, could represent a world class of leading capability in the area of sustainable crop bio-systems management. It does not currently exhibit this capacity, given the system fragmentation.

The Alberta R&D/TT system, if better focused, integrated, and managed, could achieve significant gains in outputs and outcomes for the money invested in R&D/TT. It would also attract new global investments if it were truly integrated for research outcomes. Otherwise, global investment will prefer jurisdictions with a stronger integrated R&D/TT system.

MISALIGNED FUNDING

The funding process in Alberta for agriculture, food and bio-products R&D/TT 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 more established and mature industries, and appear to be well funded. The new and emerging sectors of bio-products, functional foods and nutraceuticals are inadequately funded, yet have the greatest need, and, have potential for significant future payoffs. These future growth industries suffer from a lack of investment, champions and 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 R&D/TT infrastructure in Alberta has significantly depreciated and deteriorated over the past ten 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. Some infrastructure reinvestment has occurred in the past two years at various locations, but more is needed. The recent investment levels of about 1% of gross industry revenue, is inadequate to maintain the infrastructure, and is low compared to other countries and jurisdictions where the investment level is closer to 2% of revenue. If Alberta wishes to harness its research capacity to capture global business opportunities, it must not limit the potential by insisting on researchers using old tools.

AGRI-FOOD R&D/TT SYSTEM NEEDS

In view of competitor R&D/TT systems, major needs were identified within the current agriculture, food and bio-products R&D/TT and commercialization system. They include the following:

- A "systems" approach needs to be introduced, in which research, development, incubation, technology transfer, early stage funding support, venture capital financing and commercialization are all linked.
- Emphasis to be placed on developing within, and attracting world class human resource capability.
- A need to integrate and use 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.
- Better linkages to the rural communities, and to the opportunities, capacities, needs and benefits of rural development are necessary.
- Provide incentives and tools to attract private sector investment into the R&D/TT system. These could include tax credits, research discoveries database, policy changes, intellectual properties service capability, regulatory approval support services, and others.
- Create better communication between funders, R&D providers and clients about research needs, priorities, review processes, and mid-course corrections.
- Look at industry wide problems, using an integrated systems approach (e.g.: integrated environmental management, adaptation to climate change, manure and odour management, water quality issues, urban-rural development).
- Further evaluation of venture capital is needed including pre-commercialization funding deficiencies and needs in the province.

FOCUS AND ACTION ARE NEEDED TO REMAIN GLOBALLY COMPETITIVE

The cross cutting themes and key conclusions are as follows:

Themes

- The time for action is now – frustration was voiced by the system participants who are contemplating their roles in attempting to satisfy the sustainable growth and life science agendas.
- 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 agriculture and food sector has to reach out to new disciplines, and sectors.
- The agriculture, food, and bio-products sector in 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 a 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 to change our mental models through strong management to make it happen.
- Overall, the R&D agenda for action is well recognized – to grow the value-added industry to $20 billion and the primary industry to $10 billion by 2010. The major themes for research include the following:
  - environment sustainability;
  - primary production competitiveness;
  - value added agri-products;
  - new uses such as functional foods, nutra-ceuticals and industrial bio-products; and,
  - enhanced market access and marketing.

Conclusions

- A new way of collaborating the research, development, technology transfer and commercialization continuum in Alberta is needed. The current approach is not working.
- Two actions present themselves: first, to develop and implement a new Alberta strategy for agri-food R&D/TT to ensure global opportunities are not missed. Second, to increase and align the resource investment in the agriculture, food, and bio-products R&D/TT system both for operating expenditures and research capital infrastructure.
- From the study review, R&D/TT performers and funders are very concerned and interested in seeing action being taken to overcome the gaps, provide integration methods, and define a clear Alberta R&D/TT strategy for agriculture, food, and bio-products.

MILLENNIUM STRATEGY FOR ENHANCING THE ALBERTA AGRI-RESEARCH SYSTEM

The Alberta R&D/TT system needs to develop a complete "systems approach" to actively link all components of the research and development and technology transfer continuum. A number of successful international models offer additional lessons learned for the new systems approach. The thrust of the strategy is to:

- Encourage networks and collaborations.
- Build focus areas for Alberta.
- Build and replace R&D capacity.
- Increase Alberta's competence to harvest science and technology from around the world.
- Develop new commercial opportunities and enhanced technology transfer.
- Integrate research funders, performers and commercialization opportunities.
- Develop human resources and entrepreneurial capacity.

A fundamental requirement for the development of a system, is that single organization be given the responsibility and resources to bring about the needed changes. AARI has been in the past playing this role. For the future success of an R&D/TT system, the role of AARI needs to be reinforced and expanded.

Table 4
Stakeholders Affected by the Millennium Strategy

Agriculture, Food and Bio-Products Research Stakeholders in Alberta		
Provincial Government	**Federal Government**	**Universities and Colleges**
Alberta Agriculture Food and Rural Development	Agriculture and Agri-Food Canada Lethbridge Research Centre	University of Alberta
Alberta Research Council	Agriculture and Agri-Food Canada Lacombe Research Centre including Beaverlodge	University of Calgary
Environment and Sustainable Resource Development Ministries	Canadian Food Inspection Agency Animal Disease Research Institute, Lethbridge	University of Lethbridge Olds College / Olds College Centre for Innovation / Other Colleges
Industry and Non Government Organizations		
Industry Development Funds	Agriculture and Food Council	Professional Services
Commodity Boards and Commissions	Alberta Technology Commercialization Network	Private industry
Alberta Environmental Sustainable Agriculture	AVAC Ltd.	Venture Capital

BASIC RESEARCH CREATES NEW OPPORTUNITIES

Basic research which is recognized as essential is important to attracting and retaining global investment. The new agriculture, food and bio-products system will have basic research (discovery) carried out at the Universities and their partners, with applied research and technology transfer carried out by industry and AAFRD. (Note: AAFRD has extensive agri-food linkages in the province and needs to focus on the latter task in collaboration with industry (seed and fertilizer companies, animal health care firms, equipment manufacturers, etc.) Basic research will recognize provincial priorities and will be enhanced. Research opportunities will be greatly expanded through building on current Alberta strengths and natural competitive advantages.

APPLIED RESEARCH AND DEVELOPMENT TESTS CONCEPT FEASIBILITY

Applied research and development will be greatly enhanced to meet market and industry needs and to facilitate access to discoveries which can be commercialized. The proposed system of supports includes research, technology development, technology transfer methods, incubators and venture capital for early stage new ventures. Incubators will be needed for value added products, bio-products and new life science/agri spin off companies. Some of this activity is currently being contemplated but needs to be accelerated. The system will include transition and business incubators, building from current facilities. A move from "technology push" to "market pull" approaches in applied research and technology development will be strongly encouraged. This approach provides for inclusion of industry and private sector investors in early stages of development.

TECHNOLOGY TRANSFER IS CRITICAL

Technology transfer needs to be improved. For primary production clients, TT will be carried out by AAFRD and industry, based on a new TT network. The network will be built in stages, using the On Farm Demo program and AAFRD expertise to assist in competitiveness and new technology adoption by primary producers.

The next level of technology transfer occurs at the value added and processing industries. For the processing industries, technology transfer is different and will involve multiple agencies such as ILO and UTI for new discoveries and spin off companies. For others, AAFRD and the Leduc Food Processing Development Centre, the Agri-Industrial Technology Centre, ARC, OCCI, IRAP, AVAC and private sector experts will become collaborators. The third level of development will occur with new "Life Sciences" and bio-products companies. These companies will mainly find collaborations with university researchers, AAFC, ARC and global industry players in specific areas of agri-fibre, bio-chemicals, bio-products and bio-fuels.

DEVELOPMENT AND RETENTION OF HUMAN RESOURCES IS CRITICAL

The availability of skilled human resources covering a wide range of disciplines and skill-sets have consistently been identified as a critical limiting factor to the achievement of Alberta's $20 billion value-added and $10 billion primary production goals. Human resources have also been identified as critical to achieving the desired outcomes of Alberta's Life Science Strategy.

Strategic Research Networks which address requirements and measures through partnerships with Learning Institutions for education and training to build Alberta's human resources competencies in specific program areas should be viewed favourably and have appropriate financial resources made available.

NEW RESEARCH/TECHNOLOGY OPPORTUNITIES MUST BE EXPLOITED

New and expanded information on opportunities is important. To help build opportunities for Albertans

and investors, a new technologies database, business and mentoring expertise and a more open Intellectual Property (IP) process will be needed. Reducing the risk of failure of new spin off companies from the universities is as important as company creation. In developing the opportunities and access, reliance will be placed on the new Alberta Supernet facilities.

COLLABORATIONS AND RELATIONSHIPS ARE ESSENTIAL

Creating an expanded and open attitude to future opportunities is equally important. To this end, developing collaborations and building new relationships among both organizations and researchers is very important. Some collaborations are occurring but more are needed. New strategic planning processes, think tank processes, common research reviews and shared priority setting within key strategic research themes will encourage change.

R&D COMPETITORS ARE CHANGING

Alberta's competitors of R&D are changing their R&D systems to reflect the demands of the new global marketplace. Examples include Australia, New Zealand, Denmark, Netherlands, UK, USA and in Canada, Ontario, Quebec and Saskatchewan. Alberta lags significantly in its approach to systems thinking. Of note, Ontario recently contracted its entire $70 million R&D function to the University of Guelph and terminated all R&D activities in its agriculture department. They also transferred agricultural colleges to the University of Guelph. As a result, Ontario has implemented a complete systems approach. Other models also offer options.

ALBERTA SUCCESSES

Table 5
Some Alberta Agriculture, Food and Bio-Products R&D/TTC Commercialization Stories

SemBioSys Genetics Inc.	Calgary based plant biotechnology company developing technology patented by U of C Department of Biological Sciences researcher.
CV Technologies Inc.	Edmonton based agri-health spin-off from a U of A Department of Pharmacology researcher.
Kinnickinnick Foods	Edmonton based functional food (disease management) company.
Alta Genetics Inc.	Calgary-based global livestock genetics firm.
Alberta Research Council	Agri-fibre research and development
AgriGenomics Inc.	A plant biotechnology spin-off company from the U of A plant biology group partnered with ARC and developing a patented genetic system to produce nitrogen efficient plants, including canola.

THE MILLENNIUM STRATEGY EXPLAINED

The Alberta agriculture, food, and bio-products research and development/ technology transfer system needs to focus on the province's sustainable growth in view of future global opportunities. The goals of the strategy are to:

- Propel Alberta into a leading agri-food and bio-products scientific position.
- Build excellence in R&D/TT practices for Alberta benefits.
- Provide new and competitive opportunities for industry growth.
- Create a world class R&D/TT system for sustained high quality agri-products.
- Demonstrate the essentiality of R&D/TT and the innovation for economic and social well being.

The key elements noted below provide the framework by which this can occur. The R&D system builds toward helping to achieve the overall growth vision posed for the sector. Alberta's current strong economic position provides a platform to become a leader in selected and specific areas. Alberta has to build strong "clusters" of expertise in selected areas and decide on its choices in a "make or buy" R&D system which considers the world knowledge reservoir of science and technology. The

strategy acknowledges current R&D/TT performers, the AARI Strategic Directions, the Life Science Strategy and other relevant Alberta initiatives (Supernet, GELS).

STRATEGY AND FOCUS AREAS

The strategy of the R&D/TT system will support and help encourage sustainable production systems within four focus areas. The focus areas are developed based on the driving trends, Alberta strengths and emerging issues which face the province. A shift from traditional primary production agriculture to a more integrated food production system of high quality traceable products will occur. In addition many new opportunities with integrated cross-sector projects will occur in the areas of agri-health, agri-fibre, bio-products, bio-chemicals and new uses. Each focus theme will be led by a specific champion and supported by others in the system. Thus collaborations for research and commercialization goals can occur.

The four focus areas are as follows:

- **Agri-health and value added foods research** – this is a very big opportunity area for both the primary and processing industries to meet domestic and export market opportunities. The collaborators should be the University of Alberta and the Leduc Food Processing Development Centre with support from others such as OCCI and private industry.
- **Primary production research** – this is an area for non-competitive research and sustainable production systems. The collaborators should be AAFC, University of Alberta and AAFRD with support from others.
- **Bio-products research** – agri-products which can be used in another industry as a feedstock, ingredient or intermediate product. This effort would be new to the province but opportunity exists for these products. AAFC nationally, NRC, ARC (agri-fibre, fermentation and industrial processing), AAFRD and AITC, and the energy and forestry industries have much to contribute to bio-products R&D in agriculture.
- **Environmental sustainability research** – with participation of the Vegreville Sustainable Agriculture Program Centre staff, and with research staff from other provincial and federal institutions. This includes research in soil, water and air quality, environmental health, sustainable life systems, food safety and traceability systems (data mining/inventory management). These are key needs given the scrutiny on the sector for sustainable, safe and socially accepted food and bio-products production systems.

These four focus areas will link to the Life Science strategy in various ways, depending on the technology platform and tools, and the researchers involved in the collaborations. The focus areas must consider the needs of large and small rural and urban communities, opportunities, and socio-economic topics including ethics, law, marketing and economics. One of the strategic goals is to greatly increase collaborations among both research organizations and researchers within Alberta, as well as nationally and internationally.

AGRICULTURE, FOOD AND BIO-PRODUCTS SECTOR'S R&D/TT PORTFOLIO BALANCE

Province-wide investment across the agriculture, food and bio-products R&D/TT continuum should be as follows: basic research - 30%, applied research - 30%, technology transfer - 30% and opportunistic projects - 10%.

The proposed portfolio balance is based on the input from participants and the Australia Rural Research and Development Corporation Model (RDC). From information obtained, it appears this Model has been successful in coordinating the research and development and technology transfer for governments, universities, the private sector, and other institutions. The current level of investment is included for comparison purposes.

Table 6
Investment Portfolio Balance

Continuum Level	Current Investment (%)	RDC Model (%)	Proposed Investment (%)
Basic Research	19	19	30
Applied Research	62	38	30
Technology Transfer	15	36	30
Opportunistic Projects/ Management	4	7	10

The province-wide portfolio balance for R&D/TT should reflect Alberta's priorities: agri value-added - 25%, primary production - 25%, bio-products - 15% and environmental sustainability - 30%. A fifth area for communication, planning policy, and overall system performance enhancement (5%) is also recommended. The portfolio funding will develop collaborative investments to help expand overall funding potentials.

AARI's R&D/TT Investment Portfolio Should Be Weighted Differently

As a strategic funder of R&D/TT, AARI's portfolio balance should be: basic research - 40%, applied research - 40%, technology transfer - 15% and system management - 5%. This portfolio balance should be achieved within five years.

Table 7
Strength in Agriculture, Food and Bio-Products Research Clusters

Cluster	Who	What
Edmonton and North Region	U of A AAFRD, LFPDC, AAFRD CDC North and Peace ARC, Edmonton & Vegreville AAFC Beaverlodge Industry - biotechnology, pharmaceutical, medical, bio-products , foods	Foods, agri-fibre, niche products, crops, apiary, horticulture, oilseeds, poultry, dairy, pork, medical foods, biotech, bio-control products, environmental sustainable research, alternative livestock, etc.
Lacombe, Red Deer, Olds Region	AAFC Lacombe Research Centre AAFRD Lacombe Industry – cereal fractionation, bio-products, foods	Meats, composting, waste management, bio-products, cereal, grain legumes, forages, etc.
Calgary Region	U of C ARC, Calgary Industry – ICT, bio-products, foods	Plant biotechnology, molecular farming, bio-informatics
Lethbridge Region	AAFC Lethbridge Research Centre CFIA Animal Disease Research Institute AAFRD CDC South Industry – foods	Beef, winter crops, potato, beans, forages, bio-control, irrigation, waste management, biotech
Peace River Region	AAFC Beaverlodge Station AAFRC Specialists Forage seed industry	Agronomy, canola breeding, forages, forage and turf seeds, apiculture

Deployment Of Resources For The Millennium Strategy

The strategy will be directed by AARI on behalf of the sector and will require a number of linked actions and resources. These are as follows:

i. **Strategic research networks.** To lead and develop the themes above, specific strategic research networks would be established. The networks will become the structure by which coordinated research plans would be developed, funded, and evaluated within a theme area. Initial funds would be made available for the network(or team) to set up the network, to develop its plans, and to establish operating agreements and charters. A network will include at least two research organizations for a minimum critical staff and facilities to be recognized as having excellent research outputs. The new networks will attract a long-term budget commitment, based on the strength of

the business plan. Networks/Teams would attract annual budgets of from $1.0 to $5.0 million, depending on the relevance and achievability of its outcomes. Each network would be led by a scientific leader responding to a specific management board. The network will prepare a Business Plan to be approved by AARI and industry. Performance measures and commercialization targets will be a part of the Plan. An example network is the Sustainable Intensive Livestock Operations Practices Network (SIPN). A separate initiative led by AARI on Strategic Research Networks (SRN's) more precisely details the function, structures and rationale for networks in R&D and technology transfer systems.

ii. **Teams.** In the case of smaller, but equally important topics areas, teams will be used to address cross-industry expertise such as agri-health and specific genomic projects which may be led by other networks. A Team can work more quickly to respond to the research problem and develop outputs. In this instance, a Team is expected to be comprised of at least two Principal Investigators (scientists) and complementary staff. An example Team is The Functional Foods Product Team.

iii. **Building science and technology capacity.** In new areas which offer global opportunities, it will be important to build capability. This includes a re-direction of some current scientific staff.

iv. **New "Technology Transfer Network".** A new technology transfer network will be developed among primary, processing and new agri-life science companies. The initial stage involves the On Farm Demo clients and system and will be championed by AAFRD on behalf of AARI. In addition, the TT network will help to develop commercial opportunities more aggressively, seeking out new non-Alberta technologies for use in Alberta, and will assist in addressing the venture capital and financing limits to growth, perhaps with AVAC, also a key to the network. The TT network will also work on regulatory gaps which are currently limiting growth.

v. **Transition incubators and business incubators.** Recognizing new spin-off companies and entrepreneurs need special help. Existing and/or new transition incubators and business incubators will be needed near the main research sites. These will be an important forum for public-private interfaces in commercialization approaches and resources. Transition incubators will be for spin off companies and business incubators will be for early stage growth/emerging companies.

vi. **Portfolio and research reviews.** The portfolios of the research funders need to be coordinated and joint research reviews need to reflect the new strategy. (Note: public funding may need to move from mature industries to emerging industries to help stimulate new discoveries and commercial opportunities). Portfolios should reflect the focus areas and research reviews should reflect mutual priorities with clear guidelines. Decision making will need to be both cyclical and dynamic for various segments of the agri-food value chain.

vii. **Pooled research projects**. To assist funders and other interested parties (venture capital), research proposals will be pooled as much as possible, and "marketed" through a research website to allow maximum opportunity for funding. Additionally, the networks will encourage joint theme specific projects through calls for proposals.

viii. **Adopting "best practices".** The system needs to adopt more best practices such as peer reviewed research proposals and projects, collaborative funding of strategic themes, and joint research reviews and management. This is a difficult area as it calls for cross-organizational work and cross-discipline reviews which are not common in the public sector.

ix. **Performance measures.** Appropriate measures need to be developed to encourage the system to respond to meet the strategy. Measures for encouraging more active IP technology transfer from universities and more spin-off companies/ receptor companies will be needed. In addition the venture capital supply will expand as more high quality "deals" are developed. Thus the need for a stronger "systems approach"

x. **More resources for the system are needed.** Overall, the system is below an optimum level of investment including both capital and

operating (research) funds. At a level of 2% of gross revenues of the sector, an additional $20 million per year in addition to at least $20 million for capital infrastructure is needed. Consolidation of research facilities and experimental farms will realize additional system cost savings, but will require new capital and management approaches.

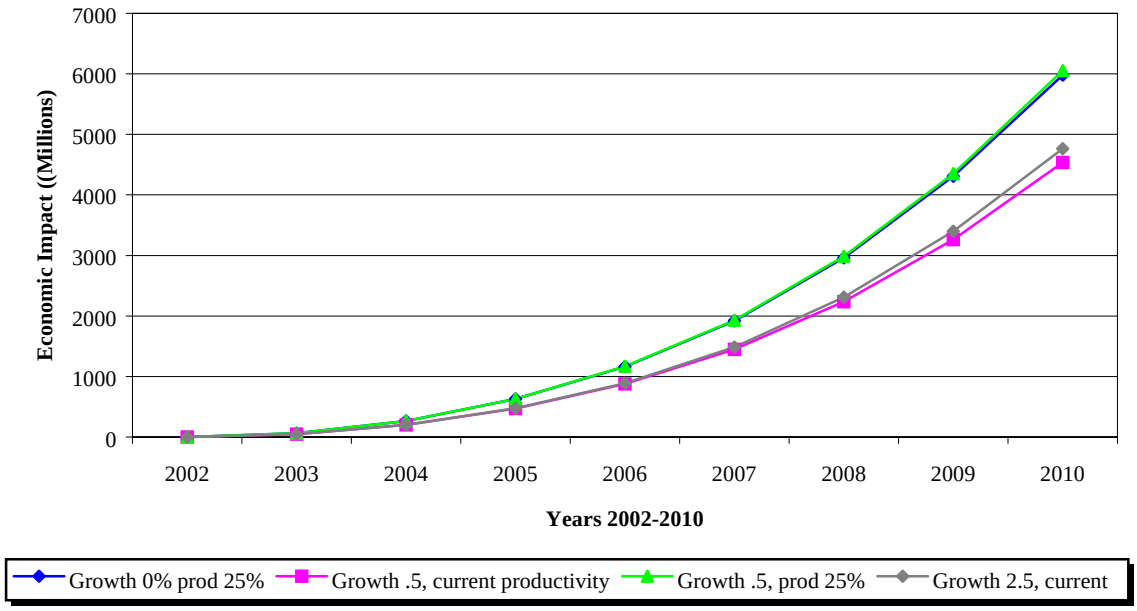
xi. **Funding System Coordination.** There are currently in the range of 20-24 different funding sources and funding organizations in the province involved in supporting research, technology transfer and commercialization in the agriculture and agri-food sector linked in some way or another to government. There is in the range of $115 million available from the Non-Government Organizations (NGO's) over the next two to four years under current budgets. The funding system needs to be made more transparent, collaborative, and interactive within the system. These funders need to develop mutual funding approaches for the focus areas.

xii. **Incentives and research supports.** Other jurisdictions have deliberately developed approaches to build the environment for new spin off and emerging companies. These approaches include special incubators near research institutions, research parks, matching grants, tax incentives, venture capital formation and policy supports. This area needs to be reviewed to ensure discoveries made in Alberta do not see the need to migrate to other jurisdictions for commercialization purposes.

ECONOMIC IMPACTS OF SYSTEM IMPROVEMENTS AND NEW INVESTMENT

An assessment has been made of the economic impacts of both increasing the existing systems effectiveness, and of increasing the investment to research and technology transfer. The detailed assessment is appended to this report. The cumulative impacts of moving toward an effective and coordinated research system in Alberta are estimated in Figure 4.

Figure 4
Cumulative Impact of Investment in the Research System



Realigning and increasing the output of the system can lead to cumulative economic impacts on the Alberta economy of up to $6.0 billion by 2010. Simply investing more dollars, without improving the structure and functioning of the system will lead to cumulative economic impacts of closer to $4.5 billion, almost $1.5 billion less.

The four scenarios include: (1) 0 growth, but a 25% efficiency gain; (2) a 0.5% growth with no efficiency gain; (3) a 0.5% growth and a 25% efficiency gain; and (4) a 2.5% growth with no efficiency gain. The efficiency gain is the most effective by far.

This economic impact is incremental to the existing benefits which the system is providing. The executing of these system changes has the potential to move the industry up $5 to $6 billion closer to the $20 billion sector goal.

AARI IMPLEMENTATION STRATEGY PROCESS

The proposed implementation of the above strategy is outlined below. The implementation strategy is focused within two overlapping areas:

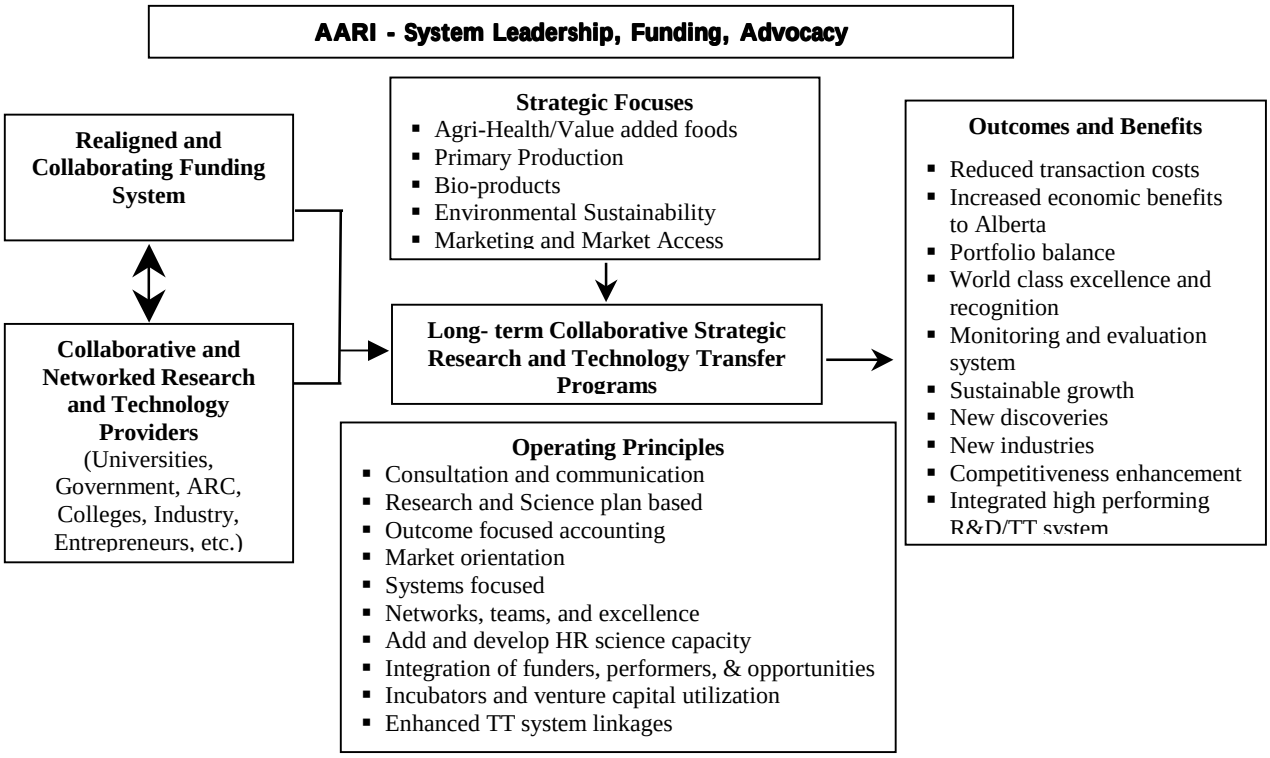
- an enhancement and improvement of the structure and functioning of the current system; and
- moving the system ahead within the Millennium Strategy.

As is evaluated in the previous section, an improvement in the functioning of the current system, could have significant economic impacts on the Alberta economy. An improvement in how the system functions and operates is a necessary and required condition. The commitment of new resources should be conditional on bringing about the required system changes. The key conclusion is that money alone is not the answer. The whole system needs to be re-organized, coordinated and better managed, to enhance outputs and performance.

This strategy is developed assuming AARI has been given the authority and resources to guide the implementation process. The new strategy needs to be implemented for results and will take time to allow for development of business plans and for industry to understand the strategy and implications. This will mean industry consultation and discussions in addition to realignment of internal plans as needed. Implementation will take place over 2001-2002 A budget commitment growing to $40 million for AARI will be required for it to oversee and support the implementation of these system changes. This increase of $30 million would be achieved as implementation plans are finalized and realized.

A diagrammatic outline of the strategy is pictured in Figure 5. Following this, a representation of the focus areas, the likely providers who would be participating in each focus area, and implementation issues are presented.

Figure 5
The Millennium Strategy



Organizational Structure

Focus Area	Network Lead and Partners	Implementation Strategy	Anticipated Budget, priority
Agri-Value Health and Food Products	Lead: U of A, partners: AARI, U of C, AAFC, AVAC, AFC, AAFRD	Strategic network likely best approach, focus	Needs seed budget to establish network. Annual budget up to $3.0 million Immediate priority
Primary Production	Lead: AAFRD, partners: AARI, U of A, U of L, AAFC, IDF's AFC	Emphasis on Industry integration, technology transfer mechanisms Closely linked to other focus areas. Consideration of rural development issues.	Annual budget up to $3.0 million. Intermediate priority
Bio-products	Lead: ARC, partners: U of A, U of C, AAFC, AAFRD, AFC, AVAC	Strategic network, likely focus on products such as agri-fibre, bio-energy, bio-chemicals	Annual budget up to $3.0 million Immediate priority
Environmental Sustainability	ARC Vegreville(Lead), partners: AESA, AAFC, AAFRD, AARI	Network likely major implementation mechanism. Most scientific capacity resident in Alberta. Coupled with recommendation for Vegreville center. Respond to needs of broad industry and departments	Small seed budget for set-up Up to $3.-$4 million annual budget, on approved plans Intermediate priority
TT Network	AFRD (OFD) ATCN/ILOS ARC	Phase 1 – transfer OFD Phase 2/3 – add processing and life sciences	$1.3 million Immediate priority

Proposed Implementation Steps, Proposed Outcomes, and Timing

Task/Objective	Actions and Steps	Expected Outputs and Outcomes	Resources and Timing
Secure buy-in on strategy and focus	Communications used to sell the vision and approach for moving the new strategy and vision ahead. The focus areas are validated, as well as approaches (networks, teams, etc.)	Alberta Industry accepts the need for and approach to a coordinated and focused System for agriculture, food, and bio-products R&D, TT and commercialization.	This communication phase would be as short as possible but may be up to three months duration.
	Steering group of senior level management representing the key agencies established for implementation	Buy-in and ownership is encouraged and established within the sector	Done by year-end
Establish networks, teams for implementation	System vehicles (networks, teams) will be initiated. A limited amount of resources will be allocated to set-up the networks/ teams, and to develop comprehensive R&D and TT plans	Eventually, up to four, or five networks and teams will be needed. Possible research networks/teams include: ▪ Agri-fibre Network ▪ Intensive Livestock Operations Sustainable Systems Network ▪ Functional Food Products ▪ Soluble Fibres for Disease Prevention and Nutrition Products for Disease Management ▪ Bio-products	The scope of the network or team, and the strength of the business plan prepared, will determine the funding of the network. Anticipate that for most viable and functioning networks, a budget of $3.0 million per year would be required. It is critical that the highest priority network(s) be first identified and implemented on a priority basis. Where the industry cannot come together , and develop collaborative research and technology plans, funds would likely not be forthcoming.
Coordinate funding system	Collaborate linkages between funders, common processes established, work toward syndication of project and theme funding	Duplication and overlap between funders reduced, better and more significant projects and strategies funded.	
Establish new incubators and increase use of existing incubators	Establish new or coordinate existing incubators at the University of Alberta and University of Calgary for new life science and emerging companies	Increased capacity within the province to facilitate technology transfer	A three year budget entails $1.8 million
Increase availability of expertise for technology transfer and commercial success	A new "Industrial Management Resource Group" to deal with in plant advice, management advice and technology assessment will be needed and delivered by the private sector.	Increased capacity within the province to facilitate technology transfer	This totals $5.4 million over three years.

Task/Objective	Actions and Steps	Expected Outputs and Outcomes	Resources and Timing
Increase scientific and discovery human resource capacity	New skill sets are acquired at post secondary education and research institutions: agri-health- two principal investigators in botanical processing and products; two in characterizing the functional food properties of new ingredients(physical, chemical, biological); two in bio-fuels and agricultural co-generation technologies; two in bio-chemicals and bio-composites/derivatives; one in regulatory systems and three in technology convergence	The scientific and potential world class capacity within the province will rapidly increase the effectiveness of the system.	These positions total $8.4 million over three years. Placement will occur at the University of Alberta, University of Calgary, and University of Lethbridge, where appropriate. Outputs will flow to the technology network for commercialization.
Establishment of technology transfer network in agri-food	AARI needs to implement the new Technology Transfer Network for the agri-food system. Specifically, in the first stage, AARI needs to transfer the OFD program to AAFRD which in turn will be the first participant in AARI's Technology Transfer Network. The second stage is to add the value-added component, and the third stage is to add a life sciences component.	Increased capacity within the province to facilitate technology transfer	Resources to be identified upon development of preparation of business plan
Establish science and technology division at AAFRD	AAFRD should form a new Science and Technology Division which includes current scientific staff involved in research and technology transfer in CDC South and North, Leduc Food Processing Development Centre, AITC and Lacombe. The Division will need a science leader. The Division will include joint research plans, staff appointments and shared labs and facilities with the University of Alberta, ARC and AAFC. There is the need to meet international standards for scientific and technology transfer excellence.	R&D and Technology Transfer System in the province is better aligned with AAFRD .	
Develop system for measuring and monitoring system performance	AARI should report to system stakeholders on the results of the system-wide scientific and financial performance assessment and recommended mid-course corrections. AARI should work with R&D/TT funding stakeholders to develop a rational and standardized approach to scientific and financial accounting and performance assessment.	A better system for measuring the performance and outcomes of the Alberta system is developed and used. Development of an accepted GAAP for full cost accounting of R&D/TT would greatly assist R&D management, funding and political decision makers in making rational and objective decisions concerning future investments in R&D/TT in the sector.	To be determined.

RECOMMENDED AARI NEW BUDGET PLAN

The budget projections for AARI are based on it assuming a leadership role in the development of the R&D/TT System, inclusive of the networks, teams, incubators, and new skills on behalf of the Alberta agriculture, food, and bio-products industry. This budget plan follows from the strategies previously outlined.

AARI New Strategic Budget Plan

Years		No.	Year 1	Year 8
1	Networks	4	$3m	$12m
2	Teams	4	$3m	$12m
3	TT Network	1	$.5m	$1.5m
4	Incubators	2	$.6m	$1.2m
5	New Skills	12	$4.2m	$12.6m
Total			**$11.3m**	**$39.9m**

A budget plan to 2010 is projected on a draft basis below.

AARI Projected Budget Requirements By Activity
($ millions)

Planned Budget Allocations	Benchmark (2001) FTE	Benchmark (2001) $	2002 $	2003 $	2004 $	2005 $	2006 $	2007 $	2008 $	2009 $	2010 $	Total $
Administration	3	0.90	0.90	0.91	0.91	0.92	0.92	0.93	0.93	0.94	0.94	8.3
Networks			3.00	6.00	9.00	12.00	12.00	12.00	12.00	12.00	12.00	90.0
Teams			3.00	6.00	9.00	12.00	12.00	12.00	12.00	12.00	12.00	90.0
Project and Program funding	2	10.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
TT Network			0.50	1.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	12.0
Incubators			0.30	0.60	0.90	1.20	1.20	1.20	1.20	1.20	1.20	9.0
New Skills			4.20	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	72.2
Capital Funding			1.00	1.01	1.01	1.02	1.02	1.03	1.03	1.04	1.04	9.2
Total Expenditures	5	10.90	12.90	20.51	28.32	35.63	36.64	37.65	38.66	39.67	40.68	290.7
AARI Proportion Total R &D %			8.1	12.7	18.7	23.4	23.9	24.4	25.0	25.5	26.0	

The budget above targets the expenditures on the directed areas which will bring about the changes to the structure and performance of the system.

INVESTMENT STRATEGIES AND PROJECTIONS

Several R&D/TT growth strategies were developed and simulated for the Alberta system. The detailed simulations are appended to this report.

CONSERVATIVE STRATEGY

A conservative strategy of 0.5% real annual growth from current levels of expenditures ($141 million) would see R&D/TT investment reaching $149 million by 2010. This would be accomplished through and augmented by the agricultural scientific research capacity in the province by approximately 12 FTE over this period. This is very insignificant number of scientists if obtained gradually over the projection period. The benefits of this investment in R&D and TT have been quantified, and are anticipated to accumulate to an annual net increase of $1.3 billion. The accumulated real investment cost over this projected period 2002-2010 would be $1.4 billion, expended over a nine year period. The accumulated direct economic benefit to the province is estimated at $4.5 billion, for this investment, for a cost benefit ratio of 3.2.

The added economic benefits to the Alberta economy over this period are projected to be $1.8 billion in new investment, $1.5 billion in new product sales, internal corporate investment of $.21 billion, and a accumulated employment income of almost $1.0 billion. This totals the $4.5 billion in direct benefit.

This conservative strategy does not keep up with a target of maintaining, in real terms, R&D expenditures at 1.5% of real industry revenue sales (agri-value food and beverage sector shipments toward the $20 billion goal).

This strategy is not considered feasible and will not achieve the goal of Alberta developing an effective R&D/TT system.

RESEARCH PRODUCTIVITY ENHANCEMENT

The key to the success of the Millennium Strategy for the agriculture, food, and bio-products R&D/TT System, is being able to enhance its productivity. Productivity is best represented by the effectiveness and speed by which a better coordinated and managed system can make research discoveries, translate these discoveries into different forms of Intellectual Property rights and agreements, and then transfer and commercialize these products into the provincial and world market place. In other words, increasing the "deal flow" within the system.

This strategy would see new scientific capacity being hired from outside the province on a priority basis over the next 2-3 years.

The conservative and aggressive strategies outlined above describe only the situation where new funds are invested, and outcomes are based on the systems current research discovery rates and deal flows. A simulation has been performed in which the research and system effectiveness has been increased by 25%. The basis of this productivity change will be the lowering of the cost for a new discovery by 25%.

The results of this change are remarkable. Keeping the real rate of research investment at the level of the conservative strategy (0.5% annually), the system could achieve a 33% improvement in outputs and outcomes, as measured by the economic criteria of industry revenue, new investment, and added employment. The total economic impact given this productivity improvement is estimated at over $6.0 billion, versus the $4.5 billion economic impact for the same growth rate, without changing the productivity of the system (conservative strategy above).

AGGRESSIVE STRATEGY

An aggressive strategy would see investment growing at a real rate of 2.5% per year over this same period. The added cost of this strategy (relative to the conservative strategy) would be $186 million, for an added benefit of $232 million.

This strategy would also see new scientific capacity being hired from outside the province on a priority basis over the next two to three years.

The accumulated economic benefits to Alberta from this more aggressive strategy are estimated to total $4.8 billion by the year 2010. This benefit is anticipated to be $1.94 billion in new investment, $1.6 billion in increased industry output revenue, $0.22 billion in company internal investment, and added employment income within the sector of $1.0 billion.

Under this strategy, R&D expenditures in real terms come close to meeting a target of 1.5% of industry output revenue.

This Millennium strategy provides the structures and plans to bring about the required changes.

SUMMARY AND CONCLUSIONS

The report outlines the deficiencies of the current agriculture, food, and bio-products R&D/TT system in Alberta. The need for an integrated, balanced coordinated R&D/TT system is outlined as well as the potential payback from such a system.

To accomplish this, the following recommendations have been prepared for consideration by the AARI Board of Directors.

RECOMMENDATION #1: RESEARCH THEME FOCUS

The following research themes came through from the consultation process and background research:

- Agri-health and value added food research
- Primary production research
- Bio-products research
- Environmental sustainability research

The themes will see new research and commercial-ization opportunities occur within the agri-food sector and with health, environment, and forestry.

RECOMMENDATION 2: PORTFOLIO BALANCE TARGETS

Because of limited resources, effective use of all funds is essential. Based on the RDC model in Australia, and Alberta needs; the following portfolio target for the R&D/TT Continuum, and the Research Themes is recommended:

- R&D/TT Continuum:

Basic Research	30%
Applied Research	30%
Technology Transfer	30%
Opportunistic Projects	10%

- Research Themes

Agri-health Value Added Food Research	25%
Primary Production Research	25%
Bio-products Research	15%
Environmental Sustainability Research	30%
Communications, Policy, Planning	5%

RECOMMENDATION #3: IMPLEMENTATION WITH STAKEHOLDERS

To accomplish the development of a new R&D/TT system for the agriculture, food, and bio-products of Alberta, the following basic implementation steps are recommended:

- Secure buy-in to the millennium strategy through communication processes
- Establish networks/teams for implementation and carry-through
- Encourage funders and researchers to align with new R&D/TT system
- Establish new and more effectively use current incubators

RECOMMENDATION #4: SUSTAINABLE AGRICULTURE PROGRAM

Previous studies of the Sustainable Agriculture Program, along with results from this consultation process, created the following recommendation.

The existing Sustainable Agriculture Program and the related Vegreville facilities be enhanced and positioned to become the "Alberta Life Science Environmental Systems Institute". The Institute would be linked with the U of A, AAFRD, ARC, AAFC, U of C, OCC1, and other research providers.

CONTACTS WITHIN INDUSTRY CONSULTATION PROCESS

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Investment and Expected Impacts of Alberta's Agri-Food R&D and Technology Transfer System

Conservative Growth Strategy: 0.5% Real Rate

	Benchmark(2001)		2002	2003	2004	2005	2006	2007	2008	2009	2010	
	FTE[1]	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	Totals
Real Growth Rate (%)			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Operating Expenditures												
Basic Research	97.4	20.3	20.4	20.5	20.6	20.7	20.8	20.9	21.0	21.1	21.2	187.3
Applied Research	309.4	75.9	76.3	76.7	77.0	77.4	77.8	78.2	78.6	79.0	79.4	700.4
Technology Transfer	177.8	35.1	35.3	35.5	35.6	35.8	36.0	36.2	36.3	36.5	36.7	323.9
Sub-Total	584.6	131.3	132.0	132.6	133.3	133.9	134.6	135.3	136.0	136.6	137.3	1211.6
Capital Budget: infrastructure		6.75	6.78	6.82	6.85	6.89	6.92	6.96	6.99	7.02	7.06	62.3
Capital Budget: research Equip			0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	6.2
Capital Catch-up			10.0	10.0								20.0
Contingency(5%)			7.0	7.0	7.0	7.1	7.1	7.1	7.2	7.2	7.3	64.0
System Totals(Real $)	584.6	138.1	156.4	157.1	147.9	148.6	149.3	150.1	150.8	151.6	152.3	1364.2
System Totals ($ nomimal)2		138.1	160.3	165.1	159.2	164.0	169.0	174.1	179.3	184.7	190.3	1545.9
Projected FTE's[3]			586.1	587.5	589.0	590.5	591.9	593.4	594.9	596.4	597.9	
Inflation factors		1.00	1.03	1.05	1.08	1.10	1.13	1.16	1.19	1.22	1.25	
	1 Full Time equivelent scientific personnel		2 Assuming Annual Inflation rate of 2.5%			3 Asuming a 50% productivity gain in output						
Expected Economic Outputs and Outcomes												
Annual New Discoveries[4]	#	58	65	65	62	62	62	63	63	63	63	568
New patents/lisc., companies[5]	#	9	10	10	9	15	16	16	16	16	16	123
New Investment Attracted[6]	$ Millions			39	83	127	169	238	308	379	449	1792
Agrivalue Sales Output[7]	$ Millions				43	92	141	187	265	342	421	1491
Company R &D[8]	$ Millions				2	7	14	23	36	54	75	210
Highly Trained Employment[9]	#			86	184	282	375	529	685	841	998	
New Employment Payroll	$ millions			6	20	41	70	109	161	224	299	930
Total Economic Impact	$ millions			45	148	267	393	558	770	998	1243	4423
Cumulative Values	4 Based on previous results, the $2.4 million appears to generate 1 new discovery					5 15% of discoveries to 2004, and 20% thereafter						
	6 Estimated capital value per commercial opportunity of $3.0 million, lagged two years					7Future sales, 1 year lagged, of $4.0 million						
	8 New investment at 5% of sales			9 estimated employment of 10 people per new opportunity								
Industry Real sales growth	$ billions	10.00	10.50	11.03	11.58	12.16	12.76	13.40	14.07	14.77	15.51	
R& D investment, 1.5% target	$ billions	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.21	0.22	0.23	
R & D Investment, 2.0% Target	$ billions	0.20	0.21	0.22	0.23	0.24	0.26	0.27	0.28	0.30	0.31	
Planned less 1.5% R & D target	$ millions		-1.1	-8.3	-25.8	-33.7	-42.1	-50.9	-60.2	-70.0	-80.4	
Planned less 2.0 % target	$ millions		-53.6	-63.4	-83.7	-94.5	-105.9	-117.9	-130.6	-143.9	-157.9	
Benefit Cost ratio												3.2

Investment and Expected Impacts of Alberta's Agri-Food R&D and Technology Transfer System

Aggressive Growth Strategy: .5 % Real Growth, 25% improvement in Research Productivity

	Benchmark(2001)		2002	2003	2004	2005	2006	2007	2008	2009	2010	
	FTE[1]	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	Totals
Real Growth Rate (%)			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Operating Expenditures												
Basic Research	97.4	23.4	23.5	23.6	23.8	23.9	24.0	24.1	24.2	24.4	24.5	215.9
Applied Research	309.4	75.9	76.3	76.7	77.0	77.4	77.8	78.2	78.6	79.0	79.4	700.4
Technology Transfer	177.8	35.1	35.3	35.5	35.6	35.8	36.0	36.2	36.3	36.5	36.7	323.9
Sub-Total	584.6	134.4	135.1	135.7	136.4	137.1	137.8	138.5	139.2	139.9	140.6	1240.2
Capital Budget: infrastructure		6.75	6.78	6.82	6.85	6.89	6.92	6.96	6.99	7.02	7.06	62.3
Capital Budget: research Equip			0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	6.2
Capital Catch-up			10.0	10.0								20.0
Contingency(5%)			7.1	7.2	7.2	7.2	7.3	7.3	7.3	7.4	7.4	65.4
System Totals(Real $)	584.6	141.2	159.7	160.4	151.2	151.9	152.7	153.4	154.2	155.0	155.8	1394.2
System Totals ($ nomimal)2		141.2	163.7	168.5	162.8	167.7	172.7	177.9	183.3	188.8	194.5	1580.0
Projected FTE's[3]			586.1	587.5	589.0	590.5	591.9	593.4	594.9	596.4	597.9	
Inflation factors		1.00	1.03	1.05	1.08	1.10	1.13	1.16	1.19	1.22	1.25	
	1 Full Time equivelent scientific personnel			2 Assuming Annual Inflation rate of 2.5%			3 Asuming a 50% productivity gain in output					
Expected Economic Outputs and Outcomes												
Annual New Discoveries[4]	#	78	89	89	84	84	85	85	86	86	87	775
New patents/lisc., companies[5]	#	12	13	13	13	21	21	21	21	22	22	167
New Investment Attracted[6]	$ Millions			53	113	173	230	325	420	516	612	2441
Agrivalue Sales Output[7]	$ Millions				59	125	192	255	361	467	573	2032
Company R &D[8]	$ Millions				3	9	19	32	50	73	102	287
Highly Trained Employment[9]	#			118	251	384	510	721	933	1146	1361	
New Employment Payroll	$ millions			9	28	56	95	149	219	305	407	1267
Total Economic Impact	$ millions			62	202	364	535	760	1049	1360	1694	6027
Cumulative Values	4 Based on previous results, the $2.4 million appears to generate 1 new discovery						5 15% of discoveries to 2004, and 20% thereafter					
	6 Estimated capital value per commercial opportunity of $3.0 million, lagged two years						7Future sales, 1 year lagged, of $4.0 million					
	8 New investment at 5% of sales			9 estimated employment of 10 people per new opportunity								
Industry Real sales growth	$ billions	10.00	10.50	11.03	11.58	12.16	12.76	13.40	14.07	14.77	15.51	
R& D investment, 1.5% target	$ billions	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.21	0.22	0.23	
R & D Investment, 2.0% Target	$ billions	0.20	0.21	0.22	0.23	0.24	0.26	0.27	0.28	0.30	0.31	
Planned less 1.5% R & D target	$ millions		2.2	-5.0	-22.5	-30.4	-38.8	-47.6	-56.9	-66.6	-76.9	
Planned less 2.0 % target	$ millions		-50.3	-60.1	-80.4	-91.2	-102.6	-114.6	-127.2	-140.5	-154.5	
Benefit Cost ratio												4.3

Investment and Expected Impacts of Alberta's Agri-Food R&D and Technology Transfer System

Aggressive Growth Strategy: 2.5 % Real Growth

	Benchmark(2001)		2002	2003	2004	2005	2006	2007	2008	2009	2010	
	FTE[1]	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	$ M	Totals
Real Growth Rate (%)			2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
Operating Expenditures												
Basic Research	97.4	23.4	24.0	24.6	25.2	25.8	26.5	27.1	27.8	28.5	29.2	238.7
Applied Research	309.4	75.9	77.8	79.8	81.8	83.8	85.9	88.1	90.3	92.5	94.8	774.8
Technology Transfer	177.8	35.1	36.0	36.9	37.8	38.7	39.7	40.7	41.7	42.7	43.8	357.9
Sub-Total	584.6	134.4	137.8	141.2	144.7	148.4	152.1	155.9	159.8	163.8	167.9	1371.4
Capital Budget: infrastructure		6.75	6.92	7.09	7.27	7.45	7.64	7.83	8.02	8.22	8.43	68.9
Capital Budget: research Equip			0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	6.9
Capital Catch-up			10.0	10.0								20.0
Contingency(5%)			7.3	7.5	7.6	7.8	8.0	8.2	8.4	8.6	8.9	72.4
System Totals(Real $)	584.6	141.2	162.6	166.5	160.4	164.4	168.5	172.7	177.0	181.5	186.0	1539.6
System Totals ($ nomimal)2		141.2	166.7	174.9	172.7	181.5	190.6	200.3	210.4	221.1	232.3	1750.5
Projected FTE's[3]			591.9	599.3	606.8	614.4	622.1	629.8	637.7	645.7	653.8	
Inflation factors		1.00	1.03	1.05	1.08	1.10	1.13	1.16	1.19	1.22	1.25	

1 Full Time equivelent scientific personnel

2 Assuming Annual Inflation rate of 2.5%

3 Asuming a 50% productivity gain in output

~~Expected Economic Outputs and Outcomes~~												
Annual New Discoveries[4]	#	59	68	69	67	68	70	72	74	76	77	641
New patents/lisc., companies[5]	#	9	10	10	10	17	18	18	18	19	19	140
New Investment Attracted[6]	$ Millions			40	85	132	177	254	333	414	497	1934
Agrivalue Sales Output[7]	$ Millions				44	95	147	197	283	370	460	1597
Company R &D[8]	$ Millions				2	7	14	24	38	57	80	223
Highly Trained Employment[9]	#			88	190	294	394	565	741	921	1105	
New Employment Payroll	$ millions			7	21	43	72	115	170	239	322	990
Total Economic Impact	$ millions			46	153	277	411	591	825	1081	1360	4744

4 Based on previous results, the $2.4 million appears to generate 1 new discovery

5 15% of discoveries to 2004, and 20% thereafter

6 Estimated capital value per commercial opportunity of $3.0 million, lagged two years

7Future sales, 1 year lagged, of $4.0 million

8 New investment at 5% of sales

9 estimated employment of 10 people per new opportunity

Cumulative Values

Industry Real sales growth	$ billions	10.00	10.50	11.03	11.58	12.16	12.76	13.40	14.07	14.77	15.51	
R& D investment, 1.5% target	$ billions	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.21	0.22	0.23	
R & D Investment, 2.0% Target	$ billions	0.20	0.21	0.22	0.23	0.24	0.26	0.27	0.28	0.30	0.31	
Planned less 1.5% R & D target	$ millions		5.1	1.1	-13.3	-17.9	-22.9	-28.3	-34.0	-40.2	-46.7	
Planned less 2.0 % target	$ millions		-47.4	-54.0	-71.1	-78.7	-86.8	-95.3	-104.4	-114.0	-124.3	
Benefit Cost ratio												3.1