Izaak Walton Killam

Born Yarmouth, Nova Scotia, 23rd June 1885
Salesman for Royal Securities 1904
Montreal 1906, Managing Director 1909
England 1909, Canada 1913, President 1915
Bought Aitken out & took control 1919

Interests in electric power, pulp & paper
Major losses in recession of 1921
Recovered by 1927, bought "Mail & Empire"
$12 million in NS mill employing 1,000, 1928

By 1929 businesses in Newfoundland, Nova Scotia, New Brunswick, PEI, Quebec, Ontario, Alberta and British Columbia

Experience of 1921 recession gave him strategy for 1930s recession
Bought up bonds of pulp and paper companies

Retired in 1954, Died in 1955

Dorothy Books Johnston
Born 1900, Married Killam 1922, Died 1965

Slide Sequence

1 Dorothy Killam
2 Izaak Walton Killam
3 ENIAC, an early computer
4 Macintosh, a modern personal computer
5 The first integrated circuit
6 A modern integrated circuit chip
7 Chips on a matchstick
8 The architecture of a chip
9 A robot hand
10 A manual car production line
11 A robot car production line
12 A piano playing robot
13 Robot hands
14 Robot pets?
15 The double-helix of DNA
16 DNA and messenger RNA
17 Man in space
18 Skylab
19 Computer-aided design
20 Computing in other languages

The Meaning of Life

The world is large and complex, teeming with people and events such that individuals and their lives may seem insignificant and feel of little consequence. Yet each of us creates ripples in the future of the world, and some create waves that far outlast their mortal existence.

Such were Dorothy and Izaak Walton Killam. Within their lifetimes they were part of the developing commercial strength of the new nation of Canada, tapping and developing its natural resources. Through their legacies to the nation they initiated a process of cultural and intellectual development which is part of our living strength.

It is my pleasure to have this opportunity to honour the Killams on this occasion when the *National Killam Conference* is being held at the University of Calgary.

Much has changed in the thirty years since Izaak Walton Killam died. Technologies that were nascent in the years around his death have matured and offer the opportunities today that the basic resource industries did in his lifetime. We face new social and economic challenges. We have new possibilities with which to meet them.

What is it to be in an information age and operate within a knowledge economy? That is the question which I address today.

The Lives and Legacies of the Killams

The pages overleaf give a synopsis of the lives of the Killams. Izaak Walton Killam rose to the control of Royal Securities and used it as a financial vehicle with which to develop businesses in electric power, pulp and paper across Canada. His early losses in the 1921 recession sharpened his entrepreneurial capabilities. He founded businesses like the paper mill in Nova Scotia that were regarded as highly risky but generated jobs and wealth. He strengthened and consolidated his position by a correct analysis of proper strategies for the recession of the 1930s.

Dorothy and Izaak Walton Killam between them returned the wealth they had created in Canada to the nation *"to help in the building of Canada's future by encouraging advanced study."* Many of us here today, and many before us, have benefited from that legacy. Advanced study in Canada has been encouraged. As we move into an increasingly uncertain future the knowledge resulting from that study is critical to our social and economic well-being.

The Entrepreneur in the Information Age

Brian R Gaines

Izaak Walton Killam Memorial Professor

University of Calgary

3rd October 1985

Dorothy and Isaak Walton Killam were remarkable people who contributed much to the wealth and culture of Canada. Isaak was an entrepreneur with a flair for wealth creation long before these terms became fashionable. He died in 1955 and the duties from his estate were used as a major part of the funding of the Canada Council. Dorothy made substantial gifts to the Council and when she died in 1965 she bequeathed her estate further to endow the Council, Canadian Universities and other Institutions. In the twenty years since her death the world has changed with the advent and maturation of many new technologies. We are told we are in a "third wave" of industrial society leading to an "information age" and a "knowledge economy." This memorial lecture considers what people of the stature and capabilities of the Killams will achieve in this new age—what will be their focus of attention, priorities and achievements—what opportunities does Canada offer them—what contributions will they make to wealth and culture?

Izaak Walton and Dorothy Killam

Royal Commission recommends formation of
Canada Council in 1951
Council formed in 1957 with $100 million
from duties on Killam estate of $83 million
and Dunn estate of $70 million

Residue of $40 million to Dorothy Killam
who made gifts to Canada Council, Dalhousie
University and Halifax Children's Hospital

Her estate in 1965 was $93 million
with duty $6 million and residue
"to help in the building of Canada's future by
encouraging advanced study"

Dalhousie University $30 million
University of British Columbia $14 million
University of Alberta (& U of C) $16 million
Halifax Children's Hospital $8 million
Montreal Neurological Institute $4 million
Canada Council $15 million

A Knowledge-Based Economy

Knowledge has always been significant to our civilization. However, in the past fifty years this significance has grown to a level where it is coming to dominate other socio-economic factors. Machlup in 1962 drew attention to the major and growing role of information services in the US economy and estimated that in 1958 knowledge production accounted for 29% of the US GNP. A detailed analysis of the 1967 US national income-and-accounts and estimated that the information sector accounted for 46% of GNP. Drucker took this up as a major issue in his 1968 book, *The Age of Discontinuity* and estimated that by 1975 the knowledge sector would account for 50% of US GNP. In the 1970s the predicted transition commenced to a post-industrial economy less dependent on manufacturing and human labour, and more dependent on knowledge and information technology.

The Advance of Technology

These statistical predictions take on more meaning if we examine some key events in the time period from Killam's death until today. The table opposite shows the period from 1947 through 1987 split up by generations of computers. At the time of Killam's death the first generation of computing was barely complete with batch processing on large, expensive and unreliable machines—the transistor had been invented but was not in widespread use—the overall structure of DNA had been discovered but the genetic code was still unknown—the first spacecraft had not been launched.

During the sixteen years of the second and third generations the increasing reliability and decreasing cost of computers made possible direct human-computer interaction—the invention of the silicon planar process gave birth to modern microelectronics and integrated circuits—the genetic code was cracked and an artificial gene fabricated—man entered space and walked on the moon.

During the sixteen years of the fourth and fifth generations further declines in cost made personal computers a consumer product , and developments in artificial intelligence allowed human knowledge to be encoded and replayed through expert systems—very-large-scale integration has reached the stage where in 1985 chips with 4 million bit capacity have been constructed—genetic engineering is being used to change the structure of living systems, plants and animal cells—the shuttle has reduced the costs of activity in space, the space station has made prolonged operation possible, and many of the planets have been explored by unmanned probes.

	1947	Stored program digital computer	
1	1948	Germanium transistor	
	1953	Double-helix model of DNA	
	1953	IBM's first computers	
	1955	Izaak Walton Killam died	
2	1959	Silicon planar transistor	(1 on chip)
	1959	Luna spacecraft	
	1960	Remote robot hand	
	1961	Manned orbits	
	1962	Communications satellite	
	1963	Interactive computing	(20 on a chip)
3	1965	Space walk & rendezvous	
	1966	Genetic code fully decoded	
	1970	Artificial gene	
	1971	Lunar landing	
	1971	Computer on a chip	(5,000 on chip)
4	1972	Expert systems	
	1973	Space station	
	1974	Genetic engineering	
	1975	Personal computers	
	1977	Space shuttle	
	1979	Saturn probe	(500,000 on chip)
5	1980	Six month manned orbit	
	1980	Genetic engineering human trials	
	1981	Fifth generation computer program	
	1985	Four million bits on a chip	
	1985	Encyclopaedia on optical disk	
	1985	Sixth Generation computer program	
	1987		(20,000,000 on chip)

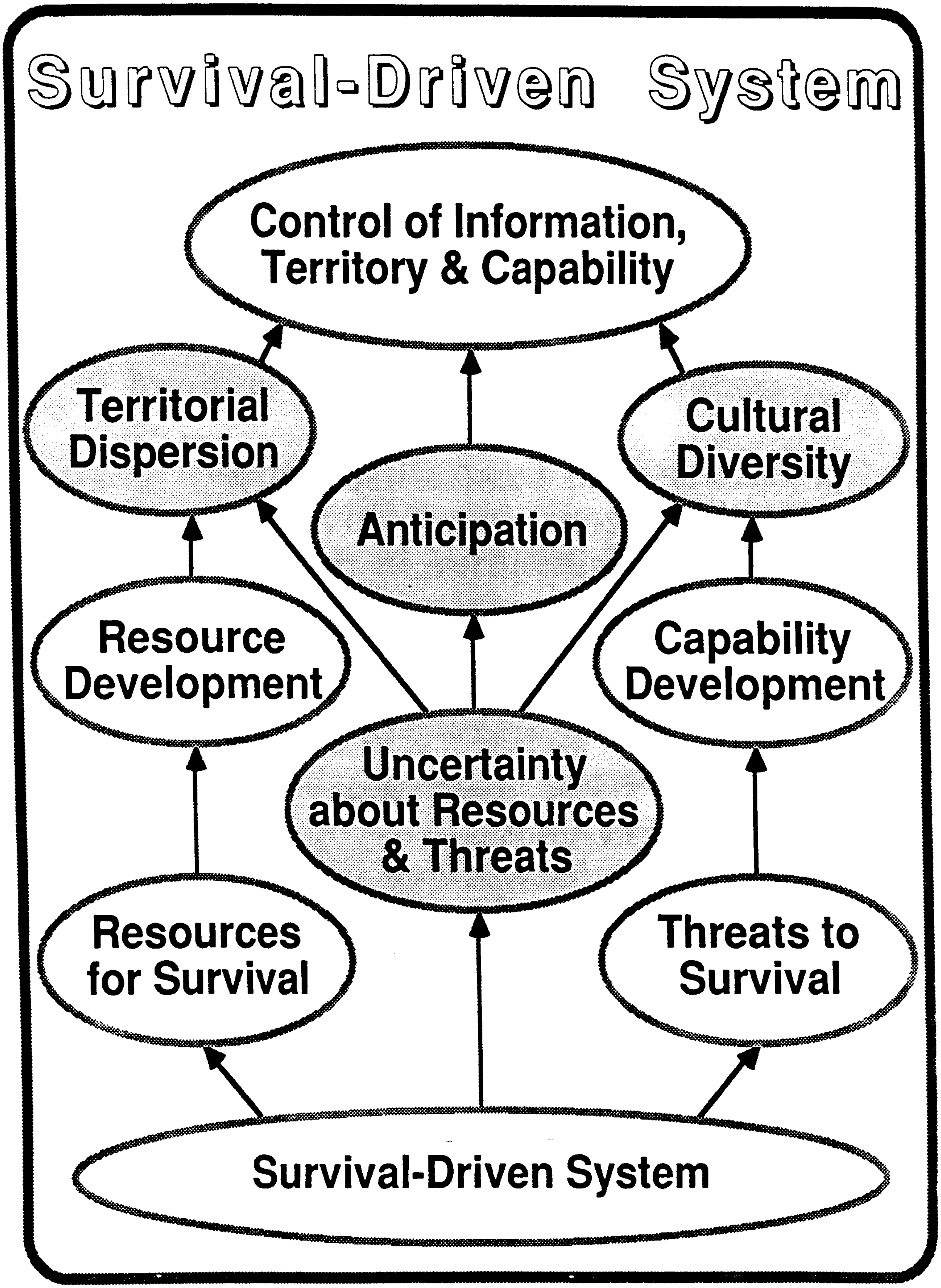
The Human Drive

Our world has changed but where is it going? Technological forecasting provides no answer to this question. Our civilization is not driven by a cause-effect chain based on the technologies available to it. Those technologies are the by-products of the processes of society, the teleological processes of a living system driven by its survival. To anticipate our socio-economic future we have to come to understand those processes—our own nature. The primary drive of a living system is its survival. To survive, the system must have access to the necessary resources and be capable of coping with threats to its survival. Systems evolve to maximize their access to resources and minimize their vulnerability to threats.

If the universe were static a simple model of resource availability and prey/predator relations would determine the dynamics of living systems. Until the advent of the human race this planet was a static universe over long periods of evolutionary time. The beginnings of the human race were set in this static universe but our activities soon began to change that universe so that uncertainty about the future began to dominate our survival processes—changes in the earth that would have taken millions of years began to occur over millenia—now they occur within our lifetimes. We developed resources far beyond their natural availability and, in so doing, changed the ecology of the earth. We extinguished all predators other than ourselves and again changed the face of the earth. Much of this planet is now a human construct and the distinction between natural and artificial is increasingly becoming meaningless.

The figure opposite shows the system dynamics underlying humanity. The shaded areas show the response to uncertainty. The keys to survival in an uncertain world are three-fold: first to maximize territorial dispersion so that some part of the system is outside the range of a threat; second to maximize cultural diversity so that some part of the system has the capability to survive a threat; third to improve anticipation of the future, passively to predict threats in advance, and actively to rebuild the universe so that they do not occur—those are the roles of science and technology.

This is the logic of our present foci of attention: information technology; genetic engineering and the space program. Killam's world was one of resource development. The resources that occupied him were the precursors of the information age: electric power underlying information technology; and pulp & paper underlying the previous medium for the disemination of information, the printed word. *Our* world is dominated by uncertainty.


Survival-Driven System
Control of Information, Territory & Capability
Territorial Dispersion
Anticipation
Cultural Diversity
Resource Development
Capability Development
Uncertainty about Resources & Threats
Resources for Survival
Threats to Survival
Survival-Driven System

Niklas Luhmann on "Trust and Power"

"The world is overwhelmingly complex
for every kind of real system...
Its possibilities exceed those to which
the system has the capacity to respond.

A system locates itself in a
selectively constituted 'environment'
and will disintegrate in the case of
disjunction between environment and 'world'.

Human beings, however, and they alone,
are conscious of the world's complexity
and therefore of the possibility of
selecting their environment—
something which poses
fundamental questions of self-preservation.

Man has the capacity to comprehend the world,
can see alternatives, possibilities,
can realize his own ignorance,
and can perceive himself as
one who must make decisions."

Edward De Bono on "Future Positive"

**"By great good fortune, and just in time,
we have to hand a device that can
rescue us from the mass of complexity.
That device is the computer.**

**The computer will be to the
organisation revolution
what steam power was to the
industrial revolution.**

**The computer can
extend our organizing power
in the same way as
steam extended muscle power...**

**Of course we have to ensure that
the result is more human
rather than less human.**

**Similarly we have to use the computer
to reduce complexity
rather than to increase complexity,
by making it possible
to cope with increased complexity."**

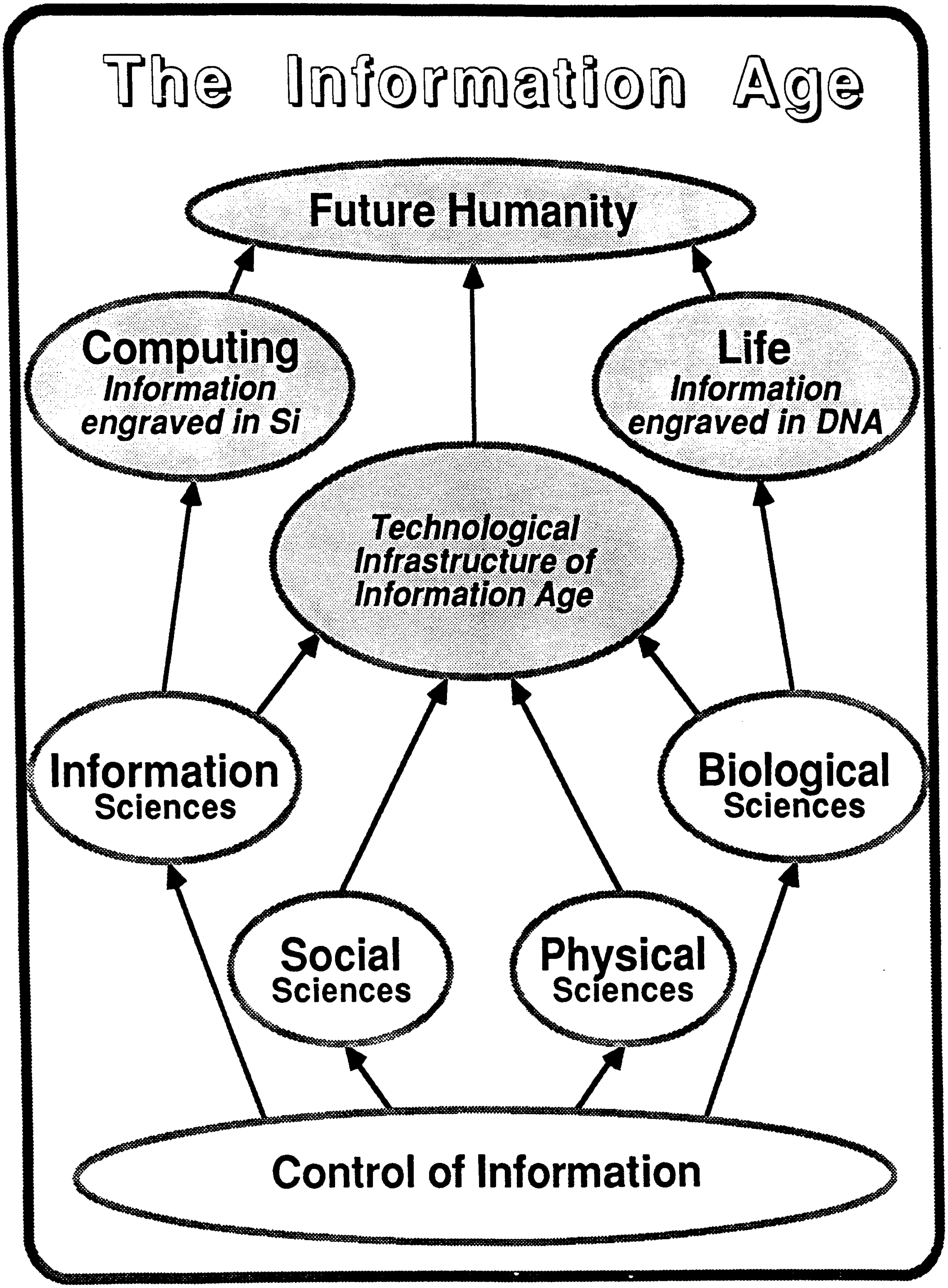
Control of Information

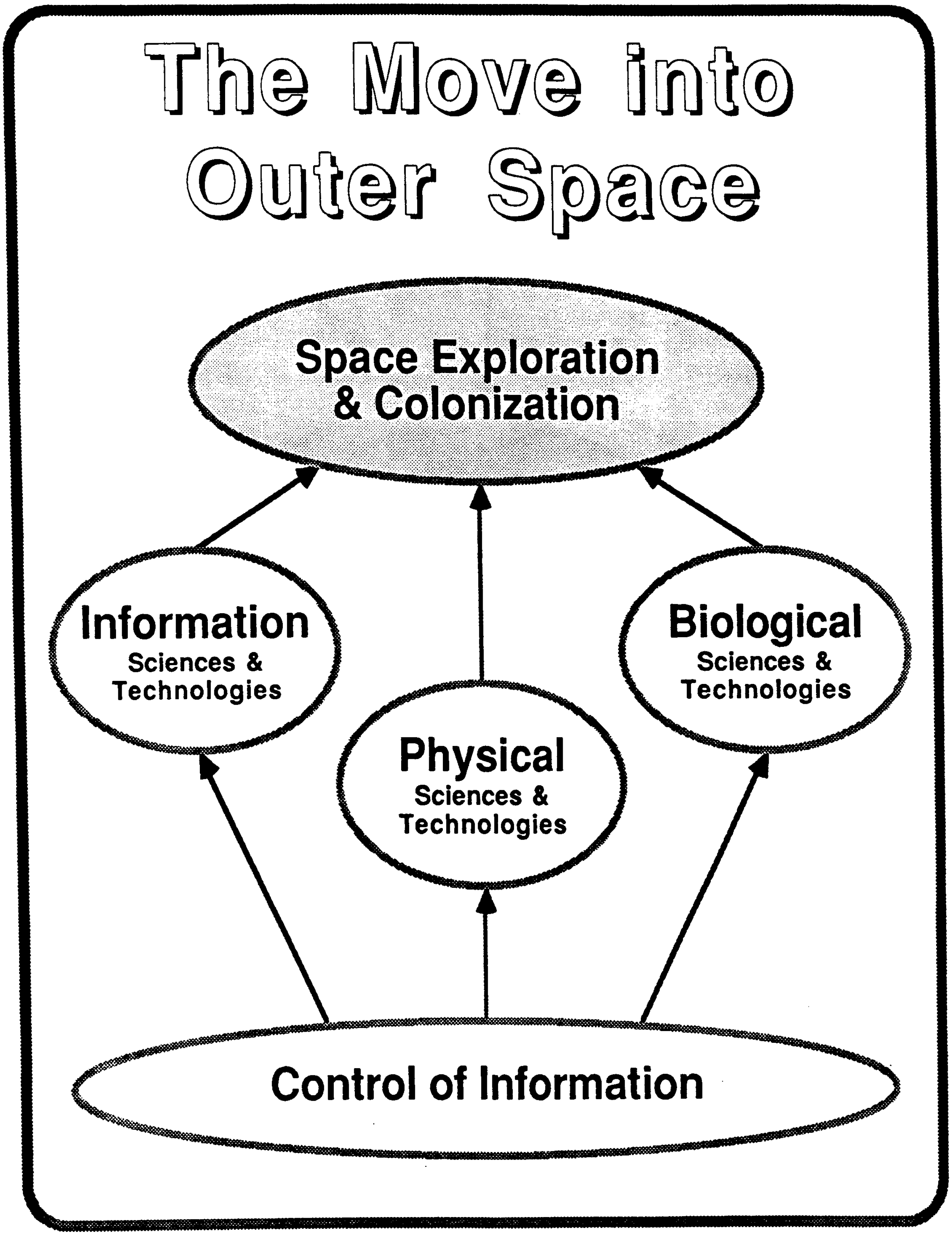
What are the implications of our transition to a changing and uncertain man-made world? The major implication is that which leads to the notion of a knowledge-based economy. Knowledge itself has become our fundamental resource. As Jerzy Wojciechowski has noted, it is human knowledge that has created the world we live in, including its problems, and it is human knowledge that provides the only available solutions. The husbanding, harvesting, and management of knowledge—what he terms the *ecology* of knowledge—is as important today as the ecology of the physical environment has ever been.

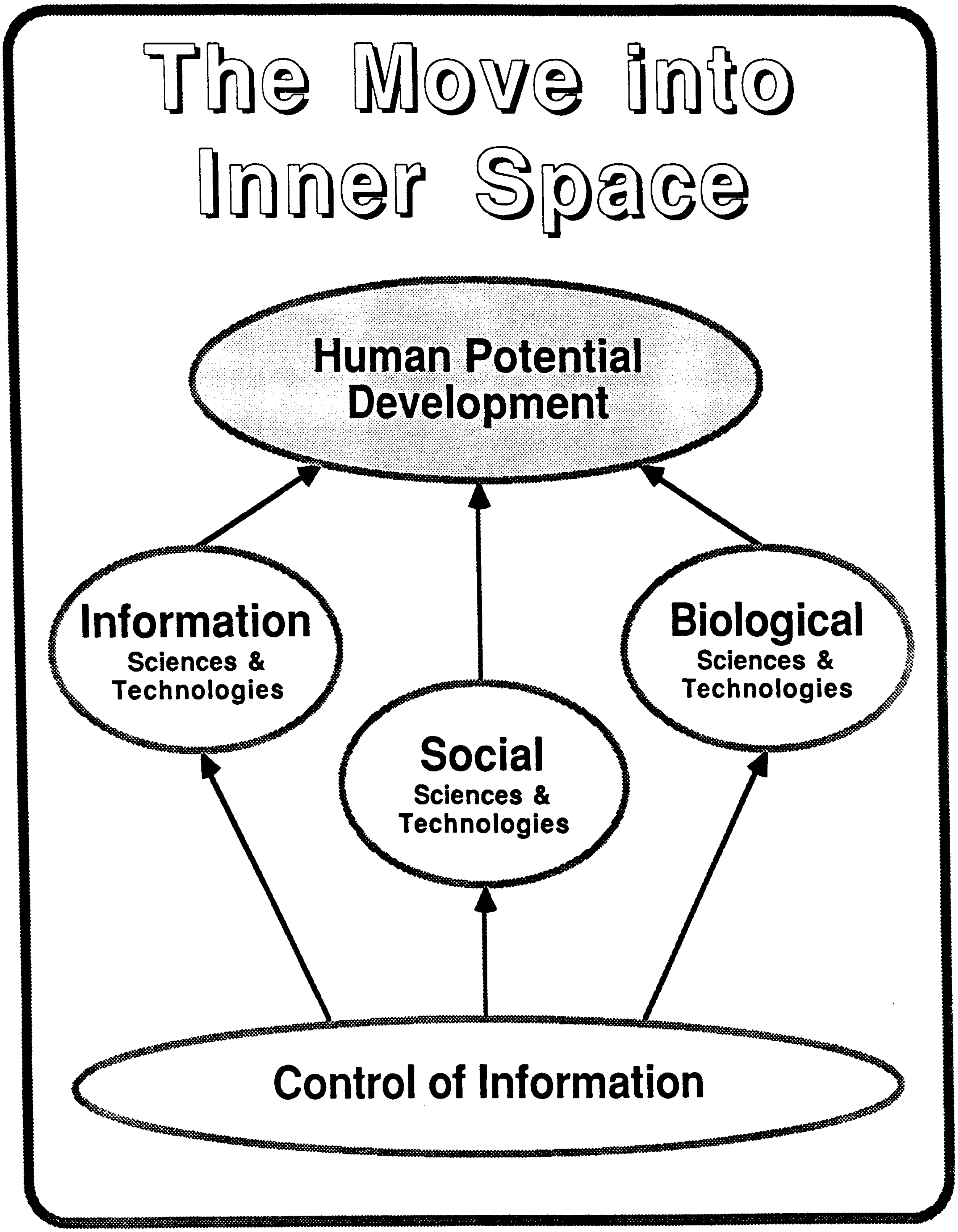
Another implication is that knowledge is a single entity in its own right and needs to be conceptualized as such. The traditional boundaries between materials, processes, devices and systems, or between physics, chemistry and biology, are fast becoming meaningless. Indeed too rigid adherence to such distinctions may be the greatest impediment to effective operation in a knowledge-based economy. Disciplinary boundaries have been the scaffolding that enabled us to construct a vast edifice of knowledge piece by piece before we had the capabilities to encompass it as a whole. Information technology has been developed to hold together the edifice without the scaffolding. The encyclopaedia on a small optical disk and the expert systems of today are the precursors of the total knowledge systems of tomorrow.

Information Underlies Computing & Life

We know that information technology underlies computing systems. However, in a wider sense it also underlies genetic engineering. Microelectronic device fabrication is the control of information structuring semiconductors devices at the molecular level. Genetic engineering is the control of information structuring living organisms at the molecular level. These apparently very different technologies have common roots, dependencies and potential, and there will be increasing interaction between them. At the macro level the socio-economic processes of a knowledge-based economy are information-driven and the key to prosperity and the quality of life in such an economy is the effective control and application of information. In manufacturing, it is the flow of information that structures the operation of a modern factory. The drive towards total automation through robotics and computer-integration is critically dependent on the development of manufacturing automation protocols to control the flow of that information.


The Information Age
Future Humanity
Computing
Information
engraved in Si
Life
Information
engraved in DNA
Technological
Infrastructure of
Information Age
Information
Sciences
Biological
Sciences
Social
Sciences
Physical
Sciences
Control of Information


The Move into Outer Space
Space Exploration & Colonization
Information Sciences & Technologies
Physical Sciences & Technologies
Biological Sciences & Technologies
Control of Information


The Move into Inner Space
Human Potential Development
Information Sciences & Technologies
Social Sciences & Technologies
Biological Sciences & Technologies
Control of Information

Knowledge Science

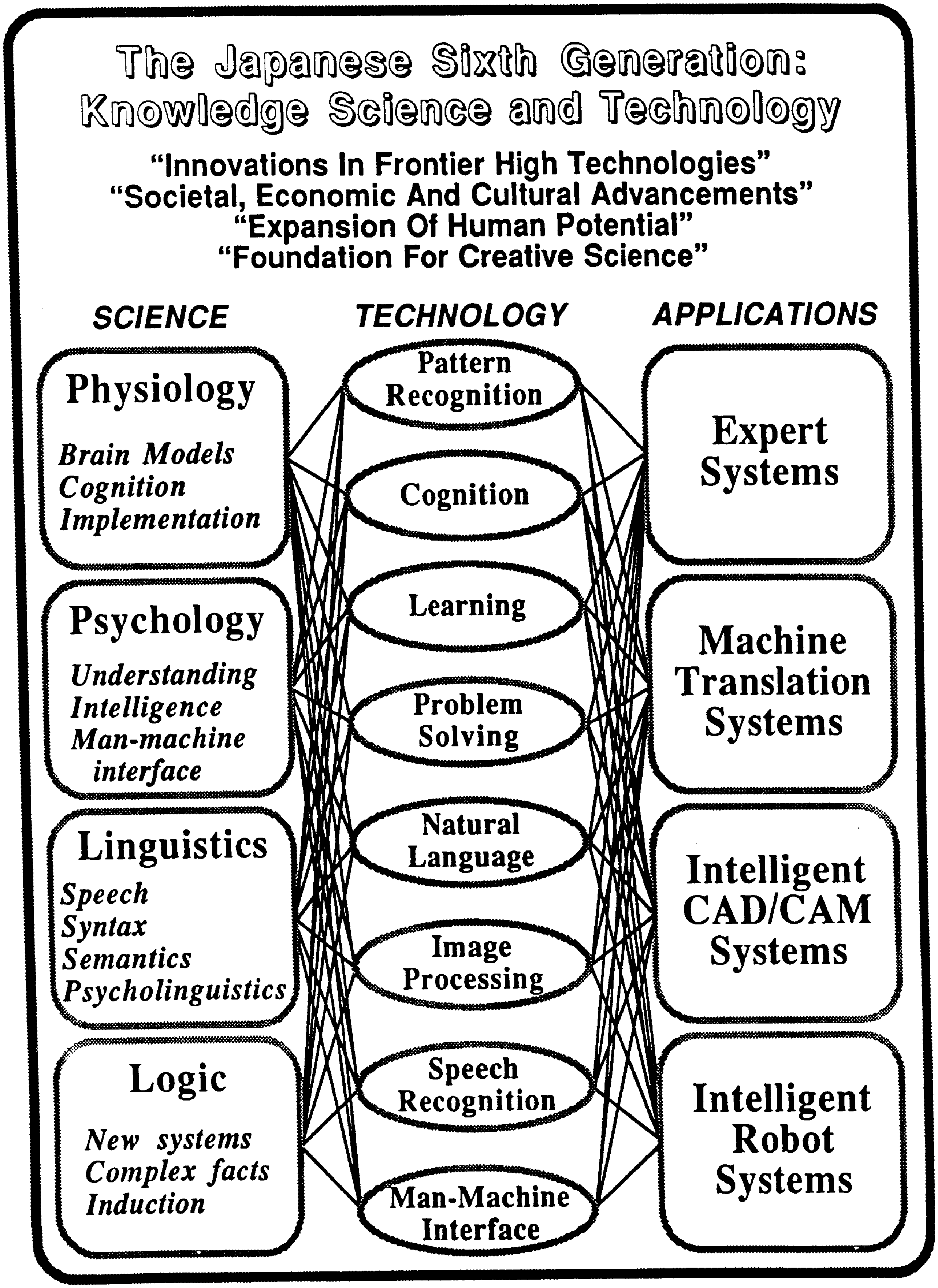
The power of knowledge-based information control systems is nowhere more apparent than through the diversity of activities now possible at a computer graphics terminal. When we see someone working at such a terminal, with the same computer, display and much common software, they may be designing: a computer program to calculate a payroll; an expert system for advising managers; a complex metal piece part; a microelectronic device; a chemical catalytic process; a genetic structure; and so on. What is even more remarkable is that the results of their design can in every case become implemented without further human intervention—the metal piece part may be turned and milled by numerically-controlled machine tools and placed in position by robot arms—the catalytic process may be simulated and then used with no empirical laboratory testing.

Sixth Generation Computing

These examples illustrate the way in which information technology by-passes disciplinary boundaries and affects all disciplines. We are moving into a world of *knowledge science* whose foundations are philosophy and system science but whose structure encompasses all our traditional disciplines and professions, and some yet to come. The development of knowledge science in its own right is crucial to the generation of our future industries. This was emphasized recently when the Japanese released their *sixth generation computing system* development proposals. The translator notes that the Japanese have "coined" the name *knowledge science* for their new thrust in information technology.

The figure opposite is a synopsis of the Japanese proposal. Whereas their *fifth generation* program is targeted on machine architectures using very-large-scale integrated circuits for artificial intelligence machines, the *sixth generation* program emphasises the knowledge that has to be programmed into these machines. They propose to put together multidisciplinary teams of computing scientists together with *neurologists*, *psychologists*, *linguists* and *philosophers*, in order to generate the technologies in the centre column for applications in expert systems, machine translation, intelligent computer-aided design & manufacturing and intelligent robotics.

This interdisciplinary program on an international scale is the first significant attempt to operationalize knowledge, making the processes involved overt and giving us knowledge science and technology.



The Japanese Sixth Generation:
Knowledge Science and Technology
"Innovations In Frontier High Technologies"
"Societal, Economic And Cultural Advancements"
"Expansion Of Human Potential"
"Foundation For Creative Science"
SCIENCE
TECHNOLOGY
APPLICATIONS
Physiology
Brain Models
Cognition
Implementation
Psychology
Understanding
Intelligence
Man-machine interface
Linguistics
Speech
Syntax
Semantics
Psycholinguistics
Logic
New systems
Complex facts
Induction
Pattern Recognition
Cognition
Learning
Problem Solving
Natural Language
Image Processing
Speech Recognition
Man-Machine Interface
Expert Systems
Machine Translation Systems
Intelligent CAD/CAM Systems
Intelligent Robot Systems

Implications for Canada

For a country like Canada, that sits between the two economic worlds of natural resource exploitation and high-technology innovation, it is particularly difficult to know how to cope with the technological and social change of the knowledge-based society. We do not have the urgent need to export high-technology products that drives Japanese economic planning. We do not have the requirement of the USA to be self-sufficient in all key technologies. Our balance of trade is favorable due to our rich natural resources. We can afford to import high-technology and make use of it to support our resource-based economy. Our need is to make use of technology to ensure more effective use of our resources and greater added value in their exploitation. We can also increase the stability of our economy by exploiting our increasing skills in the application of technology in worldwide markets .

An emphasis on Canada as an applier of technology does not de-emphasise the need for basic research and development. To develop the skills to use the new technologies we have to provide opportunities to innovate. It will not be possible to understand them fully if we do not attempt to develop them as well as use them. Research and development is much lower in cost than manufacturing and marketing. Its role in developing the knowledge and skills to apply a new technology is just as important as its role in generating products. We need to be foundational and eclectic in our research and then highly targeted in our exploitation of the resulting knowledge.

What we have to understand in applications is both the logic of the marketplace and that of the technology. We must analyse the needs for which society is prepared to devote resources, and the technologies which can shape the world to satisfy these needs. It is the combination of a clear perception of the needs and the effective application of the technology which will determine those organizations and nations which cope most effectively with the transition to a knowledge-based economy.

Canada has one of the most educated populations in the world. Educated people through their knowledge provide the raw material for the knowledge-based economy. We have that raw material but we have to manage it effectively in order to take advantage of our position. We have to couple the knowledge of the technology with that of the marketplace. We must also maintain awareness of the areas of expertise in which we excel and those that we must continue to develop and acquire if we are not to become a third world country technologically.

Information Technology in Canada

Canada has sunk resources into information technology that give it the basis for widespread understanding and application of the new knowledge-based technologies based on information control. Computer Science, Information Science and Electrical Engineering Departments have developed curricula and research that make Canada relatively rich in information technology professionals—there is a worldwide shortage and no country is well-off. Natural and Social Science Departments have encouraged the inclusion of computing applications in their own disciplines. Management Science and Industrial Engineering Departments have required computing literacy from their students and incorporated computing in their research. The raw material is there but to exploit it we must come to understand the management of information and knowledge throughout industry, commerce and government.

Computer and communications systems are only tools not ends in their own right. They are neutral to their use and do not supply a model on which to base their application. One can view computing as an advanced technology and look for an application. This is like being impressed by the availability of motor vehicles and trying to see what is the natural direction for them to drive. There is no natural direction for computers either. They will travel on any road formed by an understanding of the knowledge structures underlying the application. That is why the Japanese fifth generation program is targeted on building knowledge bases. We need to encourage students, technologists, market developers, managers and entrepreneurs to think in these terms.

Bio- & Space Technology in Canada

Bio-technology has been recognized for its importance to the Canadian agricultural and petrochemical industries and for its significance as a new industry in its own right. Our universities, research institutes and industry have been quick to grasp the opportunities of genetic engineering and develop world-class competence in Canada. In space technology the resources required to date have been such that no country can compete directly with the USA and USSR. However, Canada has a number of institutes and industries that have made major and widely recognized contributions to the space program. It is important that these initiatives be recognized, supported and exploited, and that the convergence between computing, bio- and space technologies is encouraged.

Knowledge Sciences in Canada

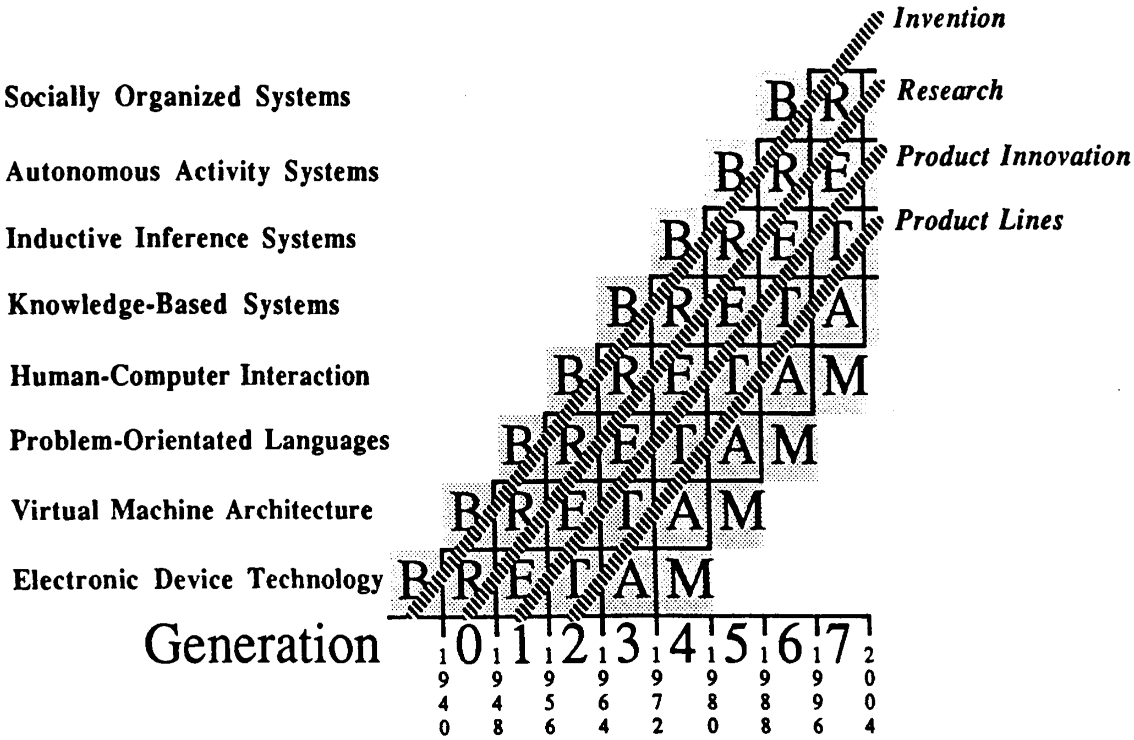
The key to socio-economic success in this information age is the development of knowledge sciences in their own right—but not as a new discipline on the model of existing institutions. All existing sciences and professions will be transformed by their incorporation of knowledge-based information technology. We need to facilitate this process of change within our existing institutions and industries. We need to promote the exchange and interaction of knowledge across disciplines rather than create new inter-disciplinary "disciplines." In time the boundaries will erode, the scaffolding will disintegrate through lack of maintenance and be dismantled because it is in the way. That will take some time and the transition must be facilitated not forced lest we destroy much of what we value.

There is a need for *Knowledge Science Institutes* that serve to facilitate the application of knowledge-based information technology. They will bring together many sciences and professions in an attempt to exploit expert systems on a broad front and re-position those disciplines involved as knowledge sciences in which knowledge, expertise, experience and theories are made overt and operational using information technology. At one level they will help to create markets for the new technologies in Canada—at another they will help to put Canadian universities and industry in the forefront of the use of artificial intelligence techniques—at another they will help create a pool of trained students who can be drawn upon by industry to aid in the effective commercial application of these new technologies.

The USA and Europe responded to the Japanese fifth generation proposals with massive programs of their own. Canada is still discussing its policy in relation to the fifth generation, although the technology is already in place and will be in widespread commercial use by 1988. The sixth generation program with its emphasis on knowledge sciences is vital to our interests as it emphasizes applications. We cannot afford to be slow in entering the sixth generation race. We have the raw material. We have the opportunities. We only need the perception of both and the will to succeed.

The entrepreneur in the information age will be like the entrepreneur in any other age. He will be someone prepared to risk more than others because of greater capability to withstand failure and greater knowledge to reduce the risk. However, the universe of risk, the nature of the risks themselves, the significance of those risks to our civilization, and the activities of the entrepreneur—all are changing as we enter the new age. Humanity is an entrepreneurial venture in survival and we are all part of it.

Infrastructure, invention, research & products through generations of computing



- Breakthrough: creative advance made
- Replication period: experience gained by mimicing breakthrough
- Empirical period: design rules formulated from experience
- Theoretical period: underlying theories formulated and tested
- Automation period: theories predict experience & generate rules
- Maturity: theories become assimilated and used routinely