BIOTECHNOLOGY IN CANADA

Phase I: UP 30/134

report

rapport

For your information —
from La Slotin

BIOTECHNOLOGY
IN
CANADA

Phase I: UP 30/134

Dr. Lewis A. Slotin
March 31, 1980

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PART A

INTRODUCTION

This background paper is part of a process to develop a federal policy for the promotion and development of biotechnology in Canada. As the first phase in this process this paper describes the present biotechnological activity in Canada, both in terms of its location and its areas of application. In addition recommendations are put forward as to the opportunities worth exploiting in a Canadian context and for the implementation of the second phase of policy development.

This paper attempts to present a reasonably comprehensive listing of Canadian biotechnological activity but does not pretend to be exhaustive. In addition no attempt has been made to evaluate in terms of excellence, the activities described.

DEFINITION

The term biotechnology has been accepted worldwide to mean the exploitation of microorganisms or their components to provide certain goods and services. Biotechnology is, in fact, an umbrella term which covers a range of technologies. These technologies, however, may be classified into three non-mutually exclusive areas: fermentation technology, enzyme technology, and genetic and cellular manipulative technology. It is, therefore, against this definition and/or description of biotechnology that Canadian research and development activity has been examined.

BACKGROUND

The present attraction of biotechnology is two-fold. First, from an industrial process point of view, the basic feedstocks or substrates are renewable resources such as cellulose, sugar or starch. This means that biotechnological processes are less likely to be affected by the same cost spirals which currently plague conventional processes based upon non-renewable resources. Second, from an environmental stand-point, the by-products of biotechnological processes can represent a net benefit to the environment in the form of carbon dioxide, water and biologically acceptable nitrogen fertilizers. This is in sharp contrast to the toxic effluents of today's chemical processes.

Internationally an investment explosion is occuring as many see biotechnology as having as large, if not larger impact upon industry and society than the microelectronics revolution. Japan, for example, has a long tradition of success in exploiting microorganisms, and one which has led to a present level of industrial activity which earns over $15 billion per year or nearly 5 per cent of its gross national product. In France, a report recently release "Science de la Vie et Société" has indicated that biotechnology will produce 30,000 new jobs in France over the next decade, including 6,000 research positions. In Brazil the highly publicized gasohol program is well underway and diversification is now being planned to supplant their petroleum based chemicals industry with one based upon alcohol produced via fermentation.

In the U.S., in addition to the Government's proposed $3 billion - 10 year program of loans and loan guarantees for the production of alcohol fuels, large industrial concerns in the chemical, petroleum, pharmaceutical and food sectors are actively engaged in developing or expanding in-house biotechnological capabilities. Most of the publicity in the genetic manipulative area has been caused by 3 new firms: Cetus, Genentech and Genex. Cetus is owned jointly by Socal (Chevron), Standard Oil of Indiana and National Distillers and has a net worth of approximately $100 million. Genentech is owned by Inco, Kleiner and Perkins, Monsanto, the Hillman Company of Pittsburgh, the Mayfield Fund of San Francisco, Soffinova and Lubrizol Corporation and has a net worth of $65 million. Genex, the smallest of the three, is owned by Emerson Electric and the Koppers Company with a net worth of $9 million.

The European Economic Community has recently received and given preliminary approval to expenditures of $50 million on biotechnology over the next five years. The program is designed to build-up capability in a number of key biotechnological areas and has been unanimously approved by European industry. In the UK a major report of the Royal Society, the Advisory Board for the Research Councils and the Advisory Committee for Applied Research and Development has called for a $10 million annual expenditure on biotechnology, over and above existing allocations, to be coordinated by a Joint Committee for Biotechnology. Within Europe, West Germany is generally considered to be the leader: government spending on the basic problems of biotechnology is about ten times that in France or the UK. All together, between 1972-78, West Germany invested $100 million in biotechnological R&D.

SECTION I

BIOTECHNOLOGICAL ACTIVITY IN CANADA - BY SECTOR

The activities described in Section I have been grouped according to three sectors, Government, Industry and University. Each listing contains the name and address of the firm, agency or institution, the individual to be referred to for further clarification and a description of the activity.

GOVERNMENT SECTOR

FEDERAL

G-1 AGRICULTURE CANADA

General: E.J. Leroux
Assistant Deputy Minister
Research Branch
Sir John Carling Building
Carling Avenue
Ottawa, K1A 0C5
(613) 995-7084

(a) Chemistry and Biology Research Institute
Ottawa, Ontario
J.G. Saha
(613) 995-3104

Development of means of fixing atmospheric nitrogen through the study of hosts, bacteria and the biological processes; also increase nitrogen fixation efficiency through hydrogen utilization.

Production of doubled haploids for breeding cereal and cruficer species, cell and protoplast cultures for mutant selection, parasexual hybridization, whole plant regeneration and interspecific gene transfer.

(b) Ste-Foy Research Station
Ste-Foy, Quebec
S.J. Bourget
(514) 694-4814

Development of means of fixing atmospheric nitrogen through the study of hosts, bacteria and the biological processes.

(c) Beaverlodge Research Station
Beaverlodge, Alberta
L.P. Spangelo
(403) 354-2212

Assessment of nitrogen fixation potential of forage legumes, bacterial selection and improvements in innoculants and innoculation methods.

(d) Lethbridge Research Station
Lethbridge, Alberta
J.E. Andrews
(403) 327-4561

Nitrogen fixation in wheat strains; transfer of specific traits to wheat.

(e) Swift Current Research Station
Swift Current Saskatchewan
A.W. Strachan
(306) 773-4621

Methodology of assessing viability and effectiveness of inocula, nodulation and nitrogen fixation by non-leguminous shrubs; utilization of high nitrogen-fixation annual legumes as fertilizers.

(f) Brandon Research Station
Brandon, Manitoba
W.N. MacNaughton
(204) 728-7234

Haploidy techniques in barley breeding.

(g) Vancouver Research Station
Vancouver, British Columbia
N. Weintraub
(604) 224-4355

Meristem tip cultures for the production of virus-free stocks; pathogen free cell lines.

(h) Saskatoon Research Station
Saskatoon, Saskatchewan
J.E.R. Greenshields
(306) 343-8214

Haploids in rapeseed; protoplast fusion for Brassica hybrids.

(i) Morden Research Station
Morden, Manitoba
E.D. Putt
(204) 822-4471

Tissue culture for disease free stocks and preservation of germplasm.

(j) Summerland Research Station
Summerland, British Columbia
J.C. Russell
(604) 494-7711

Tissue culture for fruit tree propagation.

G-2 ENERGY MINES AND RESOURCES

M. Silver
Canada Centre for Mineral and Energy Technology (CANMET)
Mineral Science Laboratories
One Processing Laboratory
555 Booth Street
Ottawa, K1A 0G1
(613) 995-4706

Microbial leaching of uranium, composting efficiencies

G-3 ENVIRONMENT CANADA

Inland Waters Directorate
Canada Centre for Inland Waters
National Water Research Institute
Burlington, Ontario
L7A 4A6
(416) 637-4303

(a) D. Liu

Biodegradation of petroleum via fermentation processes

G-4 HEALTH AND WELFARE CANADA

General: A.J. Clayton
Director General
Laboratory Centre for Disease Control (LCDC)
Health Protection Branch
Tunney's Pasture
Ottawa K1A OL2
(613) 992-6385

(a) J. Konowalchuck and L. Perelmutter

Hybridoma techniques for selective immunoglobulin production

(b) J.R. Dillon

Molecular genetics of plasmids and transposable elements of medical importance

G-5 NATIONAL RESEARCH COUNCIL OF CANADA

Atlantic Regional Laboratory

General: F. Simpson
Director
1411 Oxford Street
Halifax, Nova Scotia
(902) 429-6450

(a) J.P. Van der Meer

Genetics of algae culture, algae as a food source.

G-6 NATIONAL RESEARCH COUNCIL OF CANADA

Division of Biological Sciences

General: C. Bishop
Director
100 Sussex Drive
Ottawa K1A OR6
(613) 995-6600

(a) S.M. Martin
(613) 992-2367

Anaerobic microbiology, methanogenic bacteria, hydrogenases, continuous culture studies, enterotoxins, growth of pathogenic bacteria.

(b) M.B. Perry
(613) 992-8995

Antigens of pathogenic bacteria, Neisseria species, chlamydia, pneumococcus, streptoccus; structure-function in polysaccharide antigens, use in vaccines and diagnostics; synthetic antigens; monoclonal antibodies from hybridomas.

(c) C.P. Lentz
(613) 992-3310

Biogas fermentation, practical production of biogas from sewage sludge and food wastes.

(d) A.P. James
(613) 992-6512

Cloning of genes in yeast and bacteria; transformation of yeast; studies on gene expression; synthesis of genes and of linker segments for plasmid linking; structure of chromatin; restriction enzymes; ribosome structure.

(e) K.R. Lynn
(613) 992-6541

Protein biochemistry; isolation and characterization of eznymes - hydrogenases, protein kinases, sulfatases; immunoglobulins.

G-7 NATIONAL RESEARCH COUNCIL OF CANADA

Prairie Regional Laboratory

General: B. Craig
Director
110 Gyminasium Road, U. Campus
Saskatoon, Saskatchewan
(306) 665-4191

(a) C.G. Young

Protein, starch and sugar processing

(b) J. Groot Wassink

Enzyme recovery and utilization; inulase and lactase production by yeast cultures.

(c) N.G. Kurz

Plant cell culture; pharmaceuticals production

(d) F. Constabel

Plant cell culture; pharmaceuticals production

(e) R. Tyler

Enzyme isolation from plant seeds

(f) R. Reichart

Food process engineering

(g) J. Child

Immobilized cells, annucleated - utilization in fermentations

(h) P.S.S. Dawson

Continuous phased culture as fermentation technology

PROVINCIAL

G-8 ALBERTA RESEARCH COUNCIL

Frontier Sciences Division
11315-87th Avenue
Edmonton, Alberta
T6G 2C2
(403) 432-8019

(a) D. Currie

Heavy oil degradation by microorganisms
Cold temperature microbes for petroleum degradation

Long Range Plan (Biotechnology)

- Low frost tolerance crop breeding
- Nitrogen fixation improvements for crops
- Exploitation of plant hormones

G-9 MANITOBA RESEARCH COUNCIL

501-One Lakeview Square
155 Carlton Street
Winnipeg, Manitoba
R3C 3H8
(204) 944-3505

(a) B.F. Dodds
Program Director

Recently opened Industrial Technology Centre will feature a life sciences section emphasizing fermentation, cellular and genetic manipulative capabilities for industrial support

G-10 NOVA SCOTIA RESEARCH FOUNDATION CORPORATION

Biology Division
100 Fenwick
Dartmouth, Nova Scotia
B2Y 3Z7

(a) K. Hellenbrand

Industrial fermentation for polysaccharide production and utilization

G-11 SASKATCHEWAN RESEARCH COUNCIL

Chemistry and Biology Division
30 Campus Drive
Saskatoon, Saskatchewan
S7N OX1
(306) 664-5400

(a) D. Thompson

Lignocellulosic treatment to increase cellulose and hemi-cellulose availability for fermentation

Compaction of lignocellulosic materials

INDUSTRY SECTOR

I-1 AYERST LABORATORIES

1025 Laurentian Boulevard
P.O. Box 6115
Montreal, Quebec
H3C 3J1
(514) 755-6771

(a) G. Vezina

Antibiotic production, pilot plant capability for antibiotic fermentations

Protoplast fusion activity

Future recombinant DNA work for production of peptide hormones.

I-2 B.C. RESEARCH COUNCIL

3650 Wesbrook Mall
Vancouver, British Columbia
V6S 2L2
(604) 224-4331

(a) C. Walden

Conversion of black liquor from pulp mills into a fermentable substrate; fermentation process for commercial production of alginic acid

(b) J. Mueller

Biohazards and studies of biotoxicity

(c) A. Brunesteyn

Microbial leaching of base metals

I-3 THE BORDEN COMPANY LIMITED

1275 Lawrence Avenue East
Don Mills, Ontario
M3S 1C5
(416) 445-3131

(a) Tillsonburg, Ontario Laboratories

Immobilization of lactases for whey treatment-waste treatment process

I-4 CAMBRIAN PROCESSES LIMITED

D.H. Lees
Director
Research and Development Division
2465 Cauthra Road
Mississauga, Ontario
L5A 3P2
(416) 272-1400

(a) Novel fermentor design and application to amylase production

I-5 CANADA PACKERS

P. Ziegler
Research Centre
2211 St. Clair Avenue West
Toronto, Ontario
N6N 1K4
(416) 766-4311

(a) Biochemicals from animal residues

I-6 CEDARLANE LABORATORIES LTD

S. Abrahams
President
493-A Wellington Road
London, Ontario
N6C 4R3
(519) 686-0415

(a) Antiserum production, monoclonal antibody production

I-7 CHEMBIOMED LTD

R.U. Lemieux
President
University of Alberta
W5-56 Chemistry Building
Edmonton, Alberta
T6G 2E1
(403) 432-3111

(a) Immunoadsorbents and artificial antigens for the improvement and development of blood typing reagents.

I-8 CONNAUGHT LABORATORIES LIMITED

D.S. Layne
Vice-President
Research and Technology
1755 Steeles Avenue West
Willowdale, Ontario
M2N 5T8
(416) 667-2922

Connaught Research Institute being established will focus on:

(a) Immunology - to build upon existing strengths and promote development of monoclonal antibodies

(b) Genetic Engineering - establish recombinant DNA capability

(c) Cell science - development of cell lines

(d) Bioengineering and technology - medical device development such as artificial pancreas.

I-9 ENS BIOLOGICALS INC

R. Bender
President
20 Victoria Street
Suite 405
Toronto, Ontario
M5C 2N8
(416) 364-2371

(a) Three main divisions (Molecular Genetics, Nucleic Acids and Fermentation) which operate primarily from leased space within Canadian universities; also own a microbiology firm in California

I-10 FRASER VALLEY MILK PRODUCERS ASSOCIATIONS

G.W. Park
President
6800 Lougheed Highway
P.O. Box 9100
Burnaby, British Columbia
V6B 4G4
(604) 298-1373

(a) Treatment and utilization of whey

I-11 GENERAL FOODS LIMITED

I.M. Saslaw
Research and Development Department
2200 Yonge Street
Toronto, Ontario
M4S 2C6
(416) 481-4211

(a) D. Mercer (Coburg, Ontario)

Protein extraction and novel fermentation products

I-12 GEORGE WESTON LIMITED

R. Lawford
Weston Research Centre
1047 Yonge Street
Toronto, Ontario
M4W 2L3
(416) 922-2500

(a) Fermentation products as foodstuffs

I-13 INSTITUT ARMAND FRAPPIER

531, boulevard des Prairies
C.P. 100
Laval-des-Rapides
Québec (Québec)
H7V 187
(514) 687-5010

(a) V. Portelance

Bacterial strain development for cellulose degradation

Genetically engineer sub-unitary viral vaccines

Production of restriction enzymes and monoclonal antibodies

I-14 IOTECH CORPORATION LTD

E.A. Delong
15 Milne Crescent
Ottawa, Ontario
K2K 1H7
(613) 592-5667

(a) Process development for cellulose and hemicellulose pretreatment to permit greater accessibility of carbohydrates in fermentation. Convert lignin to a chemically active, easily extractable form

I-15 KERR-ADDISON MINES LIMITED

P.O. Box 91
Commerce Court West
Toronto, Ontario
M5L 1C7

(a) Processing of low-grade uranimum ore microbiologically at Agnew Lake, Espinola, Ontario

I-16 LABATTS BREWERIES OF CANADA LIMITED

B. Shelton
Corporate Director
Research and Development
150 Simcoe
London, Ontario
N6A 4M3
(519) 673-5050

(a) High fructose syrup manufacture, food processing

(b) G. Stewart (519) 673-5326

Physiology and genetics of yeasts; ethanol tolerance and production; Application of recombinant DNA technology to yeasts

I-17 L.J. McGUINNESS AND COMPANY LTD

2 Algoma Street
Toronto, Ontario
M8Y 1B9
(416) 259-3761

(a) Distillery waste utilization

I-18 MARINE COLLOIDS

I.C. Welsh
Head
Cultivation Division
660 Portland
P.O. Box 2610
Dartmouth, Nova Scotia
B2W 2EO
(902) 434-2840

(a) Marine plant cultivation for specialty chemicals

I-19 MDS HEALTH GROUP LTD

J. Nixon
Research Director
30 Meridian Road
Rexdale, Ontario
M9W 4Z9
(416) 675-7661

(a) Development of diagnostic reagents based upon the antigenic properties of microorganisms, diagnostic system for gonorrhea

(b) Enzyme linked immunochemical diagnostics

(c) Development of antibodies to chlamydia

(d) Future development of monoclonal antibodies to microorganisms

I-20 MICROBIOS LIMITED

J.W. Costerton
President
4828 Dalhousie Drive N.W.
Calgary, Alberta
T3A 1B2

(a) Biocide development against corrosion causing bacteria

(b) Biocide development against sulfur cycle bacteria affiliated with oil recovery

I-21 MOLSON BREWERIES OF CANADA LIMITED

R.L. Weaver
Director
Research and Development Division
1555 Notre-Dame Street East
Montreal, Quebec
H2L 2R5
(514) 527-5151

(a) Fermentation genetics, rapid fermentations and product analysis

I-22 MUTATECH

J. Heddle
Department of Biology
York University
Downsview, Ontario
M3J 1P3
(416) 667-2335

(a) Diagnosis of genetic defects

I-23 NORTHERN PURIFICATION SERVICES LIMITED

139 Riverside
North Vancouver, British Columbia
V7H 1T6
(604) 929-1271

(a) Thermophilic conversion of wood waste into animal feed

I-24 ONTARIO RESEARCH FOUNDATION

Chairman
W.R. Stadelman
Sheridan Park
Mississauga, Ontario
L5K 1B3
(416) 822-4111

(a) Application of wet air oxidation technology to preparation of fermentable substrates from biomass

(b) Actively recruiting recombinant DNA expertise

I-25 PULP AND PAPER RESEARCH INSTITUTE

570 St. John's Boulevard
Pointe-Claire, Quebec
H9R 3J9

(a) L. Jurasek
Biological Chemistry Group
(514) 697-4110

Biological degradation of lignin and modification of lignocellulosics

Enzymatic conversion of cellulosic residues into fermentable substrates; enzyme isolation, characterization; development of enzyme mimics

(b) Pollution abatement division

Microbial process for the separation of bark and wood

(c) Product development division

Wood seasoning - biological hydrolysis of wood extractives

I-26 REED LIMITED

J.V. Benko
Director
Lignin Products Division
P.O. Box 2025
Quebec, Quebec
G1K 7N1

(a) Utilization of spent sulfite liquor for single cell protein production

I-27 RUSH ENGINEERING SERVICES LIMITED

R.J. Rush
Director
Research and Development
Rural Route 3
Listowel, Ontario
N4W 3G7
(519) 887-9073

(a) Thermophilic anaerobic fermentation of animal waste for protein and methane production

I-28 J.M. SCHNEIDER INC.

321 Courtland Ave East
Kitchener, Ontario
N2G 2X8
(519) 885-8100

(a) F. Murray

Waste utilization

I-29 SHELL CANADA LIMITED

T. McIvor
505 University Avenue
Toronto, Ontario
M5G 1X4
(416) 597-7622

(a) Considering fermentation facility in southwestern Ontario for antibiotic production

I-30 SILVERWOOD INDUSTRIES LTD

A. Sargent
Director
Research and Development
75 Bathurst
London, Ontario
N6B 1N8
(519) 672-9111

(a) Single cell protein production from whey, fermentation process development

I-31 SYNTEX CORPORATION

J. Freed
President
Syntex Research
3401 Hillview Avenue
Palo Alto, California
94304
(415) 855-5163

(a) Will establish basic research facility in Mississauga, Ontario in mid 1981. Research will focus on enzyme regulation with eventual lead into health care product development.

UNIVERSITY SECTOR

U-1 UNIVERSITY OF ALBERTA

Edmonton, Alberta
T6G 2E1
(403) 432-3111

Department of Biochemistry

(a) L.B. Smillie - Industrial enzymes

Department of Chemical Engineering

(b) F. Otto - Food processing, systems development

Department of Chemistry

(c) R.U. Lemieux - Immunochemistry, immunoadsorbents (Chembiomed Ltd.)
(d) S. Wolfe - Microbial transformations, microbial antibiotic production

Department of Immunology

(e) E. Diener - Immunoregulation, immunology and industrial applications

Department of Microbiology

(f) D. Westlake - Microbial metabolism, antibiotic production

U-2 UNIVERSITY OF BRITISH COLUMBIA

2075 Wesbrook Place
Vancouver, British Columbia
V6T 1W5
(604) 228-2211

Department of Biochemistry

(a) M. Smith - Studies on nucleic acids, bacterial genetics
(b) G. Tener - Genetic controls, cloning

Department of Chemical Engineering

(c) R. Branion - Fermentation parameters of single cell protein production
(d) K.L. Pinder - Waste treatment

Department of Chemistry

(e) J.P. Kutney - Plant cell alkaloids as pharmaceutical agents

Department of Medical Genetics

(f) R.C. Miller - Recombinant DNA and studies on bacterial genetics

Department of Microbiology and Immunology

(g) J. Levy - Studies on monoclonal antibodies
(h) R.A.J. Warren - Recombinant DNA

U-3 UNIVERSITY OF CALGARY

2920-24 Ave. N.W.
Calgary, Alberta
T2N 1N4
(403) 284-5110

Department of Biology

(a) R.B. Church - Studies on gene expression, cloning
(b) J.W. Costerton - Microbiological antibiotic production against Pseudomonas
- Vaccine production utilizing bacterial exopolysaccharides
(c) - Metering devices and methods to control bacterial fouling of industrial heat-exchange systems
(d) G.M. Dixon - Bacterial and mammalian genetic engineering
(e) E. Layshley - Microbial leaching of minerals

Department of Chemistry

(f) G.M. Gaucher - Fungal secondary metabolism and extracellular enzyme production

Faculty of Medicine

(g) L.M. Jerry - Medical applications of genetic manipulations, interferon and other immunology studies

U-4 CARLETON UNIVERSITY

Ottawa, Ontario
K1S 5B6
(613) 231-4321

Department of Biology

(a) B. Iyer - Nitrogen fixation studies
- Application of recombinant DNA techniques to studies of bacterial genetics

(b) G. SeHerfield - Plant cell culture, cell fusions to produce new plant strains

(c) H. Yamazaki - Genetic engineering, regulation of metabolite production

U-5 DALHOUSIE UNIVERSITY

Halifax, Nova Scotia
B3H 3J5
(902) 424-2211

Department of Biochemistry

(a) W.F. Doolittle - Bacterial and algae genetics

Department of Biology

(b) L.C. Vining - Antibiotic fermentations

U-6 UNIVERSITY OF GUELPH

Guelph, Ontario
N1G 2W1
(519) 824-4120

Department of Chemistry

(a) B.E. Ellis - Secondary metabolites in plant cells, pharmaceutical applications

Department of Microbiology

(b) P. Dobos - Viral control of insects, pancreatic necrosis virus and spruce budworm polyhedrosis virus
(c) N.A. Epps - Monitoring system for salmonella, structural barriers to microbial penetration
(d) C.W. Forsberg - Microbial activity of bovine rumen, feedstock degradation
(e) K.F. Gregory - Single cell protien from starchy substrates by thermotolerant fungi
- Recombinant DNA application to bacterial amylase production
(f) R.A. Johnson - Diagnosis of bacterial and viral induced fish diseases
(g) R.E. Smith - Waste treatment and utilization by microbial conversion
(h) - Single cell protein production as animal feed
(i) - Biodegradation of cellulose and lignin
(j) R.M.W. Stevenson - Diagnostic techniques for microbial diseases in fish

Ontario Agricultural College

Department of Environmental Biology

(k) D.L. Collins-Thompson - Food microbiology
Control of food-borne pathogens by inherent microflora in food and by antimicrobial food additives
(l) C.T. Corke - Microbial degradation of pesticides, soil microbiology
(m) J.D. Cunningham - Industrial microbiology, fermentations and industrial waste management

U-7 UNIVERSITÉ LAVAL

Cité universitaire
Québec, Québec
G1K 7P4
(418) 656-2131

Alimentation

(a) D.J. Goulet - Cheese whey fermentation; lactic acid production

Génie Chimique

(b) A. LeDuy - Studies on yeast cultures, treatment of industrial effluents

Faculté de Foresterie

(c) J. André Fortin - Studies on nitrogen fixing bacteria and their industrial inoculation

U-8 UNIVERSITY OF MANITOBA

Winnipeg, Manitoba
R3T 2N2
(204) 474-8880

Department of Immunology

(a) A. Sehon - Monoclonal antibody production

Department of Physiology

(b) H. Friesen - Genetic engineering and endocrinology

Department of Plant Science

(c) W. Bushuk - Energy from agricultural biomass (affiliation with Biomass Energy Institute)
(d) H.M. Lapp - Energy from agricultural biomass (affiliation with Biomass Energy Institute)

Department of Zoology

(e) M. Samoiloff - Mutant bacterial strain development for commercial use

U-9 McGILL UNIVERSITY

P.O. Box 6070
Station A
Montreal, Quebec
H3C 3G1
(514) 392-4311

Department of Agricultural Engineering

(a) P. Kok - In situ fermentation electrode calibrator

Department of Biochemistry

(b) A. Graham - Gene cloning, recombinant DNA

Department of Biology

(c) A.H. Bussey - Fundamental studies of yeasts
(d) D. Verna - Genetics of nitrogen fixation

Department of Chemical Engineering

(e) B. Volesky - Biosorbent properties of microbial biomass
(f) - Industrial solvents from renewable resources via fermentation
(g) - Fermentation process optimization

Department of Physiology

(h) T. Chang - Enzyme immobilization

U-10 McMASTER UNIVERSITY

Hamilton, Ontario
L8S 4L8
(416) 525-9140

Department of Biochemistry

(a) W.W. Chan - Enzyme immobilization

Department of Biology

(b) J.J. Miller - Yeast sporulation, physiology

Department of Chemical Engineering

(c) A. Benedek - Waste treatment
(d) K.L. Murphy - Waste treatment; systems development

Department of Medicine

(e) J. Bienenstock - Production of monoclonal antibodies to herpes viruses

Department of Pathology

(f) W.E. Rawls - Studies virus replication, monoclonal antibody development

U-11 MEMORIAL UNIVERSITY OF NEWFOUNDLAND

Elizabeth Avenue
St. John's, Newfoundland
A1C 5S7
(709) 753-1200

Department of Biochemistry

(a) B.H. Sells - Bacterial genetics

Department of Biology

(b) R.A. Nolan - Fungi as bioinsecticides

Department of Pathology

(c) M. Laird - Vector pathology, isolation and applications of insect pathogens

U-12 UNIVERSITÉ DE MONTRÉAL

Ecole Polytechnique
Case Postale 6128
Montréal, Québec
H3T 1J4
(514) 343-6111

Génie chimique

(a) A. Rollin - Food processing, reactor design
(b) D. Rouleau - Bioreactor design
(c) - Utilization of immobilized enzymes for lactose hydrolysis

U-13 UNIVERSITY OF OTTAWA

Ottawa, Ontario
K1N 6N5
(613) 231-3311

Department of Biochemistry

(a) I. Altosar - Xylitol dehydrogenases in chemostats

U-14 UNIVERSITÉ DE QUÉBEC
à TROIS-RIVIÈRES

335 boulevard des Forges
Trois-Rivières, Québec
G9A 5H7
(819) 376-5011

Génie

(a) J.J. Garceau - Single cell protein production from sulfite liquors

U-15 QUEEN'S UNIVERSITY

Kingston, Ontario
K7L 3N6
(613) 547-5511

Department of Biochemistry

(a) J. Spencer - Studies of bacterial genetics, recombinant DNA

Carbohydrate Research Institute

(b) W.A. Szarek - Development of sweetening agents

Department of Chemical Engineering

(c) D.H. Bone - Microbial conversion of plant waste, single cell protein production

U-16 UNIVERSITY OF REGINA

Regina, Saskatchewan
S4S OA2
(306) 584-4111

Department of Microbiology

(a) D.R. Cullimore - Photosynthetic bacterial digestion of animal waste

U-17 UNIVERSITY OF SASKATCHEWAN

Saskatoon, Saskatchewan
S7N 0W0
(306) 343-2100

Department of Chemical Engineering

(a) E. Davis - Microbial waste treatment
(b) D.A. MacDonald - Sugar production from aspen cellulose
- Single cell protein production from biomass

Department of Chemistry

(d) J.M. Pepper - Aspen lignin degradation by fungus

Department of Dairy and Food Science

(e) W.M. Ingledew - Single cell protein production and yeasts for food and feed
(f) - Alcohol production without substrate modification
(g) - High gravity fermentations and quality control methods
(h) - Studies on yeasts
(i) G.A. Jones - Degradation of aromatic compounds in anaerobic fermentations
(j) - In vitro digestibility procedures for unconventional forages
(k) - Rumen fermentations

Department of Microbiology

(l) G. Khachatourians - Anucleated microbial cell, production and physiologies
(m) - Anucleated microbial cells in vaccine production
(n) - Fermentation processes using immobilized cells
(o) - Single cell protein and alcohol production from starch

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UNIVERSITY OF SASKATCHEWAN (cont'd)

(p) - Genetic and cellular studies of fermentation processes

(q) I.A. Rainshaw - Monoclonal antibody production

Department of Veterinary Microbiology

(r) C.H. Bigland - Vaccine development for infectious diseases in food producing animals

U-18 UNIVERSITY OF TORONTO

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(a) M. Wayman - Alcohol production from wood
(b) - Autotrophic microbes for organic materials production
(c) - Single cell protein production

U-19 UNIVERSITY OF VICTORIA

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Department of Biochemistry

(a) T. Pearson - Production of monoclonal antibodies to common antigenic components of trypanosomes

U-20 UNIVERSITY OF WATERLOO

Waterloo, Ontario
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Department of Chemical Engineering

(a) M. Moo-Young - Production of single cell protein from organic wastes
(b) - Production of alcohols and methane from agricultural and municipal wastes by fermentation processes
(c) - Development of multi-phase contactors as bioreactors
(d) K.F. O'Driscoll - Immobilized enzymes for biomedical applications
(e) C.W. Robinson - Production of single cell protein from organic wastes
(f) - Production of alcohols and methane from agricultural and municipal wastes by fermentation processes
(g) - Food processing and rheology
(h) - Bioreactor development
(i) J. M. Scharer - Single cell protein production via anaerobic digestion of cellulosic waste
(j) - Production of alcohols and methane from organic waste
(k) P. Silveston - Waste treatment
(l) - Computerized design of bioreactors and processes

U-21 UNIVERSITY OF WESTERN ONTARIO

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(a) R.G.E. Murray - Bacterial cytology

Department of Biochemistry

(b) G. Mackie - Bacterial genetics
(c) B.D. Sanwal - Somatic cells and enzymology

Department of Plant Science

(d) R.B. Van Huystee - Secondary metabolites in plant cells, pharmaceutical applications

Faculty of Engineering Science

(e) N. Kosaric - Industrial wastewater treatment
(f) - Single cell protein and other foodstuff production from industrial and agricultural residues
(g) A. Margaritis - Reactor development for biochemical processes
(h) - Bioenergy production of gaseous and liquid fuels by fermentation
(i) - Microbial separation of bitumen from tar sands, biosurfactants and bioemulsifiers

U-22 YORK UNIVERSITY

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Department of Biology

(a) J. Friesen - Gene cloning, recombinant DNA, yeast genetics and fermentations
(b) J. Heddle - Genetic defect diagnosis
(c) R.E. Pearlman - Biochemical and genetic analysis of nucleic acid metabolism

Department of Chemistry

(d) C. Leznoff - Insect sex pheremones

SECTION II

BIOTECHNOLOGICAL ACTIVITY IN CANADA - BY AREA OF APPLICATION

The three groupings of technologies (fermentation, enzyme, cellular and genetic manipulative) which comprise biotechnology are recognized to be applicable to a number of important areas. Those areas which can presently be identified include:

A Waste Treatment and Pollution Control - The treatment or reprocessing of industrial, agricultural and domestic waste, and the control of environmental pollutants.

B Raw Material Extraction and Preprocessing - The concentration and isolation of minerals and metals, petroleum recovery, and the pretreatment of potential fermentation feedstocks.

C Biomedical Product Development - The preparation of pharmceuticals, vaccines, and diagnostics as well as methods of toxicity evaluation.

D Food Production - The development of new animal and human feedstocks.

E Agricultural Improvements - The creation of new plant strains, pesticides, fertilizers, and new fertilization methods.

F Fuels, Industrial Chemicals, Biochemicals and Catalysts - The generation of alcohol and hydrogen fuels, new petrochemical sources as well as enzyme isolation and utilization.

G Process and Equipment Design - The design of new fermentation reactors, alternate batch processes, monitoring devices, instrumentation and other aspects of process engineering.

In this section, some of the activities described in Section I have been classified according to the aforementioned seven areas where biotechnology is seen to apply. However, since not all of the Section I listings lent themselves to this classification, the number of identified activities in Section II is less than Section I. Moreover some duplication of assignment amongst the categories has been necessary to ensure a more complete representation of the activities of an individual or group.

The numbering in this Section coincides with that utilized in Section I. For example U - 3(b) refers to the University sector, entry number three (University of Calgary) and J. W. Costerton. The reader is then directed to Section I for more detailed information.

A. Waste Treatment and Pollution Control

G-3(a), G-6(c), G-6(d), G-8(a)

I-2(a), I-3(a), I-10(a), I-17(a), I-23(a), I-25(b), I-26(a), I-27(a), I-28(a)

U-2(d), U-6(g), U-6(1), U-6(m), U-7(b), U-10(c), U-10(d), U-14(a), U-15(c), U-16(a), U-17(a), U-17(i), U-20(a), U-20(e), U-20(i), U-20(k), U-21(e)

B. Raw Material Extraction and Preprocessing

G-2(a), G-11(a)

I-2(a), I-2(c), I-14(a), I-15(a), I-20(a), I-20(b), I-24(a), I-25(a)

U-3(e), U-6(i), U-17(b), U-17(d), U-21(i)

C. Biomedical Product Development

G-4(a), G-4(b), G-6(b), G-6(d), G-7(c), G-7(d)

I-1(a), I-2(b), I-6(a), I-7(a), I-8(a), I-8(b), I-8(c), I-8(d), I-13(a), I-19(a), I-19(b), I-19(c), I-19(d), I-22(a), I-29(a), I-31(a)

U-1(c), U-1(d), U-1(f), U-2(e), U-3(b), U-3(g), U-5(b), U-6(a), U-6(c), U-8(a), U-9(h), U-10(e), U-10(f), U-17(m), U-17(q), U-17(r), U-19(a), U-20(d), U-21(d), U-22(b)

D. Food Production

G-5(a), G-7(a)

I-10(a), I-11(a), I-12(a), I-16(a), I-23(a), I-26(a), I-27(a), I-30(a)

U-2(c), U-6(e), U-6(h), U-6(k), U-7(a), U-14(a), U-15(b), U-15(c), U-17(c), U-17(e), U-17(o), U-18(c), U-20(a), U-20(e), U-20(i), U-21(f)

E. Agricultural Improvements

G-1(a), G-1(b), G-1(c), G-1(d), G-1(e), G-1(f), G-1(g), G-1(h), G-1(i), G-1(j), G-7(d)

U-4(a), U-4(b), U-6(b), U-7(c), U-9(d), U-11(b), U-11(c), U-22(d)

F. Fuels, Industrial Chemicals, Biochemicals and Catalysts

G-6(a), G-6(c), G-6(e), G-7(b), G-7(e)

I-5(a), I-16(b), I-18(a), I-25(a), I-27(a)

U-1(a), U-8(c), U-8(d), U-8(e), U-9(f), U-10(a), U-12(c), U-13(a), U-17(f), U-17(1), U-18(a), U-18(b), U-20(b), U-20(f), U-20(j), U-21(h)

G. Process and Equipment Design

G-3(a), G-7(f)

I-4(a), I-14(a), I-21(a), I-25(c), I-27(a), I-28(a)

U-1(b), U-2(c), U-3(c), U-9(a), U-9(g), U-10(d), U-12(a), U-12(b), U-17(g), U-20(c), U-20(g), U-20(h), U-20(l), U-21(g)

PART B

GENERAL OBSERVATIONS

Throughout the course of the consultations which were carried out in preparation of this paper a number of significant aspects of current Canadian biotechnological activity were found. These are:

1. Apart from the breweries the level of industrial biotechnological activity including both scientific and engineering considerations is very low.

2. From a biotechnology perspective programs such as PILP and IRAP have been successful in transfering government research results to the industrial sector, especially for such firms as MDS HEALTH, ENS BIOLOGICALS, CONNAUGHT LABORATORIES and the PULP and PAPER RESEARCH INSTITUTE.

3. There does not exist, in any Canadian university or technical college, a department of applied microbiology.

4. From a university perspective there are pockets of biotechnological expertise scattered across the country with little, if any, interconnection within institutions, let alone between institutions. The university scientists, even amongst the applied disciplines, lack the necessary marketing and financial appreciations to determine the commercial potential of their work.

5. The production of research-trained manpower from Canadian universities in disciplines such as biochemical engineering, applied microbiology, biochemistry and applied genetics is weak. Moreover people presently being trained in gene-splicing techniques required for recombinant DNA research are being actively recruited by American companies.

6. The biomedical product development field in Canada is showing signs of expansion. Recent developments at Connaught Laboratories Limited, Institut Armand-Frappier, MDS Health as well as the recent overtures of Shell and Syntex could see the reemergence of a biomedical industry in Canada. Of course the recombinant DNA and hybridoma technologies are receiving most attention but it is difficult, at this stage, to discern any clear direction in the Canadian efforts. In addition it is not easy to see what direction Canada should move in given the nature of the competition, the market characteristics and the effect of compulsory licensing. The comments in #5 above are also worth noting in this regard.

OPPORTUNITIES WORTH EXPLOITING IN A CANADIAN CONTEXT

Bearing in mind the rapidly progressing nature of biotechnology as well as the weak and scattered nature of Canada's current biotechnological efforts, it is still possible to identify those areas of application of biotechnology which are to Canada's advantage to exploit.

First it should be remembered that irrespective of how the fermentation technologies, the enzyme technologies or the genetic and cellular manipulative technologies are to be applied, the processes developed will, at some stage, depend upon the availability of carbohydrate. Carbohydrate is, however, derived from a renewable resource, biomass. Canada, because of its large resources of biomass is therefore richly endowed with the basic "feedstock" for practically every conceivable biotechnological process. The question, then, is where can Canada realistically expect to exploit biotechnology to its fullest advantage.

The answer lies within the nature of our economy. A large portion of our economy is resource based: energy, forestry, food/agriculture and mining. Without being too critical, it is undoubtedly safe to say that Canada has failed to realize the true potential of its natural wealth. Biotechnology, if exploited correctly, promises to enable us to exploit our resources more efficiently, while at the same time developing our potential to be world leaders in resource management.

To be more specific each of these four sectors is discussed below, with suggestions on where applications of biotechnology should be directed.

1. Energy

The production of alcohols via fermentation offers an additional source of liquid fuels to méet our growing energy demands. A great deal has been written, discussed and analyzed concerning the use of alcohols as alternate liquid fuels and it seems reasonable to expect that alcohol will form one part of Canada's future energy puzzle. In fact a major paper dealing with an alternate liquid fuels policy for Canada is presently being drafted by EMR. From a scientific and technical point of view, the fermentation of alcohol is well understood. While future studies will focus on efficiencies, namely microorganism selection, substrate modification and process engineering, it is doubtful that Canada could hope to carve a technological wedge for itself in this well established area. Moreover it would appear that the introduction of alcohol fuels programs will be largely determined by region. For example it is likely that Saskatchewan's Gasohol Program will soon be launched and the province could realistically become a net exporter of alcohol to the U.S. The same situation is not comparable in most parts of the Maritimes. Within the concept of a national biotechnology initiative, therefore, an alcohol fuels R&D program would not be recommended.

A more effective initiative would be in the area of methane production. Methane can be generated biologically from the anaerobic fermentation of industrial, domestic and agricultural wastes. Methane thus derived can be introduced directly into existing natural gas pipelines for domestic

use or export. Another avenue for methane is its subsequent hydration to methanol, providing an alternate source of liquid fuel. One side product of this fermentation is a residue rich in nitrogen and minerals. This residue becomes an excellent source of natural, environmentally acceptable fertilizers.

The opportunities seen for Canada are (1) increased source of natural gas; (2) developers of new aspects of waste treatment and pollution control technologies which are exportable; (3) capitalization upon existing activities in NRC and universities; (4) reduction of costs to industry of waste treatment and disposal; (5) production of environmentally acceptable fertilizers thereby further reducing demands upon petroleum based fertilizers.

Biotechnology should also be exploited in connection with Canada's petroleum reserves. One specific area which should be addressed is petroleum recovery. Canada has vast reserves of petroleum locked within the tar sands of Alberta and Saskatchewan. The current processes for petroleum recovery from these areas are expensive, energy intensive and inefficient. One major problem which accounts for a major portion of these ills is the difficulty in bitumen separation. Microbial methods for the separation of bitumen are currently being investigated at the Alberta Research Council and the University of Western Ontario with encouraging results. A greater emphasis on this application of biotechnology could impact considerably upon the effective recovery of this resource.

Another problem of oil recovery, generally, is complete tertiary oil recovery, that is, recovery of oil which has seeped from major basins and is dispersed throughout a variety of geological formations. Microbial exopolysaccharides are polymers produced by microorganisms possessing a range of characteristics. One of these characteristics is their ability to alter the rheological properties of aqueous solutions, either through gelling or through the alternation of their flow characteristics. The polymers can therefore be used to improve water-flooding techniques in which the aqueous solution of polymer gives an increased efficiency of contact with, and displacement of, oil.

While this biotechnological method of oil recovery is being examined in other countries, little activity is noticeable in Canada. The importance to Canada of developing its own technological expertise in this area, as opposed to purchasing it from abroad, lie in the fact that no two oil fields are similar. Canada's oil fields have distinct differences in salinity and pH as well as temperature, as compared with fields in the North Sea or Persian Gulf, for instance.

An added spin-off in the development of microbial polysaccharide expertise is the utilization of these polymers in the detergent - laundry, textile, paper, paint, food and pharmaceutical - cosmetic industries.

Thus within the energy area, methane generation, bitumen degradation and microbial exopolysaccharide utilization are seen as important areas for Canada.

Forestry

The recent paper by DOE on forestry concentrated upon the effective management and utilization of the forestry resource. Through two not unrelated applications of biotechnologies, major contributions can be made to improving the exploitation of this resource.

In the production of pulp and paper the major waste effluent to be discharged is termed spent sulfite liquors. These liquors contain, in addition to carbohydrates, many toxic compounds such as resin acids, chlorinated resin acids and chlorinated unsaturated fatty acids. In principle, the discharge of such industrial wastes is subject to ever increasing regulations, with the result that firms now pay enormous costs for waste treatment or sewage system utilization. It is now possible, however, to ferment this waste into a valuable feedstock for animals and human consumption; this feedstock is known as single-cell protein (SCP) and will be discussed more fully in the section on food/agriculture. Suffice to say biotechnology offers to the pulp and paper industry reduced costs in terms of waste treatment and increased revenue in terms of supplementary product production.

Approximately 37% of Canada's landmass is covered by forests. This is potentially an extremely large source of carbohydrate. The problem of trees as a carbohydrate source is that this carbohydrate is bound up in a complex package of lignin and various celluloses. In order to generate carbohydrate from a wood source one must degrade or extract the lignin and degrade the celluloses. Traditionally this has been done chemically with limited

efficiency and resulted in a significant waste problem. Microbial degradation offers clear advantages here and could provide a logical route for the utilization of the entire forestry resource. The resultant increased availability of carbohydrate could have implications for many areas which exploit fermentations based on carbohydrate substrates.

Thus within the forestry area, waste treatment and utilization and carbohydrate generation offer significant benefits to Canada.

Food/Agriculture

The food/agriculture area in Canada can benefit considerably both in the short and long terms with the judicious exploitation of biotechnology.

In the short term, single cell protein (SCP) production will become an important source of human and animal feedstuff. SCP is merely a microorganism whose protein content, on a dry weight basis, can range from 50-80% of total weight. The amount of protein is usually determined by the nature of the carbon source and the subsequent amino acid ratios controlled genetically. The techniques of mutant selection and genetic engineering will allow for control over the actual protein composition of SCP, making it possible for selective generation of highly specific dietary supplements. While the exploitation of SCP domestically as, for example, animal feed will no doubt free up other carbohydrate sources (corn) for alternate fermentations, Canada could also export a large quantity of SCP to underdeveloped countries.

A more long term possibility is the application of biotechnology to the field of nitrogen fixation. Several types of plants generate their own nitrogen fertilizers by "fixing" nitrogen from the atmosphere via a bacterially-mediated system. The advantage of this type of system being exploited more broadly would be the resultant lack of requirement for artificial nitrogen fertilizers thereby decreasing the environmental hazards posed by these unnatural elements. Since most commercial fertilers are petrochemicals or petrochemically-based, this type of system, if more widely applied, would reduce the demand for these increasingly costly fertilizers.

Through cellular and genetic manipulative technologies research is being aimed at adapting both the bacterially-mediated system and the plants to create a greater variety of nitrogen-fixing crops. Agriculture Canada's R&D profile has designated nitrogen-fixation as a prime area for emphasis.

In addition to nitrogen fixation, biotechnological techniques such as plant cell culturing, cell fusion and genetic manipulations will provide new plant strains more resistant to low temperatures and soil variability, higher yielding and tailored more specifically to requirements.

Pest management is another area worth exploiting biotechnologically. Emphasis in this area will settle on viral and bacterial pathogens as insect controls and will result in highly selective measures for the eradication of unwanted insects. Because of the diverse nature of the pest control problem in Canada a broad effort is required which, if successful, could result in Canada becoming a world leader in insect control.

Thus within the food/agriculture area, SCP production nitrogen fixation, plant strain development and pest management are seen as important areas for the exploitation of biotechnology in Canada.

Mining

One of the weakest areas of understanding concerning the application of biotechnology is in the area of mining. The economically significant interrelation of organisms and metals can be divided into two main areas. First, the extraction of metals from insoluble materials principally through leaching by acidophilic iron-oxidizing and sulphur-oxidizing bacteria. Second the recovery of metals from solution by organisms. It is in these two areas where biotechnology can impact most heavily for Canada, in a non-energy intensive, non-polluting means of efficiently exploiting its mineral wealth.

From Canada's mineral resource perspective the bacterial leaching of copper, uranium, nickel, lead and zinc would seem to be obvious first choices. Internationally this method has been applied to low-grade ores with modest success but a more focussed effort is needed. The microbial treatment of metal mixtures, mine tailings etc. also offer considerable promise and yet little activity is presently underway in Canada.

A more futuristic possibility lies in the use of microorganisms as vehicles of metal recovery. It has been known for some time that certain bacteria have selective affinities for certain metals. Applications of these characteristics or even the genetic engineering of the organism to make it more selective could result in tools for trace metal recovery and water purification.

Thus within the mining area, biotechnology will find its most important applications for Canada in metal extraction and recovery.

* * *

Additional Comments

The aforementioned areas and topics selected for the exploitation of biotechnology in Canada, while different in their outlook, will nevertheless require similar types of expertise. As indicated earlier under General Observations, serious shortages are already occurring in many key disciplines. Without these people it is doubtful that the necessary critical masses can be created to capitalize upon the opportunities presented.

The absence of mention of opportunities in the health care products field is not to be construed as meaning this is not a biotechnological opportunity area for Canada. On the contrary, based upon the analysis in Part A, Section II of this report, this is seen as an area of considerable activity. The difficulty lies in weighing the scientific opportunities against the commercial realities; the commercial reality being the lack of an established health care products industry in Canada.

The field of immuno-diagnostics offers the most realistic area for Canada to establish a niche. Activity underway at Connaught, Armand-Frappier, MDS Health Inc. as well as several universities and government agencies would indicate that emphasis is being channeled into this area.

It is not possible, however, given the embryonic stage of these developments, to identify specific directions for this work, in a Canadian context. The most appropriate approach to follow, therefore, is to ensure the training of appropriate manpower and encourage maximal interplay between the sectors.

RECOMMENDATIONS FOR PHASE II

In the original PMC project outline, Phase II was proposed as a series of seminars or workshops involving experts from various sectors and interests to more specifically identify what ~~federal action is required to~~ aspects of biotechnology could best be promoted ~~biotechnology~~ in Canada. The following recommendations are for the implementation of that Phase.

1. Section I of this report be published as a MOSST background paper to provide information to the workshop participants as well as to provide a useful directory of biotechnological activity in Canada to both national and international interests.

2. Two workshops be held which would report to the Minister of MOSST.

3. Workshop # 1 be directed to describe the appropriate federal action necessary to promote and develop biotechnological activity in Canada. Some possible questions to be answered by this workshop would be:

   a) Is a major Government Statement on the general importance of Biotechnology to Canada, necessary?

   b) What type of structure is required to ensure coordination and direction of federal programs which will affect the growth of biotechnology in Canada? Terms of reference?

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c) Should the proposed structure have access to resources and how should these be administered?

d) Are the particular areas of application outlined (forestry, food/agriculture, energy, mining) and the priorities within, appropriate for Canada? If not what are the alternatives?

e) Would tax incentives such as 150% R&D write-off or tax holidays for establishment of production facilities based upon Canadian developed technologies, be effective vehicles for industrial stimulation?

f) Should cost-sharing arrangements with the provinces be negotiated to allow each province to pursue its own priorities for the application of technology (for example, expansion of DREE sub-agreements)?

g) How can the appropriate manpower be recruited and retained and how can government-industry-university interfaces be expanded?

4. Workshop # 2 be directed to evaluate present and future developments of biotechnology, to describe the perceived impacts upon society of these developments and to comment on future capabilities required to deal with these impacts. This workshop would not be expected to determine, precisely, what hazards the new technologies will bring, but to document our current understanding or appreciations of the problems, to identify what mechanisms and regulations are currently

in place in Canada and what sort of structure is necessary to insure that these safeguards are continually reviewed and modified to reflect new knowledge and the possibility of increased bio-technological activity in Canada. The Science Council has indicated its interest in co-sponsorship of this workshop as part of their own study of science and the law.

5. Both workshops be directed to produce reports which could form the basis of a Cabinet memorandum and discussion paper (phase III of biotechnology in Canada project).

6. A Steering group be established within MOSST to:

   1. Oversee publication and distribution of Section I of this report;

   2. Develop the parameters for the two work-shops (terms of reference, membership, secretarial services, supply needed infor-mation, etc); and

   3. Be responsible for formulating policy recommendations based upon workshop results and other factors.

The following is a list of individuals suggested as possible participants in the workshops.

WORKSHOP # 1

Dr. R.U. Lemieux
President
Chembiomed
University of Alberta

Dr. D.S. Layne
Vice-President
Research and Technology
Connaught Laboratories Ltd.

Mr. R. Bender
President
ENS Biologicals

Dr. B. Shelton
Corporate Director
Research and Development
Labbatts Breweries of Canada Ltd.

Dr. C. Bishop
Director
Division of Biological Sciences
National Research Council

Mr. M.B. Koffler
Vice-President
Four-Seasons Hotels Ltd
Member of the Board of
Canada Development Corporation

Dr. G. Cloutier
Chairman
Alberta Research Council

WORKSHOP # 2

Dr. M.B. Bayles
Director
Westminster Institute
for Ethics and Human Values

Dr. F. Rolleston
Director
Special Projects
Medical Research Council

Dr. D. Suzuki
Department of Zoology
UBC

Dr. A. Morrison
Assistant Deputy Minister
Health Protection Branch
HWC

Dr. K. Kristjanson
Vice-President
Great West Life Assurance Co.
Winnipeg

Professor H.R.S. Ryan
Faculty of Law
Queen's University

Dr. L. Siminovitch
Chairman
Department of Medical Genetics
University of Toronto

WORKSHOP #1 CONT'D

Dr. K.F. Gregory
President
Canadian Society of Microbiologists
Department of Microbiology
University of Guelph

Dr. A. Sargent
Director
Research and Development
Silverwoods Industries Ltd.
Past-President
Innovation Management Institute
of Canada

Dr. H. Friesen
Department of Physiology
University of Manitoba

WORKSHOP # 2 CONT'D

Dr. J. Friesen
Department of Biology
York University

Dr. K. Izumi
School of Regional and Urban
Planning
University of Waterloo