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# NETWORKS OF CENTRES OF EXCELLENCE

NCE PROGRAM BACKGROUNDER

Canada

# **NETWORKS OF CENTRES OF EXCELLENCE**



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NCE PROGRAM BACKGROUNDER

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Government of Canada

Gouvernement du Canada

Natural Sciences and Engineering Research Council of Canada

Medical Research Council of Canada

Social Sciences and Humanities Research Council of Canada

Industry, Science and Technology Canada

## NCE PROGRAM - BACKGROUNDER

In May 1988, the federal government approved a budget of \$240 million for the Networks of Centres of Excellence Competition. The program was announced as part of the new federal science and technology strategy, **innovAction**, and within the context of the National Science and Technology Policy, then just negotiated with the provinces.

From the outset, the NCE competition captured the imagination of the Canadian research community, and stimulated a massive positive response. By the closing date of the competition, 158 applications had been submitted, involving some 4,000 Canadian researchers and totalling over \$2 billion in requests. The program challenged researchers to break down barriers between disciplines, ideas and institutions and to come together to devise projects to:

- boost Canada's performance in science and technology and the country's involvement in long-term basic and applied research
- develop world class engineers and scientists
- pass on to industry new technical knowledge gained
- begin a new era of collaboration and "networking" between researchers at different institutions and companies across the country.

To run its flagship program, the federal government called on its three granting councils - the Social Sciences and Humanities Research Council, the Natural Sciences and Engineering Research Council, and the Medical Research Council. They, in turn, established an internationally-renowned jury to review the proposals and make recommendations on funding to the Minister of State (Science and Technology). The 23-member International Peer Review Committee, chaired by Dr. Stuart Smith, former head of the Science Council, was made up of experts from the industrial, academic and government sectors. Rating by the committee took place on the following basis:

- excellence of the research and the participants (50%)
- effective linkages and networking (20%)
- relevance to future industrial competitiveness (20%)
- administrative and management capability (10%).

The peer committee's final recommendations were reviewed by the Minister of State's Advisory Committee made up of 13 eminent Canadians, co-chaired by Dr. John Evans, Chairman and Chief Executive Officer, Allelix Incorporated, Mississauga and Dr. Gilles Cloutier, Rector, Université de Montréal.

The selected networks and the research projects chosen by the federal government represent the very best in Canadian research. The networks are not only significant in the numbers and breadth of scientific disciplines and partners but also in their geographical spread across Canada.

With federal approval in hand, the research teams, **outlined in the** remainder of this booklet, can now move ahead and help prepare Canada for the 21st century. Provincial governments, Canadian industry, federal laboratories and others are all eager to formalize their links with the new networks and capitalize on this unique opportunity.

# BACTERIAL DISEASES: MOLECULAR STRATEGIES FOR THE STUDY AND CONTROL OF BACTERIAL PATHOGENS OF HUMANS, ANIMALS, FISH AND PLANTS

Bacteria often cause rapidly progressing, highly infectious diseases that exact untold human suffering as well as billions of dollars of losses worldwide in the agriculture, forestry and aquaculture industries. New technologies including monoclonal antibodies and genetic engineering offer considerable promise in turning the tables against these scourges. However successful application of these advances depends on basic research into the nature of the bacteria and the diseases they cause.

The network will launch a novel, highly focused, multi-targeted study of bacterial attack and host response in very different biological systems (humans, animals, plants). Some of the projects involve strengthening the host's defences, others are aimed at developing models for human infections. The team features internationally-known researchers, as well as strong financial and research linkages with small and medium-sized Canadian companies. The pressing demand for vaccines, antibiotics and diagnostic kits presents both a major challenge and a commercial opportunity for Canada.

The team will study the causative agents of such diseases in humans as whooping cough, gonorrhea, toxic shock syndrome, lung infections in cystic fibrosis, bacterial meningitis, and hospital infections, which alone take up to 20,000 lives annually in North America. In addition, researchers will investigate major bacterial pathogens affecting the aquaculture industry, the causative agents of plant wilt and crown gall diseases, and shipping fever in cattle. Each of these diseases costs Canada millions of dollars annually.

## Participating Centres

Chembiomed, Edmonton Connaught Labs, Toronto International Broodstock Technologies, Vancouver Laval University Microteck R&D Limited, Sydney, B.C. National Research Council of Canada University of Alberta University of British Columbia University of British Columbia University of Calgary University of Guelph University of Victoria VIDO, Saskatoon

## **BIOTECHNOLOGY FOR INSECT PEST MANAGEMENT**

The importance of pest control to the agricultural and forestry industries cannot be overestimated. Agricultural crop losses due to insect pests range from 35 to 50 percent, while, in forestry, insects are estimated to destroy up to 65 million cubic metres of timber annually, fully half of Canada's annual cut.

With demand growing for new, environmentally acceptable methods of pest control, integrated biological management strategies are expected to be the major wave of the future. The 25 members of this research network are well qualified to make a major international contribution to this effort as insect physiology is an area of particular strength for Canada. The network includes a number of world leaders, and many of its members enjoy the benefit of previous collaboration.

The network program will zero in on developing new, environmentally acceptable methods of pest control through biotechnology. Researchers will explore means to alter naturally occurring viruses to render them more toxic and selective in their attack on insects. Related studies will be conducted on the molecular basis of pesticide resistance in insects, with the twin goals of minimizing resistance in pests and transferring protective genes to beneficial species. One expected practical result is a genetic "probe" that can accurately measure resistance in field populations. Researchers will also look at promising genetic and hormonal mechanisms of control.

Demand for insect pest management strategies that are not harmful to the environment increases daily. Products arising from this research will be tested in collaboration with industry.

## Participating Centres

Agriculture Canada Forestry Canada Laval University National Research Council of Canada Queen's University University of British Columbia University of Calgary University of Calgary University of New Brunswick University of New Brunswick University of Ottawa University of Ottawa University of Waterloo University of Western Ontario York University

## CANADIAN NETWORK FOR SPACE RESEARCH

Over the past two decades, Canadian space scientists have acquired a strong international reputation for excellence in the field of space research. From the Alouette satellite program of the sixties to the present day CANOPUS ground-based system, Canada can claim a string of brilliant successes in space and upper atmosphere investigations and remote sensing of the Earth. The Network of Centres of Excellence for Space Research combines the industrial and academic expertise that has grown out of these initiatives in an ambitious new program. Four of the five industrial partners in this network are, in fact, spin-off companies from Canadian space research. A world wide market has emerged for their imaging systems and environmental sensors.

The network will seek a better understanding of how the hostile plasma of space affects satellites and other structures. It will use remote sensing to look at processes that take place in the middle atmosphere and in the polar environment. These findings may be critical to developing knowledge on global climate change and polar ozone depletion. The network's auroral and magnetic studies may shed more light on phenomena such as last March's major power grid failure in Quebec. The more applied aspects of the program will be directed at advances in spacecraft instrumentation and remote sensing technology.

The program builds on a unique combination of technical talent that has arisen in the country, as well as on geographic advantage as an arctic nation. The network will cooperate with Canada's new Space Agency, participate in international space science missions, and interact closely with the industrial partners on long-term, fundamental studies.

## Participating Centres

Atmospheric Environment Service, Toronto Canadian Astronautics Limited, Ottawa Com Dev Limited, Cambridge Institute for Space and Terrestrial Science, Toronto Itres Research, Calgary Myrias Corporation, Edmonton National Research Council of Canada (Herzberg Institute for Astrophysics) SED Systems Inc., Saskatoon SCI TEC, Saskatoon Scientific Instruments Limited, Saskatoon University of Alberta University of Calgary University of Saskatchewan University of Western Ontario York University

# CENTRE OF EXCELLENCE FOR MOLECULAR AND INTERFACIAL DYNAMICS

Canada has a surprising number of world-class chemical physicists given the country's population size. This network builds upon the great tradition of Canadian strength in the field, drawing upon the skills of the country's best researchers in this area.

Chemical physics, the fertile area at the boundary of chemistry and physics, has been at the core of some of the most exciting technological advances in the last half century. Chief among these is the development of the range of complex instrumentation on which most modern scientific research laboratories and high technology industries depend. This includes analytical instruments, lasers, spectrometers of all kinds and hundreds of specialized monitoring, measurement and process control instruments. The field has also given almost every branch of science an unparalleled view of the submicroscopic realm of atoms and molecules, and has contributed immeasurably to our knowledge of how they interact.

Spectroscopy, the discipline that provided Dr. Gerhard Herzberg with Canada's first Nobel Prize in Chemistry, is one of three areas that the network will focus on, with researchers in optical, laser and mass spectroscopy combining their talents. A second study area, reaction dynamics, will involve the winner of Canada's second Nobel Prize in Chemistry, Dr. John Polanyi, as a network member. This study is a key to understanding such important processes as ozone depletion, combustion and atmospheric pollution as well as industrial technologies such as the fabrication of integrated circuits. The final study area - interfacial dynamics - is an exiting new field that looks at the properties of surfaces and promises great industrial relevance for the fabrication of new materials.

#### Participating Centres

Carleton University Dalhousie University Laval University McMaster University National Research Council of Canada Queen's University University of British Columbia University of Guelph University of Montreal University of New Brunswick University of Ottawa University of Saskatchewan University of Sherbrooke University of Toronto University of Waterloo University of Western Ontario

## GENETIC BASIS OF HUMAN DISEASE: INNOVATIONS FOR HEALTH CARE

Canadian scientists have been at the forefront of a technological revolution in the study of genes and their mutations. Their research discoveries about the genetic aspects of diseases such as cystic fibrosis, Huntington's disease and muscular dystrophy have made front page news in many countries.

This network will see the best of our talent - 39 individuals from 11 centres - combine their efforts with pharmaceutical and biotechnology companies to study the genes that directly cause or predispose us to disease. The goal is to determine the biological function of each of the relevant genes, and to discover how mutation in each causes disease. From the new knowledge, it may be possible to detect carriers of most of the common genetic diseases, and, for some, to devise a treatment or cure. This innovative research could lead to major commercial opportunities for Canada in the areas of DNA diagnostics and therapeutics. The results could be fewer affected persons and reduced health care costs.

With its strong leadership, the network will be at the leading edge of research in this field. It promises a cohesive, interdisciplinary approach combining new technological developments with biological advances. Industrial commitment and research training are also emphasized. Canada is in a favoured position to carry out this research as our health care system and facilities provide records that do not exist in comparable quality elsewhere in the world.

#### Participating Centres

Biomedical Research Centre, Vancouver Clinical Research Institute of Montreal Laval University McGill University Queen's University University of British Columbia University of Calgary University of Calgary University of Montreal University of Ottawa University of Ottawa University of Toronto

## HIGH PERFORMANCE CONCRETE

Concrete plays a central role in the economic development of industrialized countries. Yet for material scientists and engineers, concrete is a complex composite for which behavioural models and applications are still in their infancy. Recent developments in reinforcing agents provide a strong thrust for the development of new concretes that rank with other "high-tech" composite materials.

Members of the High Performance Concrete Network are at the leading edge of knowledge needed to tailor the properties of concrete to specialized uses. The network links materials experts, designers and practitioners from seven universities and two consulting firms, many of whom have a long history of multi-disciplinary collaboration and partnerships with industry. The new knowledge should help Canadian consulting firms add to their impressive record of success in bidding on large international construction projects.

Researchers will investigate the whole concrete-making process, from colloidal phenomena in fluid concrete through to problems in the design of large structures. The anticipated benefits of this research include more durable and corrosion-resistant concrete for highways and bridges, as well as better testing methods for the safe use of high performance concrete in offshore platforms, tall buildings, hydro-electric dams and structures used to store nuclear wastes.

#### Participating Centres

Bickley and Associates, Toronto Hardy B.B.T., Vancouver Laval University McGill University University of Alberta University of British Columbia University of Ottawa University of Sherbrooke University of Toronto

# INSTITUTE FOR ROBOTICS AND INTELLIGENT SYSTEMS (IRIS)

The Institute for Robotics and Intelligent Systems (IRIS) pulls together the country's best talent in these fields into a unique national network. The network will operate as a separate component of PRECARN Associates Inc., a consortium of 32 companies whose mission is to carry out advanced research and development in robotics and artificial intelligence (AI). Members of PRECARN include resource and energy companies, suppliers of AI and robotics products, and communications and aerospace companies. Also integrated into the network are the 14 AI and Robotics Fellows of the Canadian Institute for Advanced Research.

The research program of IRIS includes projects within three related areas of enquiry - computational perception, knowledge-based systems, and intelligent robotic devices - the essential elements of a system's ability to perceive, reason, plan and act.

The use of "intelligent systems" of all kinds will play a major role in keeping Canadian industry competitive. The search for technical advances will focus on the development of expert systems and technology for our resource and manufacturing industries. Specific niches for Canada are also identified in robotic devices for use in difficult and hazardous environments. Few segments of the economy will fail to benefit from these new technologies.

#### Participating Centres

Concordia University École Polytechnique INRS-Telecommunications Laval University McGill University McMaster University PRECARN Associates Inc., Nepean Queen's University Simon Fraser University Technical University of Nova Scotia University of Alberta University of British Columbia University of Guelph University of Montreal University of Saskatchewan University of Toronto University of Victoria University of Victoria University of Waterloo University of Western Ontario York University

## INSTITUTE FOR TELECOMMUNICATIONS RESEARCH

Canadians, pioneers of telecommunications technology for the past one hundred years, now possess a telecommunications infrastructure that is recognized as one of the finest in the world. Last year our exports of telecommunications equipment totalled nearly \$2 billion, this area of manufacturing being one of the very few in which Canada exerts world leadership. The Institute for Telecommunications Research will bring together 30 participants from 12 universities, one university-based research institute and one non-profit company in a highly coordinated effort to boost our lead in telecommunications services and manufacturing.

The network will focus on broadband and wireless communications, two rapidly growing areas that present the most important emerging markets for telecommunications over the next decade. Broadband communications refer to high-speed communications made possible through advances in optical fibre technology and semi-conductor lasers. To maximize the effectiveness of optical telecommunications, light-switching devices have to be incorporated into micro-chips. Fibre systems must be designed with built-in "traffic control" so that each of the thousands of fibre users receive just the needed amount of transmission resource without delaying others. Finally, sophisticated new software technologies are needed to manage and maintain the system in real-time. The companion study area, wireless communications, includes the development of high-speed voice or data transmission networks in office buildings, factories, and hospitals, improvements in digital cellular radio systems, and mobile communications for rural areas.

#### Participating Centres \*

Alberta Telecommunications Research Centre Carleton University Concordia University INRS-Telecommunications Laval University McGill University McMaster University Queen's University University of British Columbia University of British Columbia University of Montreal University of Ottawa University of Toronto University of Victoria University of Waterloo

# MICROELECTRONIC DEVICES, CIRCUITS AND SYSTEMS FOR ULTRA LARGE SCALE INTEGRATION (ULSI)

ULSI describes the technological challenge of squeezing more than ten million functioning electronic components onto a microchip layer smaller than a fingernail and thinner than soap film. The technology is expected to become the mainstay of the next generation of telecommunications and computer systems, and an area vital to the future of Canadian industry.

The ULSI network consolidates Canada's strong research presence in microelectronics by tying together efforts in devices, circuits and systems. Such a coordinated, vertically integrated, approach is rarely seen outside of large-scale industrial research organizations, yet is a key to success and competitiveness. The network creates a novel environment where participants and students working in one area will be exposed to the issues and constraints in the other two. Industry has actively participated in defining the directions of the network's research. Continuing strong industrial participation is guaranteed through personnel contributions, access to expensive facilities and the membership of high level executives on the network advisory board.

The network's device research program will deal with the complex design, modelling and processing techniques needed to fabricate the different types of microscopic devices on the chip. Circuit researchers will take the device models and build efficiently designed, functioning circuit blocks. Finally, systems researchers will smooth the way for ULSI applications in computers and communications. Efficient signal processing hardware, new networks and structures specifically for ULSI, and the ability to test for and repair faulty components are just a few of the fundamental areas that will be addressed.

## Participating Centres

Carleton University INRS-Energy McGill University University of Calgary University of Calgary University of Manitoba University of Toronto University of Victoria University of Waterloo University of Windsor

## NEURAL REGENERATION AND FUNCTIONAL RECOVERY

Canada has an unusual concentration of expertise as well as an impressive track record of major scientific contributions in the neurosciences. This new research network draws together leading research teams from 14 Canadian universities in a close collaboration with the private sector. The initiative promises new advances in this important field and new hope to neurologically disabled persons.

The objective of the research is to promote nervous system regeneration and recovery of functions lost as a result of trauma or disease. A major reason for the permanent disability caused by injuries to the brain and spinal cord or by common neurological disorders such as Alzheimer's or Huntington's disease is that damaged nerve cells are not replaced, nor do they restore connections with their natural targets. Major advances have been made recently in uncovering a previously unsuspected potential of the nervous system to re-grow after injury. The field is expected to undergo a further explosion of knowledge with the application of new technologies in molecular biology and genetic engineering.

Research by the network will lead to a better understanding of the underlying causes of neurodegenerative disorders, which in turn would allow for the design of better drugs for the treatment of these diseases. Indirect benefits could be reduced health care costs and re-entry into the workforce by the disabled.

Over 100 researchers will work on 17 interrelated themes. Five new core facilities and a training program are also envisaged. Membership on the network's Board of Directors will include "Man in Motion" marathoner, Rick Hansen.

#### Participating Centres

Carleton University Concordia University Dalhousie University Laval University Ludwig Institute, Montreal McGill University McMaster University National Research Council of Canada (Biotechnology Research institute) Queen's University University of Alberta University of British Columbia University of Calgary University of Lethbridge University of Manitoba University of Montreal University of Ottawa University of Saskatchewan University of Toronto

# OCEAN PRODUCTION ENHANCEMENT NETWORK (OPEN)

The Ocean Production Enhancement Network (OPEN) is a network of university, industry, and government scientists created to contribute to the economic health of Canada's fisheries. Headquartered at Dalhousie University, it has the support of three of Canada's largest seafood companies - National Sea Products Ltd., Clearwater Fine Foods and Fishery Products International, as well as the province of Nova Scotia. Each firm has pledged up to \$1 million to the network's research activities.

OPEN will bring together Canada's best fisheries biologists and oceanographers in a highly integrated research program. The initial focus of the program will be on two species which are of great commercial value: the sea scallop and the Atlantic cod. Using these species as models, the scientists will investigate the processes which control the survival, growth, reproduction and distribution of fish and shellfish. The results of these investigations will be relevant to both the aquaculture and capture fisheries. Other network scientists will develop new techniques in molecular genetics and new instrumentation for studying the oceans. Much of this work will be done in close partnership with local industries who will be encouraged to market the products and expertise.

#### **Participating Centres**

Dalhousie University Fisheries and Oceans Canada Laval University McGill University Memorial University University of British Columbia

## **PROTEIN ENGINEERING: 3D STRUCTURE, FUNCTION AND DESIGN**

Heralded as biotechnology's new wave, protein engineering uses a variety of techniques to understand the functioning of proteins, then to improve them by making systematic changes to their building block structure. Proteins and their enzyme cousins are important because they are responsible for most of the essential functions of all living things. Improved proteins can be of enormous benefit in the treatment of infectious diseases. They will be used in the food industry, in a variety of industrial products, and in the development of disease-resistant crops. Their potential has stimulated large investments in Europe, Japan, and the U.S.A.

This network proposes a research program that will help guarantee Canada's competitiveness in this crucial area of science, technology and industry. To accomplish its objectives, the network brings together outstanding scientists of world-class calibre from a number of top-ranked research organizations. Close industrial ties give the network an excellent potential for technology transfer and spin-offs. As an additional benefit, more than 25% of the ongoing budget will be devoted to the training of graduate students and post doctoral fellows.

Initial studies will concentrate on developing new peptide hormones, cell growth factors for the treatment of cancer and infectious diseases, improved diagnostic reagents, and new enzymes that can efficiently convert agricultural and forest waste into high-grade chemicals. In addition to a program of fundamental studies on protein design, the network will offer its facilities for protein structure determination to scientists from other universities, research institutes and industries.

## Participating Centres

Biomedical Research Centre, Vancouver National Research Council of Canada University of Alberta University of British Columbia University of Toronto

## **RESPIRATORY HEALTH NETWORK OF CENTRES OF EXCELLENCE**

The Respiratory Health Network will focus on the treatment and prevention of breathing problems that result from a variety of environmental factors and diseases. Ten companies are involved in the network research program along with 54 university-based researchers. Improved patient care, reduced health care costs and marketable products are their common goal. Participants are committed to a close sharing of data and analytical methods.

The ambitious suite of research programs includes a collaboration with Merck Frosst to create drugs to overcome airway blockage in cystic fibrosis and asthma. Other segments of the network will look at improvements to mechanical lung ventilator technology and automated imaging systems that could, for example, be used to scan the lungs of smokers. Kits to test lung and diaphragm functioning, measure drug efficiency and rapidly diagnose viral lung infections form other key research areas. A final group of investigators will focus on occupational safety and on improvements to building ventilation and purification systems. The spread of allergens, bacteria and harmful gases is a problem in many buildings, and has given rise to what is commonly called the "sick building" syndrome.

## Participating Centres

Employment and Immigration Canada Engineering Interface, North York Graham and Bierman, Montreal Laval University McGill University McMaster University Merck Frosst, Pointe Claire Trudeau Medical, London University of British Columbia University of British Columbia University of Manitoba University of Montreal University of Saskatchewan

# SCIENCE AND ENGINEERING FOR HIGH-VALUE PAPERS FROM MECHANICAL WOOD PULPS

In 1986, the pulp and paper industry contributed \$13.9 billion to Canada's gross national product and employed some 80,000 Canadians. The industry, however, is increasingly being undercut by tough new international competitors, particularly in the export pulp market.

This research network is a strategic response to that challenge by the Pulp and Paper Research Institute of Canada (PAPRICAN), a private sector research consortium of Canadian pulp and paper companies, and researchers from 10 universities. The goal: to develop the mechanical pulping process to the point where it can produce superior grade papers that will not yellow. The process relies primarily on the mechanical breakdown of wood fibres as opposed to the chemical separation used in various "kraft" processes. It accepts a much wider range of common northern tree species and allows Canada to take advantage of its inexpensive hydro power. Mechanical pulping has the additional attraction of being intrinsically much less wasteful of trees. Mills that use the process have lower start-up costs.

Developing the process, nevertheless, is not a trivial exercise. The researchers, who include chemical, mechanical and electrical engineers, and chemists, will look at all stages of pulping. Key among their objectives will be an understanding of lignin, a highly complex polymer whose components are responsible for photochemical yellowing. Success in eliminating this problem could create a new, and more efficient paper industry, plus the opportunity to develop a unique Canadian processing technology.

#### Participating Centres

Lakehead University McGill University McMaster University Mount Allison University National Research Council of Canada Pulp and Paper Research Institute of Canada, Pointe Claire Queen's University Université du Québec à Trois Rivières University of British Columbia University of British Columbia University of Ottawa University of Toronto

University of Western Ontario

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