Technology and Innovation in Canadian Industry

An Information Kit for Social Studies Teachers

Canada

Technology and Innovation in Canadian Industry

An Information Kit for Social Studies Teachers

Tim Fielding
and
Graham Orpwood

Orpwood Associates
Toronto

1988

National Conference on
Technology and Innovation

Desktop Publishing by DTP Training Centre Inc., Toronto

CONTENTS

PREFACE

In January 1988, the Right Honourable Brian Mulroney, Prime Minister of Canada, invited some 200 "key decision-makers from industry, universities, labour and government" from all parts of Canada to meet with him in Toronto for a special purpose: "to discuss the challenge facing the Canadian economy and to develop a consensus on the changes needed to meet the challenge."

The objectives of the conference were:

- to consider the international challenges to the competitiveness of Canadian industry;
- to highlight the importance of technology and innovation as the basis for change; and
- to encourage a commitment on the part of industry, governments, universities and labour to accelerate the shift to a knowledge- and technology-intensive economy.

While education in elementary and secondary schools was not the major focus of the conference, its importance, in meeting the technological challenges facing Canada today, was constantly referred to. Not only does Canada need more people to enter the fields of science and technology, it needs a population that understands more about the impact that science and technology are having on society and it needs young people with the knowledge, skills and attitudes that are appropriate for work in a knowledge-based society. The quality of our elementary and secondary school education was therefore considered to be one of the most significant factors in the future competitiveness of Canadian industry.

From the point of view of the conference organizers, therefore, disseminating information about technology and innovation to schools was seen as important. It is equally important to schools as well. New curricula in science and social studies in most provinces stress the importance of students learning about the linkages between science, technology and society and of their learning this information "in a Canadian context."

These kits -- one each for science and social studies -- have been developed in the form of sets of case studies, in which accounts of recent technological innovations in a variety of Canadian industries illustrate the general themes of technology and innovation. It is intended that teachers will be able to integrate this information readily into their courses in science or social studies at the senior levels of high school.

It is also hoped that the information contained in the kits will stimulate both students and teachers to research further into the many ways in which Canadian companies are using science and technology to create new "higher value-added" products and to renew the methods of producing traditional products.

The kits have been produced by Orpwood Associates, a consulting firm specializing in the areas of science and education, through a contract with the Ministry of State, Science and Technology. The authors of the kits, Douglas Wrigglesworth (Science) and Tim Fielding (Social Studies) are both teachers with the North York Board of Education and their release to attend the Conference is gratefully acknowledged.

Orpwood Associates wishes to acknowledge the contributions of a very large number of people who have helped to make the publication of these kits possible, and especially the following: Janet Ferguson (Manager) and the members of the Secretariat (National Conference on Technology and Innovation, Ottawa); Christine Westover (Alcan International Ltd., Montreal) and James Davis (Alupower Inc. Bernardsville, NJ); Joseph Shlesak (Department of Communications, Ottawa); Catherine Enright (Seafarm Venture, Sambro Head, Nova Scotia); Danielle Gagnon, Diane Hardy and David Nostbakken (International Development Research Centre, Ottawa); Bruce Jenk and staff (Wastewater Technology Centre, Burlington, Ontario); Jim Hendry (MacDonald- Dettwiler, Richmond, B.C.); Don Nickerson (NewTech Instruments, St Johns, Newfoundland); Bill Atkinson (Forintek, Montreal); Lynda Moore (B.C. Forest Industries, Vancouver); James MacFarlane (International Submarine Engineering, Port Moody, B.C.); Susan Forbes (Allelix, Mississauga, Ontario); and Graham Johnson (Ostred Sea Farms, Halifax, Nova Scotia). The authors also acknowledge the assistance of their colleagues, particularly Dave Simpson and Nicole Hodge (North York Board of Education), in reviewing earlier drafts of this document.

June 1988

Graham Orpwood
Toronto

TECHNOLOGY AND INNOVATION

Teaching Social Studies for the 21st Century

> *One theme (emerging from the National Conference) is the importance of fostering and consolidating a culture of science and technology in Canada, a climate within which excellence in science and technology is no longer taken for granted but is celebrated for the magnificence of their contribution to our national life.*

With these words, the Right Honourable Brian Mulroney, Prime Minister of Canada, closed the National Conference on Technology and Innovation in January 1988. But what is this "culture of science and technology" which needs to be fostered? What contributions, indeed, do science and technology make to our national life? And what, concretely, does "fostering" such a culture imply for the teaching of social studies in high schools?

These are questions to which there are no definitive answers at this stage. However, we cannot wait for the theory to emerge before the practice begins. This document presents some ideas, information and teaching strategies (for social studies teachers) on the subject of scientific and technological innovation in Canada. The use of this material in the senior grades in high school is intended to encourage amongst young Canadians a more active awareness of and participation in the excitement of technological innovation and entrepreneurship.

Before discussing the pedagogical uses of the information contained in this kit, however, we review some of the ideas presented at the National Conference that touch on the importance of teachers' interest and action in relation to technology in Canada today.

Education for a Technological Society

If Canada is to produce a technically literate labour force capable of handling the anticipated competitive and creative demands of the international economic scene of the 21st century, then its educational systems must adopt an integrated strategy that blends technological knowledge and skills with a programme of sophisticated communication, analysis and development skills.

The pure and applied physical and biological sciences are, of course, important but cannot stand alone if this is to be achieved. Educators should be aware that providing a program that merely increases scientific knowledge and technical capability is not enough. It must be combined with a programme of equal importance that creates increased social awareness ofthe impact of technology on society.

Developing this awareness should be a major goal of social studies education for the next decade and beyond. No society can function technically, let alone be technologically creative, unless the social infrastructure and climate of public opinion acts as a driving force towards those objectives. One might even say (with an eye to the Japanese or the Koreans) that such a climate of public opinion is a major hallmark of a "science and technology culture."

The Government of Canada has recognised the need for an interdisciplinary strategy towards education in science, technology and increased public awareness through statements in its program to support science and technology in Canada, called "Innovaction."

> Innovaction will help to increase basic scientific and technological literacy in Canada. The degree to which we can achieve a national focus for Canada's efforts is largely dependent on the degree to which Canadians understand and appreciate the importance of technological innovation.
>
> Innovaction will promote a more diverse approach to keep Canadians aware of, and participating in, science and technology. It will encourage schools to play an active role teaching young people about the history, achievements and impacts of technology on society. It will support media efforts to communicate scientific and technological developments. The government will play a facilitating role, creating a positive social environment for science and technology.

The following case studies are designed to give social studies educators the chance to participate in this effort to increase public awareness of the importance of science and technology in Canadian society. It provides them with concrete examples of the nature of current technical innovations and their social and economic background.

Hopefully, they can use them as co-curricular materials to generate interest and/or involvement among students concerning entrepreneurial initiatives with a technical component. Teachers could attempt to instil student curiosity along with the development of a sense of contemporary pride and responsibility for the future, with respect to Canadian technical needs and concerns.

It is anticipated that the material will have a broad national range of application. The selection and presentation of the material is based on the issues and content encountered in geography and other social studies course guidelines from ministries (departments) of education in all the provinces. (See the appendix for specific references to the various provincial documents.)

Technology in Canada Today

This document describes, in the form of a set of four case studies of how Canadian industry is already becoming innovative in its use of technology, drawn from four different areas of the natural resources sector, as follows:

1. Technology for Managing our Forest Resources;
2. Ocean Technologies and Underwater Innovation;
3. Biological and Environmental Technologies;
4. Appropriate Technologies and the Third World.

Some readers may be surprised about this apparently traditional emphasis on the natural resources sector in an information kit about technology and innovation. Much has been made of the need for Canada to emulate the Japanese technological drive and business acumen to create a new industrial base for the future. This would be one based on manufacturing, and on the inventiveness of the population in generating new products, rather than on the exploitation and use of the country's natural riches and environment.

The strengthening of Canada's manufacturing sector is very important, of course, and the development and use of new technology to this end is growing rapidly. However, as the case studies in this document illustrate, much of the technological innovation in our society has always stemmed from the need to study, conserve, and maximise the use of our tremendous natural wealth. As one of the working groups at the Conference concluded:

> The longer term approach to adding value to Canadian products for international competitiveness should be oriented to building on Canada's traditional strengths and needs.

Even the many inventions that have been developed in Bell Canada's pioneering work in telephone transmission, for example, often sprang from a need to tackle problems arising from the natural features of our land (such as its enormous size) and to catalogue and manage its resources (such as its forest resources). For these reasons, this information kit is focussed primarily on the use of technology to innovate new processes (and thus increase productivity) in the natural resources sector.

Suggestions for Teaching Strategies

Although each case study is designed to stand alone as a one lesson concept/theme supported by teacher-selected class questioning techniques, some teachers may prefer to integrate allthe case studies under a single conceptual approach.

Business education and economics teachers, in particular, may select the "jigsaw" approach as follows:

(1) Divide the class into "home groups" of 3 or 4 students;
(2) Have the group assign a case study to each group member;
(3) Each member reads and makes notes on his/her case study;
(4) The member of each group doing a given case study gets together with the corresponding members of the other groups to form an "expert" group to reach a consensus;
(5) They then return to their home groups to "teach" their colleagues about the technological innovations they have studied.

The groups should consider specific questions that the teacher poses such as:

- What are the difficulties a new entrepreneur would face? How have some of the case-study entrepreneurs dealt with these problems?

- Why do these entrepreneurs concern themselves with foreign markets?

- What roles do governments play in innovation? Why are Canadian governments usually more involved than U.S. governments?

- What impact do these innovations have on Canadian productivity (output per worker in each industry)?

After the groups have finished their deliberations, the teacher could emphasize general concepts such as the following.

- Technological innovation is the critical factor in economic growth (a follow-up activity based on the work in this field of 1988 economics Nobel prize winner, Robert Solow, could provide enrichment for advanced students).

- In a mixed economy like ours, most technical innovation is done in the private sector.

- Growth is essential if we are to have more social amenities and welfare.

- Government should aid individual entrepreneurs (debate this point - if so, how?).

With this approach, teachers can underscore the importance of these and other concepts, using the set of case studies as a resource.

In order to extend the study of themes introduced by the case studies, teachers may wish to approach local companies for more specific information about themselves and their products. Most companies produce, along with the mandatory annual report,highly-illustrated advertising brochures and technical information sheets that describe their products.

Although much of this material may be technically inappropriate for direct curriculum-related classroom case study analysis using standard teaching techniques, it can often be used in a bulletin board or school hallway displays. If the teacher edits and captions the material appropriately to draw student attention to relevant themes, such displays can fire the imagination and interest in new technologies that might otherwise not be considered relevant to course aims, goals and objectives.

One such example might be entitled "Canadian Geography and Technology: What's New?" and could illustrate land/resource survey and development themes for senior Canadian Geography course students.

Another strategy might involve the establishment of a regular liaison between an industry involving the development of material of interest to the objectives of the course. Why not consider an "adopt-an-industry" or "adopt-an-innovator" program for your school? One could follow the progress of the particular business endeavour, and suggest ways in which material could be produced (eg. informative videos, slides, posters, diagrams) that would be of mutual benefit to the classroom teacher and the company.

Such an initiative could make students interested and aware of the development of an innovative technology and its business aspects, while providing useful information, public relations exposure and mutual feedback about educational topics for both the educational and the business communities involved.

Many schools already have participated in an "adopt-a-school" program and have an industrial "sponsor". What better way to promote the liaison than to invite the respective sponsoring businesses to develop school displays and curriculum materials that outline their innovative economic endeavours and their positive role in Canadian economic development?

On a smaller scale, guest speakers, knowledgeable in a particular educational or technically innovative field could be exchanged between the participating schools and businesses. Educators could advise the industrial co-operator concerning any relevant educational curriculum and potential in-service learning strategies and advise on the production of any suitable educationally-relevant materials and strategies by industry.

References

Botting, D., Gerrard D., & Osborne K. *The Technology Connection: The Impact of Technology on Canada* (Vancouver: CommCept Publishing, 1980).

Competing in the New Global Economy, Report of the Premier's Council (Toronto: Government of Ontario, 1988).

Gradwell, J., Welch, M., & Vincent, J-F., *Techno 2000: An Introduction to Technology* (Toronto, Copp Clark Pitman, 1986).

Foster, R. *Innovation: The Attacker's Advantage* (New York: Summit Books, 1986)

Ministry of State, Science and Technology, *Innovaction: The Canadian Strategy for Science and Technology* (Ottawa: Ministry of State, Science and Technology, 1986).

National Conference on Technology and Innovation, *Proceedings* (Ottawa: Ministry of State, Science and Technology, 1988).

Schofield, B.T. & Thomson, R. *Technological Change and Innovation in Canada: A Call for Action*, Discussion Paper prepared for the National Conference on Technology and Innovation (Ottawa: Ministry of State, Science and Technology, 1988).

Smith, Stuart L., *Technology and Work in Canada's Future* (Toronto: Guidance Centre, University of Toronto, 1986).

TECHNOLOGY FOR MANAGING OUR FOREST RESOURCES

High school economic geography and social studies curricula around the world invariably mention the paramount importance of Canada as the second major source of wood products for our globe (after the internally supplied, centrally planned economy of the USSR).

Such an emphasis is hardly misplaced. In 1986, the forest-product contribution to Canada's trade balance was $15.8 billion, more than mining, food, agriculture and fisheries combined. 800,000 Canadians were directly employed in the industry, which supplies 51% of the world's lumber, not to mention its pulp & paper requirements. From another perspective, 300 communities in Canada depend primarily on the forest and its products for their economic survival. Forestry resources can truly be said to be Canada's "number one natural asset."

The Canadian Council of Forest Ministers has developed a National Forest Sector Strategy, which is concerned with the need both to maximise the use and prevent the abuse of this resource. And Canadians have produced technological initiatives in the forest industry -- in both public and private sectors -- that reflect the need to manage and utilise our wood reserves for the on-going benefit of the global community.

Given the strategic economic importance of this industry, therefore, it is certainly no surprise to see Canada at the forefront of research and development in the fields of wood technology and use, forest monitoring and surveillance techniques, and the development of equipment to maximise the value and minimise the wastage of tree products. This case study features a selection of these innovations.

Maximising the Use of Forest Resources

Forintek Canada is a private, non-profit corporation dedicated to assisting, stimulating and coordinating the research and development endeavours of over 140 member companies, associations and federal/provincial forestry services. Its motto is "innovation through partnership".

Forintek's mission is:

> to be the leading force in the technological advancement of the Canadian Wood Products Industry, through the creation and implementation of innovative concepts, processes, products and education programs.

The main goal of the company is to expand the range of technical and competitive uses of wood products. After all, the forest is an on-going renewable resource which, if properly managed, could be a mainstay of the Canadian economy far into the future. This goal is in keeping with the statement of the Council of Forest Ministers that:

> this economic and employment base must be protected. To do so, we must adjust to increased competition in the forest products sector worldwide and develop and apply new technologies. The strategy recommends expansion of our international markets along with increased research and development into new technologies and products to continue the modernization now under way across the sector.

Working through its affiliates, Forintek has developed several innovative strategies for maximising the use of the raw material. Three of these are discussed in more detail below:

(a) an enzyme process that promises new value from wood waste;

(b) the development of an infra-red moisture sensor;

(c) ways of improving band-saw reliability and computerised bucking operations.

Also under investigation are biotechnological methods of wood-fungus control to ensure product cleanliness and longevity.

Enzymes and the Processing of Waste Wood

The original goal of the enzyme research was to turn wood biochemically into valuable chemicals such as ethanol (gasohol). The enzyme *xylanase* is a natural wood-degrading agent which, when isolated and purified from its source compound, can do this job extremely effectively.

In 1985-6, the Forintek research team made major progress on a technique that yielded 99.9% pure xylanase. During the research it was discovered that the method of obtaining the xylanase had an unexpected spin-off in that it could improve yields and grades of "dissolving pulp" (chemical cellulose used in manufacture of fabrics, detergents and pharmaceuticals).

This is normally produced by bleaching wood chips but this leaves a residue that clogs acetate thread-spinning machinery and generates a thread that does not take dye very well. The addition of strong alkalis alleviates this but further degrades the cellulose and thus reduces the value and effectiveness of the dissolving pulp. Pure xylanase leaves the cellulose portion of the pulp untouched. However, it was hard to obtain xylanase in sufficient purity and quantity for large-scale industrial application. As a result of the Forintek R & D, a new, closely-guarded technique uses wood chips, "left over" from low value wood species or from other wood technologies, to feed the micro-organisms that produce cellulase and xylanase. The technique then isolates and purifies both enzymes.

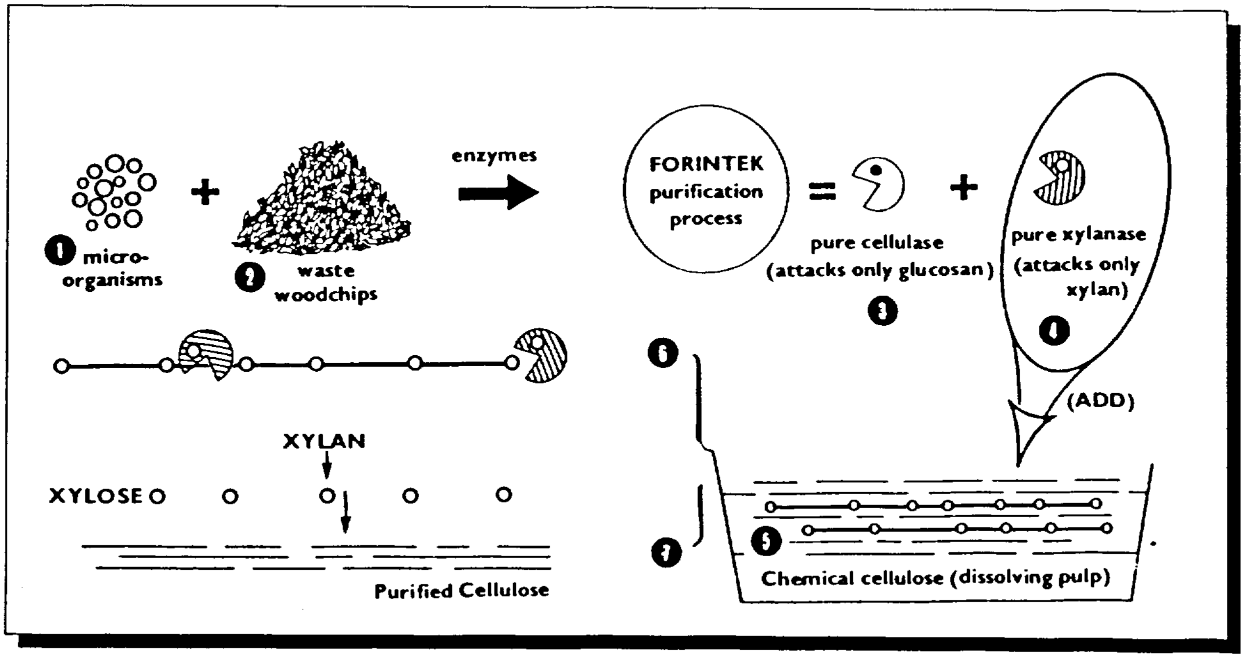


Figure 1: Processing Waste Wood with Enzymes

A cost/feasibility study was initiated in 1986 involving two major Forintek pulp affiliates. If this shows industrial cost effectiveness, then an immediate and substantial market could develop, as the process is easily adapted to current equipment hardware structures. Smaller companies could potentially find a ready market for wood waste with larger chemical organizations producing dissolving pulp or biochemicals for many different uses. Dissolving pulp already has a global market demand of some 4,500,000 tonnes of which 300,000 tonnes are produced in Canada and 1,100,000 in the U.S.A. It appears that once again, co-operative and innovative Canadian wood technology is poised to dominate another world economic scenario.

Wasteful wood processing and storage techniques are often the target of socially high-profile and concerned environmental awareness groups. It is also the target of Forintek's forest industry member companies. The trouble is that wood arriving at the processing plant is of very variable nature and quality just as it is in the forest.

Several detection and sensing devices have been developed by Forintek to assist optimum assessment and processing of the raw material. ELISA (Enzyme-Linked Immune-Specific Assay) has incorporated some biotechnological gene-splicing techniques of the 1970s to produce a more sensitive method of detecting decay fungi in wood before any damage develops. Once the damage is detected, one can inoculate the lumber with micro-organisms that kill decay and sap-stain agents. The aim is to make obsolete the old chemical wood protection methods that are themselves potentially hazardous to health.

An Infra-red Moisture Sensor

"A sawmill's ultimate goal is lumber that's dry, but not too dry for optimum processing and use," states Mr. W. Shiels of Forintek's affiliate, Weldwood of Canada. The industry goal is 19% moisture content for every piece, but this is hard to achieve, given the variability in moisture content of the raw material. The kiln-drying pre-shrinkage of lumber, necessary to produce non-shrinkable lumber suitable for building construction, has often led to over-dried lumber, which must then be sold off as utility or economy grade if it is even useful for construction at all.

An accurate moisture sensing device has long been sought by mill operators. Until recently, the only sensing mechanism was one that inferred moisture content from the wood's electrical properties. However, there are too many variables that canaffect or change those properties. Ray Clarke of Forintek conceived a new remote sensing system based on infra-red radiation, which provides instant readout and has no moving parts. It is accurate over the full range of moisture content and, although it only samples surface moisture, this is a good indication of internal moisture content if the wood has not already been partly dried. Initial mill trials have shown that the readings of this new sensor correlate well with those obtained by the more complex, time-consuming and traditional means.

The sensor has also been successfully linked directly to the Weldwood line computer, which is designed to sort the rough sawn lumber, and has thus become part of an integrated computerised decision-making system of wood evaluation and processing. It has been proposed to use a second sensor for assessing the combustible potential and other characteristics of scrap fuel wood lines. In these ways, such sensors can assist the industry in extracting the maximum potential from existing forest resources and reduce the misuse and wastage of a sensitive natural asset.

Computerised Quality Control

Computerised sensing and quality evaluation systems give future promise of possibly reduced cutting, much more effective use, and less wastage across the entire spectrum of the forest industries. The industry must maximise the worth of what it makes from their initial stems, what is called the "value return to the log".

"Bucking," the process of cutting the stems into logs, starts the process. Computerised bucking (COB) is now widely applied and can boost the average "value return to the log" by over 10%. Moreover, if the COB system can model the mill accurately, it can also calculate volumes of by-products such as chips, sawdust, and planer shavings. Scanners can assess all relevant measurable parameters of a stem providing the latter is kept motionless.

Forintek has provided a systems analysis checklist for COB operation that identifies how to maximise the use of computer sensors and scanners in the lumber industry for direct, automatic mathematical assessment of the stem to eliminate wastage and error. In the future, an on-line, automatic sensing, evaluating and decision-making system for every operation would appear to be a desirable goal for the industry. It would also partially appease the concerns of those who feel that current technology is rapidly wasting our finest renewable resource.

Surveying and Mapping Forest Resources

If forest resources are to be used more effectively and wisely in the future, then state-of-the-art survey and protection of the raw material must be carried out "in situ". MacDonald-Dettwiler of Vancouver have had many successes in aerial mapping and photo-imagery including MERIDIAN, an innovative system of digital mapping that has, as one of its major objectives, the assisting of resource management organizations such as forest product companies.

It uses every available data source to help forestry specialists determine the state of timber holdings. The system can digitize aerial photographs and combine them with satellite images to produce forest surveys, and analyze the economics of harvesting, hauling and sorting. In addition, regional events such as forest fires and infestations can be monitored and assessed. Existing paper maps can be digitized and compared with the remote images to allow changes in land use and potential harvest to be determined quickly and efficiently.

The wide range of input devices that can be integrated with MERIDIAN means that the cartographic results could well form a series of quickly up-dated "real time" atlases. These could include maps based on the already developed METDAS (Meteorological Data Analysis System) for display and analysis of climate and weather characteristics. These developments parallel those of the Canadian Forestry Service in Petawawa (Ontario) which uses remote sensing for continuously-updated forest fire prediction and computer-mapping systems. Overall, it appears that mapping developments in Canadian forestry and meteorology may herald a new role for Canadian technology in the development of innovative "hi-tech" atlases and other advanced visual information systems for educators and students of the 21st century.

Suggestions for Teaching Strategies

The future of our trees -- in particular, the allegation that we are cutting them down far too quickly

Remote Sensing for Weather Mapping

and with too little concern for the future -- is high profile material both for schools and for the media. But what are the facts? Usually, we only get the negative side of the story. Rarely do educators investigate the positive conservation methods and strategies of forest industry companies.

It might be productive for teachers to introduce individual research topics by asking each student to contact assigned affiliate members of FORINTEK (the list is in the company's Annual Report) concerning what each industry is doing to conserve and maximise the use of our forests . A class debate about the "future of our forests" stressing both positive and negative factors, both successes and mistakes, would seem to be in order.

A regularly up-dated bulletin-board "watch" concerning media coverage of these could further encourage student interest. An awareness research/display project as to the increasinglyubiquitous presence of wood in our daily lives in one or another form/use might also be revealing. Teachers could lead the class in a discussion of one of Forintek's major business-oriented concerns: namely that wood can be replaced by other raw materials and that we might end up with an economic resource "white elephant", a concept definitely not covered by the media.

Other questions include: What do we need to know in terms of "real time" information about our forests? How is the information obtained? How quickly, and why is this important? Again, the school/classroom display boards seem to be the best vehicle for interesting the students in this highly graphic topic. B.C. educators in particular may find the material highly suitable for use with the excellent "Forest Education Modules" (FOREM) produced by the B.C. Forest Industries and associates for the B.C. Teachers Federation and available in all secondary schools in that province. Teachers should endeavour to seek visual and chart-form information from mapping and survey resources in both the private and public sector. The striking advertising posters from Macdonald-Dettwiler provide a leading example of this. Demands from teachers could lead to more production of similar teaching aids from many sources.

References

Banks, G. "Wood Preservatives" *Canadian Architect*, vol 32, no. 10, October 1987, pp. 45-47.

Canadian Council of Forest Ministers, *A National Forest Sector Strategy for Canada* (Ottawa: Canadian Council of Forest Ministers, 1987).

FOREM (Forest Education Modules - Curriculum Resource Information Kit); B.C. Forest Industries/B.C. Teachers Federation, Fall 1986.

"Forestry: Eyeing the shape of an uncertain field" *Canadian Business*, vol. 60, no.6, June 1987, pp. 114-115.

Myers, N. *GAIA - An Atlas of Planet Management* (New York: Doubleday, 1984), Forests, pp. 28-29, 54-58.

OCEAN TECHNOLOGIES AND UNDERWATER INNOVATION

Most Canadians live a fair distance from the ocean and many of them regard the water as an arena for sport or recreation rather than as a venue for scientific or entrepreneurial activities. In addition, the news media seem to reinforce the public image of the "poor fisherman" and underline political and environmental problems associated with the ocean and our apparent incapacity or lack of concern with respect to them.

In reality, Canada has the world's second longest coastline with offshore lands and waters which are a reservoir of relatively underexplored and untapped economic wealth and environmental discovery. Scientists have called the oceans "the last frontier" of scientific inquiry with respect to our planet's secrets -- secrets which remain less extensively investigated than those of outer space in many cases. Many oceanographers and marine biologists expect that, in the next century, Canada's emphasis on research and development will shift significantly from land resources towards greater use and control of its ocean domain.

Until recently, for example, urban-dwelling Canadians in central and prairie regions of the country preferred protein from animal rather than fish products. After all, fresh fish has to be transported great distances to reach the market while cattle ranches and dairy farms are still virtually on the doorstep. Yet, for the majority of the world's population, fish forms the main item of protein diet and lack of protein has been identified by the Food and Agricultural Organization of the United Nations as the main deficiency in world food production. It has further recommended that fish cultivation (aquaculture or mariculture) should be regarded as the most viable method of improving and expanding world protein production and foodstuff trade between countries. This fact has been recognised by many projects of the IDRC and CIDA whose initiatives are mentioned elsewhere in this document. It is also a fact that has not gone unnoticed by some young entrepreneurs near Halifax.

Mariculture of Oysters in Atlantic Canada

At first sight, an oyster farm hardly compares to the glamorous innovations of high-technology elsewhere. Yet in its way, the embryonic business of aquaculture could well be one of the initiatives on which the 21st century international reputation of Canadian expertise and know-how may rest.

Seafarm Venture: A view of the bay

Similarly, at first encounter, Catherine Enright of Seafarm Venture, of Sambro Head, Nova Scotia, may appear an unlikely leader in the field of industrial development in the fishery sector. For a start, she comes from Windsor, Ontario, a less-than-likely location for someone who has become an innovator in commercial marine biotechnology. However as public awareness of the vital importance of aquaculture grows and as venture capital investors in other parts of North America realise the long-term market benefits of supporting their commercial drive, young entrepreneurs from inland cities may become a lot more common on our coasts.

Catherine Enright credits a high school guidance teacher with providing her with the initial drive and incentive to investigate the possibilities of a career in marine biology. Originally, she intended to follow a very traditional career in nursing, but her love of water and a sensitive school advising policy fired her enthusiasm for ocean research. Now, instead of nurturing young swimmers as a student instructor in Windsor swimming pools, she is a pioneer in a "fish farming industry" which could replace the traditional "agribusiness" as one of the world's most productive food strategies.

Catherine Enright Preparing the Nets

Instead of nursing people, she is "nursing" living organisms which may -- in the long term -- help solve the world's dietary problems.

However, Catherine Enright has discovered -- like many entrepreneurs and would-be millionaires in private enterprise -- that, just as with any self-starting operational dreams, farming oysters requires far more than just love of water and a curiosity as to what lies under it and in it. She found that she could not just acquire some coastline property overnight, throw in some oysters and sit back to watch them reproduce and grow while she collected sales money from a clamouring market.

For a start, she moved from Windsor to study at Dalhousie University in Halifax from which she eventually received a PhD for her research work in the culture of the *Ostrea edulis* (the Belon or European oyster as distinct from the more common (Canadian) Malpeque species). She also realised that marketing and commercial skills must go hand in hand with research knowledge if she was to make her scientific experiments pay off in commercial profit; hence, the MBA acquired in 1986.

The author of many papers about problems of human management of the natural coastline sub-aquatic ecosystems, she has won world-wide acclaim for her discoveries concerning the biological control, through the use of periwinkles, of on-site fouling in commercial shell-fish farming operations and discovering just the right diet of algae to encourage growth. This has helped her produce clean, fast-maturing and uniformly high quality Belon oysters which is something that the more traditional European oyster collectors were failing to do in their polluted and declining natural locations off the coast of France. This fact gives her the possibility of eventually accessing a huge and lucrative international market.

The potential for a widening market and international acclaim for Canada's "new" aquaculture products has been impressively identified in several economic articles and documents including a 1984 government task force report ("Aquaculture: A Development Plan for Canada"). This stressed the need for Canada not to get left behind by other countries. It also noted that new techniques for managing the marine environment are vital to avoid over-exploiting existing resources by relying on traditional methods of harvesting.

Clearly, the future appears bright on paper for the pioneering oyster-farming aquaculturists of Atlantic Canada. But what of the problems? As any would-be entrepreneur quickly learns, no new business enterprise -- with a few exceptions almost as rare as lottery winners -- guarantees overnight riches and success for the owner/operator.

Graham Johnson, of Ostred Seafarms, Halifax, is another leading aquaculturist, specialising in the Belon, and the traditional North American, oysters. Like Catherine Enright -- and perhaps significantly so -- Graham is an Ontario native (Oakville) who has nurtured an interest from a scuba-diving high school hobby into a love of and commercial partnership with the sea coast. Also the possessor of degrees from Dalhousie, he notes that a lot has still to happen before Canada can be a world leader in the marketing of aquaculture products.

For a start, he points out that, while it is easy to foresee large international sales for high-protein shellfish with today's $3,000,000 production likely to rise to $20,000,000 in the 21st century, it will be some time before that is achieved. He notes that the speedy development of a centralised hatchery enterprise for common use of the aquaculturists is vital if the industry is to grow in the manner that the market optimists predict. Since the industry has no high-profile lobbyists in the investment markets of the continent, seed capital has been hard to attract. In order to cover any market disaster that might result from too specialised a product, he is diversifying into more traditional (and more profitable) shell-fish and trout operations in the Bras d'Or lakes of Cape Breton Island.

In addition, retail seafood merchants in Toronto report that, while the Belon oyster looks better than its native Malpeque cousin and has a higher nutritive value, it is also a high-priced "Cadillac-quality" shellfish with a distinctive salty taste that has not as yet won over the lovers of the traditional variety. And respectable returns from the high-value but still small North American market may be necessary before the Atlantic aquaculture products can be sold overseas in large competitively-priced quantities.

After all, while the European market may be prepared to pay $1-$3 for a Canadian Belon, because its own supplies are dwindling because of pollution in the oyster beds, it is a long expensive journey which must be accomplished quickly by air. Moreover there is increasing competition from growers on the U.S. eastern seaboard, who appear have more access to seed capital and an aggressive marketing infrastructure. Indeed, some Toronto oyster-eaters prefer the Pine Island farmed oyster from New York over the Belon, in spite of its more watery texture because it is larger in meat quantity, less salty-tasting and considerably cheaper.

Mr. Johnson suggests that the universities could perhaps help by promoting more interest in aquaculture among biology majors and establishing separate departments of aquaculture science. He also notes that time is of the essence in delivering a competitive product to the various markets both in Canada and elsewhere to offset the constrictions of business cash-flow. He stresses the problem of finding private seed and venture capital which seems to dog many small entrepreneurial enterprises in Canada while those in the U.S. flourish.

Dr. Enright reports that all her still-small specialised farm stock of market-ready Belons are being sold locally in Nova Scotia where a taste for the product is growing. Mr. Johnson still sees diversification into a larger aquaculture operation, able to access a wide variety of markets with a variety of products, as his ultimate goal. He adds:

> ".....to develop a strong aquaculture industry, there needs to be a strong combination of biology of the species, technical expertise and business know-how. It is a complex business and unfortunately you have to be good at everything. The principles may be simple but, when trying to control animals and the ocean environment, it is solving problems that is the key to success. Education is definitely essential to the future of aquaculture. We have seen the Europeans and Scandinavians move into Canada to take advantage of our water resources, (while) our manufacturers and investment community are only beginning to learn about aquaculture."

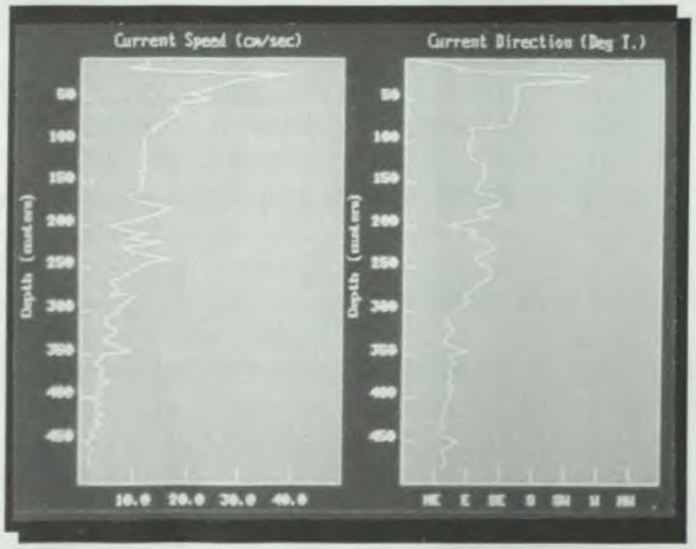
Similarly, Dr Stuart Smith, comparing Canada to Japan, points out that:

> "we have ideal conditions for aquaculture in Canada, particularly on our two coasts, yet we're hardly in that business at all."

Submarine Mapping and Oceanographic Research

If Canada -- and, in fact, the entire world -- is to develop an advanced technology of ocean resource exploitation and management without destroying the environment, then it must be at the leading edge of the development of devices and strategies that will tell us more about the precise physical and biological nature of this vast "last frontier".

The world population of the 21st century will need to utilise the ocean more and more as pressure on land resources grows to a critical point. It is widely acknowledged that we do not know enough particularly about the undersea environment. Yet it will, in many ways, dictate our ability to survive on the land. The challenge to marine engineers and their innovative technical skills is to design research instruments that can inform us about the changing parameters of the ocean.



HYDROBALL in use:
(Top) The probe transmitting data pulses to the mother ship; (Bottom) Profiles of the speed and direction of he current.

Don Nickerson, of NewTech Instruments, St. Johns, Newfoundland, has attempted to meet that challenge. NewTech's "HYDROBALL" may look more like a cartoon spy's bomb than a sophisticated current measuring system, but its potential is amazing. The system provides top-to-bottom profiles of current speeds, directions and water temperatures in water up to 500 metres in depth. The results can be immediately monitored, profiles printed, and data stored in a computer for later retrieval and analysis. The hydrophone that receives this data from the "ball" is equipped with pitch and roll sensors and a compass and is deployed over the side of the ship. As the ball descends through the water at the rate of 1 metre every 3 seconds it sends signals every second. The on-deck analyzing software converts the data and removes ship motion variables to establish a three-dimensional track of the probe's fall through the water. This enables calculations of current speeds and directions at different depths.

The original idea was conceived in 1976 by Dr. Wilson Russell while carrying out research on potential iceberg impact on oil rigs off the Eastern coast of Canada. The concept had several other proposed uses concerning the profiling needs of military, oceanographic and other offshore industry concerns, but global technical developments in shipboard computer electronics lagged behind the idea until 1983 when Dr. Russell finally outlined the prototype system. This was later handed over to Don Nickerson and his newly-formed NewTech Instruments in late 1986 in order to turn the prototype into a commercial product. The first product was tested in June 1987, refined, and tested again in December. Finally, on the 19th of February 1988, the system was successfully demonstrated to several customers just off Cape Spear, Canada's most easterly land point.

HYDROBALL presents intriguing possibilities for expansion through the development of additional probes and -- although other systems measure the same parameters -- it offers a considerable reduction in the costs of oceanographic research compared to alternative methods of analyzing salinity changes. The technology is unique in that it is the only current measuring system to use the motion of an object in the water to determine what the water is doing at that particular moment, to measure water flow past an object rather than to rely on water salinity as a guide. A high degree of risk and uncertainty was involved in its development as the mathematical treatment of the data had to be developed, tested against real life situations and revised as new conditions were found.

HYDROBALL is a classic example of how one person's nagging idea combined with another's unshakable idealism and belief in the engineering potential can lead to successful innovation and the development of a world-respected product. Don Nickerson calls them the "Four D's:"

- DESIRE for success;
- DRIVE to bring an idea to life;
- DEDICATION on behalf of a team of players each with a specific goal/role towards achieving a combined outcome; and, finally,
- DEFINITION of the goals so that they are clearly understood by the team.

Clearly, socio-psychological co-ordination and motivation of a team, in which each player has one or two but not all the required talents, is vital today in the final development of a technologically innovative product.

Newtech's product is a product that cannot, as yet, move laterally in the water as well as vertically nor can it move in response to a remote command. No doubt NewTech's engineering crystal ball gazers have envisaged something like that for future product developments. Yet, as always, the need for a more flexible and more far-ranging oceanographic research devices is apparent to all concerned with gathering more information about our planet's "last frontier".

On Canada's west coast, International Submarine Engineering (ISE) has responded to that global challenge with the development of a remote control-operated submarine vehicle (ROV). As company president James MacFarlane points out, although there is nothing new in the current attempts to produce ROVs, there have been both spectacular successes and failures in their development around the world. However "over the last 18 years, Canada has quietly become a world centre for underwater vehicle design and construction".

After manned vehicles, tethered ROVs were developed starting about 10 years ago and were primarily used in the offshore petroleum industry to depths exceeding 2000 meters and involved inspection of pipelines and drilling rig supports. As might be expected, military needs and interests have also played an important part in project development and funding. However, the umbilical-like control cord that attaches the ROV to the monitoring surface vessel has always proved a nuisance in the deployment of the ROV. Hence ISE (with the support, significantly, of the U.S.Navy) has developed two radio remote controlled autonomous underwater vehicles (AUVs) called DOLPHINand ARCS.

DOLPHIN is described as a "stable instrument-sensor-radiator platform" and looks like a mini-submarine. It is 8 meters in length and travels at 15-20 knots. Currently it is being tested by the U.S. Navy for carrying "defensive devices" in the North Atlantic, although it was initially conceived to improve the collection of hydrographic data from the Canadian continental shelf and potentially can carry a wide variety of sensors. Future uses will include route survey and channel conditioning.

ARCS, which is 6 meters long and 65 cm in diameter, looks like a torpedo. It was originally designed for the Bedford Institute of Oceanography as an under-ice survey vessel for the Arctic. It carries a digital echo sounder for bottom depth measurement and a long baseline ranging system for positioning and course following as well as a sonar for obstacle avoidance. Current ARCs are battery powered and can submerge and go off on their own to carry out preassigned tasks. However, because of band-width limitations of the water column, it cannot transmit large amounts of "real time" data. Typically, it operates on a 5 x 5 mile square pre-programmed path but, at speeds up to 5 knots, it can range up to 100 miles. Although both vehicles are being considered for military use as "force multipliers" their scientific potential is clearly evident.

Perhaps the data sensor devices in Hydroball could be adapted to them to create a multipurpose autonomous oceanographic data collecting laboratory of awesome future capacity? Canada, which has been a strong contributor to underwater vehicle developments over the past two decades, appears well-positioned to continue to do so in the future. The world's oceans are at last yielding their environmental secrets to the challenge of Canadian marine engineering entrepreneurs.

Suggestions for Teaching Strategies

Teaching strategies will obviously vary a great deal depending on the specific course and proximity of the classroom to the ocean. As a dramatic introduction to the nutrition element of the ocean resource issue, and bearing in mind the normally conservative dietary preferences of teenagers, the teacher could consider the preparation of some Belon oyster fare for class sampling or a visit to a restaurant/market specialising in shellfish products.

Classes with access to the oceans could arrange field trips to an accessible mariculture enterprise while some interior-located classes could investigate local freshwater fish farming possibilities. Most commonly, teachers could lead classes in question/answer discussion of such topics as the dietary role of sea food, reasons for the desirability of expanding the role of aquaculture in food production in both developed and less-developed countries, problems of marketing/dietary expansion of sea food and issues connecting environmental pollution and the health/safety of inshore fish products such as shellfish.

Class or individual display or research projects could analyze the future exploitation of the oceans as a Canadian and global resource or focus on the techniques,old and new, of ocean resource exploitation. Problems associated with expanding the use of the oceans or the marketing of fish products in North America would be alternative topics.

Marketing or Economics teachers could ask students to do local research on the availability of fish products and their popularity/origin, or to analyze the problems and potential of Canadian business opportunities presented by expanding the seafood industry. Contacting the Scientific Information & Publications Branch, Fisheries & Oceans Canada (200 Kent St., Ottawa K1A 0E6) will help to find specific industries and projects. Writing to one or more of these to obtain information for a project/report might prove a rewarding class or individual exercise. Canada's Ocean Industries - Products and Services, is the title of a publication from the Department of External Affairs (125 Sussex Drive, Ottawa K1A 0G2). Fisheries and Oceans also produce a Directory of Marine & Freshwater Scientists in Canada.

The Huntsman Marine Science Centre, at St Andrew's, New Brunswick, is a research and educational institution that operates courses for both students and teachers. Its publications for schools are designed to interest young people in the flora and fauna of Atlantic Canada and its beautiful location on the South coast of New Brunswick makes it an ideal place to visit for further study of these topics. Further information can be obtained by writing to Ms Inka Milewski, Director of Development, Huntsman Marine Science Centre (Brandy Cove, St Andrews, NB, E0G 2X0).

Information concerning ocean surveys and investigation could be followed up by a class discussion as to the nature of the information required about the ocean and its retrieval, past, present and future. The influence of the political/strategic significance of the world's oceans on Canada's ocean research and development could be emphasised and the gathering of media reports about that political and environmental importance could be a stimulating and demanding bulletin-board creation or class/individual reporting exercise. Coastal-based classrooms could incorporate a field trip to a marine or hydrographic research institution as an integral part of a course unit on Canada's ocean resources.

References

Aquaculture: A Development Plan for Canada, report of an industry task force (Ottawa: Fisheries and Oceans Canada, 1984).

Canadian Aquaculture (a magazine containing a broad variety of articles on shell-fish mariculture, January - October 1987).

"Catherine Enright: A superscientist entrepreneur whose world is her oysters," *Canadian Business*, August 1986.

External Affairs Canada, *Canada's Ocean Industries: Products and Services* (Ottawa: External Affairs Canada, 1987).

Fisheries and Oceans Canada, *Discovering the Ocean's Secrets* (Ottawa: Fisheries and Oceans Canada, 1987).

Fisheries and Oceans Canada, *Charting the Future* (Hydrography) (Ottawa, Fisheries and Oceans Canada, 1987).

Science Council of Canada, *Aquaculture: An Opportunity for Canadians* (Ottawa: Science Council of Canada, 1985).

Taylor G. and others, "Aquaculture: Revolution in fishing or backyard hobby" and other articles, *Atlantic Insight*, January 1985.

BIOLOGICAL AND ENVIRONMENTAL TECHNOLOGIES

Allelix, of Mississauga, Ontario, is one of North America's largest biotechnology companies. It was formed in 1981 to exploit the many business opportunities made possible by advances in the biological sciences -- advances which involve harnessing natural or genetically engineered plants and organisms for commercial use. Allelix employs 220 scientists and business people of whom 170 -- 65 with PhDs -- are engaged in research within their three divisions of Agriculture, Biochemicals and Diagnostics.

The company has had successes in many fields. In biochemistry, it has developed genetically-engineered fungi to produce high value-added chemicals, and an anti-tumour agent, while its research concentrates on the discovery of molecules central to the disease process and the development of therapeutic agents based on information derived from molecular structure and function. The Diagnostics division has produced test kits for pregnancy, strep throat, and some VD and cardiac conditions, and these are marketed throughout the world.

As its inventions progress through product development, Allelix -- whose research is underwritten by such giants as John Labatt Ltd., Polysar Corp., and the Ontario Development Corporation -- forms joint ventures or corporate partnerships to develop and commercialise its products. In 1987, it signed an R & D agreement with the multi-national giant, Procter & Gamble (Richardson-Vicks Division) to develop more diagnostic tests. Clearly, Allelix is a classic example of a company that believes in technological diversification as a hedge against failure in any one venture.

The Genetic Engineering of Canola

One of the earliest successes of the Agriculture Division of Allelix was the development of the high-yielding hybrid spring "canola" oil seed. Every Canadian geography student knows of the vagaries of wheat cultivation on the Prairies, and the marketing and environmental perils that face the farmers of this sometimes only marginally suitable cropland. They are aware that "diversification" into a variety of high-yield, high-value crops may be the only way out of the grain farming dilemma.

Rapeseed -- the crop that provides the generic origin of the canola oil derivative -- has long been touted as a nutritious oil and meal-providing alternative to corn and wheat. Rapeseed and canola are together the fourth largest source of vegetable oil in the world but canola is slowly edging out the old rapeseed varieties. The 7,000,000 hectares of canola planted in Canada make it Canada's third largest field crop, valued at $900,000,000as a major source of edible oils and animal feed in both the country and the world. Only wheat provides more income for the Canadian farmer.

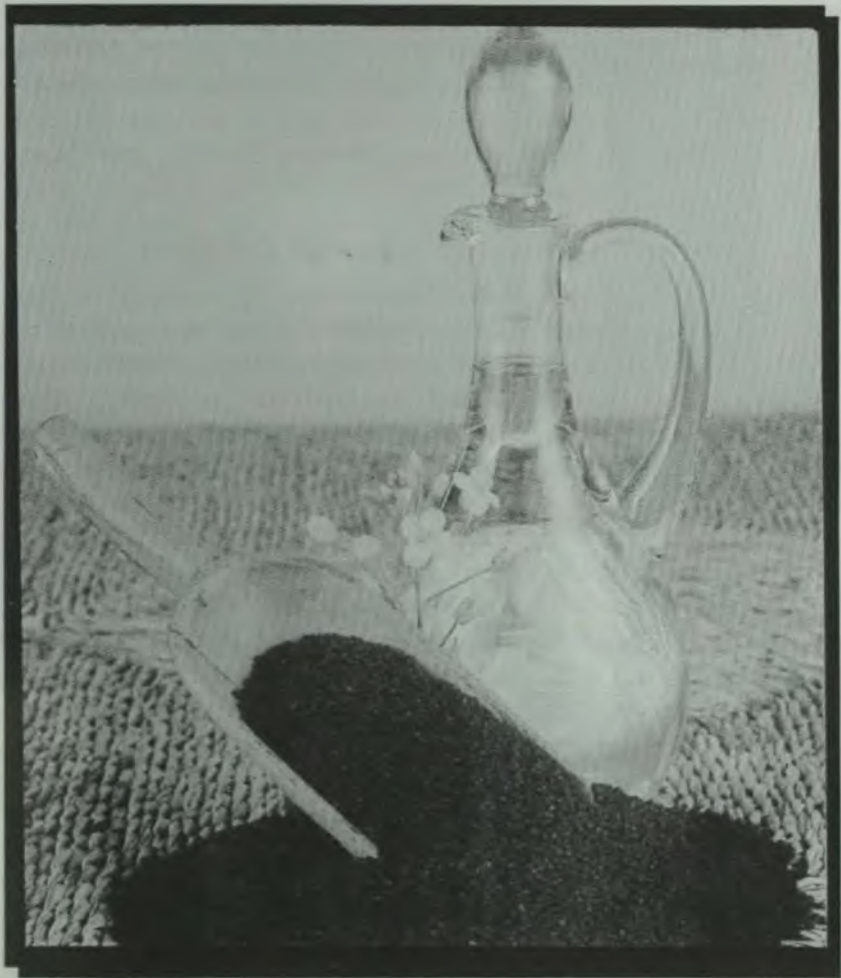
Canola, which is the Canadian-trademarked name for this distinctly different rapeseed derivative, was developed in Canada in response to an old rapeseed problem of acidity which caused fatty tissue and thyroid problems in humans and livestock alike. Canola oil is naturally low in saturated fatty acids compared to traditional rapeseed, soybean and corn oil. It is one of the few crops in which substantial value remains to be added through genetic manipulation. The original rapeseed contains much more inherent diversity than most crops and -- compared to corn or soybeans -- is much more responsive to new biotechnological techniques.

By 1990, Allelix plans to market hybrids that will increase yield by 20-30% as well as having extra disease resistance, herbicide tolerance and modified fatty acid profiles. It believes that it is well ahead of the competition -- although European agro-geneticists are now entering the field -- and plans to test-market the first spring hybrids in 1988, with the first of the winter variety following in 1989. James Castagno of Allelix is optimistic about canola's potential to expand in the U.S., noting that "yielding potential, coupled with the inherent variability (adaptability) of the crop and the ability of scientists to manipulate it further, is really the source of all the current interest in the crop. Farmers would like to find a high-yielding oilseed to plug into their rotations, while technology-based companies are attracted by its receptiveness to new plant transformation techniques, in contrast to major field crops like corn, wheat and soybeans which have proved difficult.

Allelix Technicians in the Canola Field

However, Castagno sounds a series of warnings about anticipating explosive expansion into the U.S., when he mentions competition from European varieties and higher-protein soybean meal, farmer acceptance, elevating-and-crushing industry positions, regulatory barriers concerning spliced-gene products, pesticide prohibition, subsidies for wheat growing, and the need to develop strains which are both pest resistance and suitable for rotation in widely differing potential growing areas with high summer heat.

The Canola Council of Canada (301-433 Main Street, Winnipeg, Manitoba) echoes these warnings when it notes that "North American text books on food science omit reference to canola or rapeseed oil because neither form of oilseed has been widely



Canola Seed, Flower and Oil

grown commercially in the USA." However, in January 1985, the Food and Drug Administration of the United States Department of Health and Human Services granted it the required safe status and opened the door to potential canola expansion there.

Meanwhile, over the last 10 years, Canada has become the world's largest exporter with exports accounting for 50% of the crop yield. Moreover, varieties equivalent in quality to Canadian canola are not yet grown to any extent outside of Canada. However, this appears likely to change in the future and, as Mr. Castagno points out, patent protection of proprietary germ plasm to protect the Canadian investment of time and money in unique gene development may become a problem in other parts of the world than in the highly-regulated U.S. This concern is underscored by the fact that, from 1983-1986, Canada contributed approximately 25% of all world rapeseed oil -- almost all of it "canola" -- thus substantially shifting world consumption towards the low-acid and nutritionally healthier varieties.

Particularly strong potential markets for canola oil exist in countries that already use rapeseed oil -- often in margarine and shortening -- but as yet have a total dietary fat which is less than the 15 to 20% of the calories recommended by nutritionists. Margarine, cooking and bakers' shortening, salad dressing and other vegetable oil ingredients are dominated by canola in Canada, where its increased use has had a rarely acknowledged but potentially dramatic effect on the health and lifestyle of Canadians, one which could spread throughout the continent if not the entire world.

It is interesting to note that Procter & Gamble -- a recent corporate partner with Allelix in medical diagnostic equipment development -- has also been at the forefront of producing healthier food oils when it introduced canola based cooking oil with its "Puritan" brand. Even in its Agricultural

Division, Allelix appears to be following the orientation of its other two divisions by embracing a "better health" theme and research goal while justifying its self-description as "a group of three businesses using state-of-the-art science to develop products and processes for agriculture and health care."

Hydrological Survey Technology

Even with respect to agricultural matters, most Canadians recognise that the nation's -- and, indirectly, the world's largest environmental challenges concern the availability, use and abuse of the phenomenal amount of fresh water in the country. As with many other enterprises involving the development of R & D products that monitor or use the natural resources of the land, federal government agencies -- in this case Environment Canada --have stimulated, initiated, advised or encouraged projects in the private sector that will potentially maximise the commercial advantages to be gained from our vast natural resource base.

Canada has more water than any other country -- about 9% of the total flow of all rivers in the world. A full twelfth of Canada's surface is water. The Water Survey Division of the Water Resources Branch of Environment Canada has theresponsibility for measuring, observing and monitoring the volume of flow, level and quality of water in lakes and rivers in order to evaluate current and future water supplies for our cities and industries. The data is used to establish water rights that are often of concern not only to farmers, fishermen and hydroelectric companies but also to federal and provincial pollution control agencies. It constitutes the basic requirement for wise allocation of water to individuals and industry.

Over the years, the measurement of water characteristics has become more computerised, automated and sophisticated. Since water as a substance is so dynamic and ever-changing, the job of measurement has become a major challenge -- a single measurement is of little value. The Water Survey of Canada collects continuous-record level and discharge data at more than 2700 gauging stations. Ancillary data that need continuous monitoring include suspended sediment, ice thickness and velocity, and temperature, among others.

Observing and recording the changes in on-site data by field observation as they happen has always proved both costly and difficult without sophisticated remote sensing equipment. Recently, technological innovation and ingenuity has been applied to the collection process to enable data to be sensed on site and transmitted via satellites to regional offices for mapping and analysis as quickly as possible since the user demands for this "real time" data are steadily increasing. Two of a host of entrepreneurial technical innovators and electronic engineers who have risen to Environment Canada's challenge are Valcom Ltd. (HYDROMET) of Guelph and Stedtnitz Maritime Technology of Eganville, Ont. (AFFRA).

The latter -- the Acoustic Flowmeter for Remote Areas -- measures average velocity of water, two water stages, velocity of sound, temperature and signal/noise level and stores, along with a designated station name, the time and date, the interval between the measurements, the time of the first measurement and the start of the remote transmission. This information may be transmitted or stored depending on external request in any customer-specified format and allows the computation of water stage relative to assigned datum, cross-sectional area, water quantity and salinity. AFFRA, which can be powered by solar energy, transmits measured data by satellite, radio cell network or modem over standard phone lines and can be remotely triggered.

HYDROMET employs a similar concept but concentrates on the remote sensing and transmission of data about atmospheric environmental moisture and other air phenomena. Clearly, Environment Canada will, in the foreseeable future, be able to observe, graph and map from a centralised command/control location virtually all meteorological and hydrological phenomena changes as they occur in any part of the country.

Monitoring Water Flow with AFFRA

Industrial Waste Management Technology

One of the public's major concerns around the world with respect to the environment has been the quality of water as affected by agricultural, human and industrial sewage pollution. Yet it has long been recognised that, not only can polluted water be either prevented or purified, but that waste water effluent from many sources can actually be recycled into a combustible energy source. Once again, Environment Canada, through its Waste Water Technology Centre in Burlington, Ontario, has been the catalyst to private enterprise technological development.

Sewage sludge is the byproduct of the biological treatment of waste water. Canada produces over 500,000 metric tonnes annually from its sewage plants and it costs over $100,000,000 to dispose of the residue as agricultural land ameliorant, landfill or by incineration. Sometimes these methods may be cost-effective, particularly where small communities can find a local land application use. However, these options create a myriad of cost or other environmental problems in larger communities, particularly in incineration where costs quickly escalate.

One alternative solution has been sought in the development of a technology to convert the sludge to liquid fuel. Petro Sun International of Montreal was contracted in 1986 to develop a one-tonne-a-day pilot plant to confirm a laboratory scale model which suggested that the method was viable in terms of costs and benefits.

The process is based on the relatively simple "natural process of oil synthesis" and on a discovery by German technologists whose North American rights have been purchased by Environment Canada. Once the water is removed, the 95% solid mass is heated to 450 degrees Celsius, producing gases which are then condensed into liquid fuel while the remaining solids form the char. The latter is then recycled as the fuel to provide thermal drying in the first stage of the conversion process.

The "oil" is easily handled, stored or transported for use in heating elsewhere. Apart from cost effectiveness, there are other advantages to the technology. The low volume of residual ash needs minimal landfill disposal space. The relatively low processing temperatures means non-vaporization of toxic metals which are instead converted to non-leachable oxides posing little environmental threat. Air emissions like sulphur dioxide compare to those of natural quality oil and could be handled with present smoke stack filter technology.

Initial experiments show that two barrels of oil suitable for commercial heating are produced for every tonne of sludge processed. Also produced is 1/2 tonne of "char" which has a heating value equal to 80% that of low grade coal. Compared toincineration, the operational savings of this method of sludge treatment is around $40-$60 per tonne. Since 80% of Canada's sludge comes from cities, the potential effect on national waste water treatment and environmental management methods is profound.

Petro Sun, which specialises in alternative energy and environmental engineering systems, hopes to validate the pilot project by mid-1988 when design and construction of the first full-scale commercial plant is expected to begin. Although energy-from-waste technologies, plagued by secondary environmental problems in the past, appear to have faded into the background of public awareness with the apparent cooling-off of the mid-1970s "energy crisis", there is still tremendous potential for fossil fuel conservation and savings in the fuel-from-sludge technology.

The optimistic backers of the system point at a market potential in the U.S.A. of 3000 tonnes per day with a projected market value over the next 10 years of $500,000,000 or more! The potential annual energy recoverable from current sludge production is worth about $30,000,000 which will more than justify the initial total anticipated investment of $15 -- 20,000,000. With the omnipresent concerns about alternative energy sources to natural fossil fuel, environmental air and water quality, and disposal of solid wastes, it is hard not to share the optimism about an environmentally-sound sludge-to-oil conversion process that takes only 10 -30 minutes.

Suggestions for Teaching Strategies

What exactly is "canola oil" and what are its uses and values? It is unlikely that few students outside the prairie provinces will have a clear idea. Teachers should contact the Canola Council of Canada, mentioned above for more information and materials for use in a class investigation study.

Canadian geography courses stress knowledge of the distribution of our agricultural products and rapeseed/canola makes a fine cartographic example. What are the conditions that favour or restrict its growing? What economic conditions could persuade a farmer to abandon wheat and adopt rapeseed/canola? An overall project study of the potential and problems of this product could be an interesting individual student assignment.

But what of the drawbacks to genetic engineering of plants such as rapeseed? Environmentalists, and some geneticists, have sounded warnings about gene manipulation. Again, students could research those general and specific concerns and seek reassurances (if any) from bioengineering innovators concerning their work on canola.

With respect to the usefulness of canola oil, a visit to a supermarket to check product content listings could be rewarding;or the contacting of a large food distributor. Where canola grows, a farm interview/study is an obvious strategy.

From an economic studies point of view, the global marketing potential and strategy for canola might provide a good case study of commodities marketing and international trade agreements or restrictions along with the problem of agricultural patent protection.

Similar questioning techniques to those in the previous case study could be applied to the distribution survey of Canada's water resources. How extensive are they? Are we conserving them? What strategies are being used to clean up or avoid pollution? Where is the pollution? What is industry research and development doing to guarantee safe re-usable water? How do we study water? What must we know about it -- immediately? What are the methods of dealing with sewage (water waste)? How do our cities deal with utilities like waste disposal, environmental cleanliness and water supply?

Each student in the class could give a presentation on a myriad of questions since this case study, perhaps more than any other in this document, lends itself to approaches from widely different angles. Urban Geography courses, as in the Ontario Geography curriculum guidelines, could include visits to local water purification and treatment plants. Rural students might investigate the source of local water and its use with respect to safety and purity. What safeguards exist? Is the supply "monitored" and if so, how?

Overall, the teacher's aim in most cases would be environmental awareness or consciousness-raising among students concerning the danger to health and economic well-being of unsurveyed or polluted water supplies for industrial or domestic use.

References

(on biotechnology and agriculture)

Agriculture Canada, *Progress in Research*, Centennial Issue 1886-1986 (Ottawa: Agriculture Canada, 1986).

Brandt, R. "Biotechnology Down on the Farm," *Business Week*, September 15 1986.

Canola Council of Canada, *Canola Oil: Properties and Performance* (Winnipeg, Canola Council of Canada, (1987).

Crick, F. "The Challenge of Biotechnology," *The Humanist* 46 (July/August 1986): 8-9.

First Choice Canada, special issue on biotechnology, vol. 6, no. 2 (Montreal, Promex Communications, 1987).

Furtan, W.H. and Ulrich A. "Biotechnology and Rapeseed Breeding," *Canadian Farm Economics* vol. 21, no. 1, (1987): 3-17.

Hrynyshyn, J. "Canola," *Science Dimension* vol. 18, no. 1, (1986): 9-10.

Myers, N. *GAIA: An Atlas of Planet Management* (New York: Doubleday, 1984), The Genetics Resource, pp 146-150.

Science Council of Canada, *Seeds of Renewal: Biotechnology and Canada's Resource Industries*, report no. 38 (Ottawa: Science Council of Canada, 1985).

(on environmental issues)

Allen G. "Crisis over Water," *Maclean's* 98 (August 26, 1985): 34-37.

Conley, M.F. A report on a World Bank series on Integrated Resource Recovery, *Environment* 28 (October 1986): 25-29.

Davis, R. and Ketchum, P. "Energy from Waste," *Geos* vol 15, no. 3 (1986): 15-18.

Kidd, J. "Politics of Energy from Waste," *Probe Post* 9 (August 1986): 6-8.

Myers, N. *GAIA: An Atlas of Planet Management* (New York: Doubleday, 1984), Waste into Wealth, pp. 136-137.

APPROPRIATE TECHNOLOGIES AND THE THIRD WORLD

Not every country is a potential market for "hi-tech" products that provide innovative substitutes for costly human labour. There will always be some countries and markets for which the products of the cutting edge of "first-world" industrial technology and invention will be expensive and inappropriate acquisitions. Although technologically advanced products may be available to them and a future aggressive Canadian sales force may be successful in catching their eye with a glittering display, "caveat emptor" should be their watchword. Similarly, Canada should resist trying to sell technically complex and advanced products to buyers who cannot -- at least at that particular time -- utilise them effectively to satisfy needs.

A great deal of market research and skill development must accompany any international sales initiative. A sophisticated assessment must be made of both the short and long-term needs of the market as well as the demands. Those needs would most likely not be as technically advanced or demanding as Canada's own. In short, Canada needs to develop, in co-operation with less-developed economies, an industrial strategy based on "appropriate technologies" if it is to become a successful and respected trading partner with much of the world.

Providing appropriate technology means quite simply supplying a product that is capable of being used to fulfil the immediate needs of a technically less advanced economy and society. The labour force or consumers must be able to handle the product, service it and gain immediately satisfying life-style or economic benefits from it. All too often in the past, the marketing strategies of the technically-advanced economies have dazzled those in less developed countries and induced them to acquire products or technologies that are completely wasted in the socio-economic and physical environment of the areas in which they are deployed.

Fortunately such an appropriate strategy seems to be emerging in Canada. These developments, which have a different emphasis and approach marketing problems from a different angle, may well become a reputable and important part of Canada's future role in world economic scenarios.

The Canadian public corporation that acts as a mentor or catalyst in developing less-advanced but appropriate technologies is the International Development Research Centre (IDRC). Although many of the manufactured items promoted by the IDRC are manufactured under Canadian supervision and with Canadian expertise in less-developed countries, the initial technology is often developed by a partnership of Canadian private enterprise and the available industrial resources of the country concerned.

Also, many agencies in Canada undertake the initial research,investigation and design of the appropriate product and often produce at least the first prototypes, if not all the resulting hardware. Then the recipient country's manufacturers may take over production if the situation is favorable.

This strategy may not lead to huge international sales and long-term markets for Canadian technical equipment, but it creates an on-going reputation for appropriate technical assistance and advice which is just as valuable for Canada's international economic image and marketability as any innovative "R & D" promotion.

The Abrasive Disc Dehuller

The IDRC has initiated and backed many small-scale innovative technical developments which very often reflect the need to improve the basic survival capacities of less developed countries where capital and industrial resources may be in short supply. Very often the technology concerns food production and environmental control utilising small-scale problem solving tactics when large capital-intensive production schemes may be inappropriate. The development and construction of the Abrasive Disc Dehuller is one such case.

This essentially very simple yet completely new invention is being used and manufactured in the Gambia, Senegal, Zimbabwe and Botswana as well as by Nutana Machine in Saskatoon. It makes wheat flour more easily obtainable from tropical cereal grains and legumes, many of which have hard but easily fractured seedcoats and vary greatly in size and hardness. These features mean that, in many parts of the tropics, the normal technology of "reduction milling" to produce wheat flour is impractical. The new dehuller was designed to overcome this problem.

The dehuller consists of a metal shaft on which a number of grinding stones are evenly spaced. These are enclosed in a semi-circular barrel which is filled with grain. The discs spin at 1500-2000 revs per minute and abrade away the outer layers - not a very technically complicated process. The time to grind off the hull varies with hull hardness. An aspirator (or winnowing machine) vacuums away the seed casings. The winnower simply consists of a vibrator which tosses the seeds allowing for a fan to blow the hulls away from the inner seed.

Originally the project was developed with close Canadian government supervision and finance but since it was designed for small-scale operation by native farmers in Africa, production and development has shifted to Africa and to the private sector both in Canada and overseas. The key to its success has been the fulfilling of a need of subsistence farmers to mill their own crops of drought-resistant sorghum and millet rather than to buy commercially milled flour.

The Abrasive Disk Dehuller in Use in Botswana

The dehuller was designed to be inexpensive,easy and simple to operate and available at the village economic level. It is simple, rugged and easy to fix with locally-manufactured spare parts. The IDRC reports that "the simplicity of the dehuller belies the amount and complexity of the research involved in its development". Before the advent of the dehuller, the processing of the tough-shelled cereal grains which account for 28% of cereal production in Africa was a debilitatingly difficult task which involved hours of pestle-and-mortar pounding by the labour force -- traditionally female family members in this case -- before they had enough flour for a daily family meal.

Although (as is the case with many agricultural improvements in Africa) the use of dehuller has been relatively slow in expanding, IDRC reports that it has already spawned local milling industries in Botswana and is helping reduce that country's dependence on South African flour. In the final analysis, the success of the dehuller -- and the corresponding increase in the reputation of Canada's technical innovation assistance programme -- emphasises the point that not all effective technical innovations need to be high-profile or "high technology".

It also provides an example of what could well become a reputable alternative role to advanced technical innovation for future Canadian enterprises with designs on an impact in the international market place.

Suggestions for Teaching Strategies

There are many sources of information suitable for individual senior students projects and investigations that apply to themes of third or developing world environments and appropriate technology. A basic source for any technical information should be the IDRC magazine "Reports," which is copyright-free and available from IDRC (P.O.Box 8500, 250 Albert St., Ottawa K1G 3H4). IDRC will also send teachers more detailed information about the Abrasive Disc Dehuller and other similar technical projects.

Several NGOs (Non-Governmental Organizations) similar to IDRC provide material that address themes and issues in less-developed countries which involve the technical dilemmas often faced in these parts of the world. Teachers could adapt techniques of individual student research/presentation or class case study analysis to enhance curriculum unit study concepts around the topics of food & agriculture, water, environmental degradation, population pressure, third-world education and a host of others.

Guest speakers from organizations such as CUSO and Canada World Youth could be invited to outline the nature of their work in LDCs and the role of appropriate technology in improving the living conditions for the people involved in their overseas projects. Perhaps some students will be enthusiastic enough to pursue an involvement in a CWY youth work/exchange programme or as a CUSO volunteer worker.

For their part, teachers could become more involved in the work of the many regional development education "learner centres" across the country and perhaps contact one of the NGOs -- such as the World Food Day Association of Canada (255 Argyle Ave., Ottawa, K2P 1B8), which produces co-curricular materials on technology and food production around the world. This could lead to the teacher both acquiring extra curriculum materials and becoming involved in the on-going development of educationally-relevant materials and activities.

The further possibilities for acquiring and developing student/teacher learning materials concerning Canada-third world technological links and issues are far too vast to mention in detail, but one overall important educational/government contact should involve the acquisition of material produced by the Canadian International Development Agency (CIDA) -- the official third world development assistance agency of the federal government.

References

Canadian International Development Agency (CIDA), *Food Aid* (Ottawa: CIDA, 1986).

Myers, N. *GAIA: An Atlas of Planet Management* (New York: Doubleday, 1984), Technology transfer, pp. 226-227.

Schmidt, O. and Toomey G. "Sorghum's Knight in Shining Armour," *IDRC Reports* vol. 16, no. 4 (October 1987): 4-5.

Shaikh, R.A. "The dilemmas of advanced technology for the third world," *Technology Review* 89 (April 1986): 56-64.

APPENDIX

Curriculum Relevance

In order to make this document easy to use across the country by teachers, this appendix cross-references the topics covered in the kit to courses in the following subjects in each province.

Economic Geography (particularly courses with a national emphasis);

Economics and Business Education (particularly courses with themes dealing with entrepreneurial strategies and technical innovation);

Sociology;

Environmental Science;

Urban Studies and Urban Geography;

Canadian and World Geography;

Contemporary World & Canadian Issues and Studies;

More specific references to provincial courses are as follows.

British Columbia

Social Studies 9 & 11: "through advances in specialization and technology, societies make scarce resources more productive"; People & World Issues: "global problems of resources, technological change, knowledge expansion";

Economics 11: Demands on Earth's Resources, Unit 8, current economic problems;

Earth Science 11: Resource sciences, atmospheric and oceanographic sciences;

Geography 12: Biogeography.

Alberta

All senior Geography courses (under revision);

Social Studies 9: People and their Technology, also part C, and locally developed study section;

Social Studies 10 & 11: Topic C and locally developed units, (under revision 1987), global issues, topic B, concepts 2.3, 3.2 & 3.6;

Social Studies 12: locally developed sections.

Saskatchewan

Geography 20;

Social Studies 30: population expansion and food production technology (contemporary canadian economic aspects);

Geography 30.

Manitoba

Ecology 305: water quality, food, pollution;

Geography 300: human/environment interrelationships;

Social Studies 100: North America, resource based factors;

Social Studies 101: people/environment in Canada;

Economic Geography 301;

Modern World Problems 301: Canada's relationship to modern world issues (Overview document, resources and technology;

Social Studies IX: Unit 5 (Social and economic change in Canada).

Ontario

Urban Studies (1971);

Environmental Science, grade 10 advanced: optional unit 6 -Forestry;

Environmental Science, grade 12 advanced: unit 3 - energy from waste, water quality; optional units 1, applied genetics and 6, plants, people and environment;

World Issues (under revision): Use of resources and application of technology;

Contemporary Studies;

20th Century World History: Unit 4, the global economy and 5, technology;
Canadian Geographic Realities: (under revision), Canada's economic development.

It is anticipated that the new Ontario guidelines for senior geography will have considerably more specific contemporary references to biogeographic-agricultural and environmental issues.

Quebec

Geography of Canada & Quebec 304: Economic development; natural resource distribution) ;

Geography 314: importance of water, agricultural resources, forest & agricultural resources;

Geographic organization of the Contemporary World 434: food supplies -- trade; world food and connected problems; the world of tomorrow; characteristics of the fishing industry;

General Geography 114 (elements of the environment, mapping).

New Brunswick (English programs)

Environmental Studies 112,113: references to obtaining of food and disposal of wastes, Units 9 & 10, natural resources, sociological/technological dilemmas, attitudes to the environment;

Physical Geography 112: hydrologic cycle; agricultural systems (mapping; forestry), impact of the oceans;

World Geography 122: Canada and the third world, suggested research theme study.

New Brunswick (French programs)

Geography 11: mapping;

Geography of Canada 10: (under revision);

Geography 12: supply of food and energy;

Economics 12: Canadian production, consumption, trade.

Nova Scotia

Geography 431: pollution, resource development, changing technology, rural life;
Geography 231: changing techniques, urbanization, resources;

Modern World Problems 341:

Oceanography 331: field/case study work;

Environmental Geography 421 and 221: These stress examples of physical processes and human/natural environmental resource interrelationships.

Prince Edward Island

Geography 421: developing world;

Geography 431;

Geography 521: hydrosphere;

Geography 531, World Geography: the influence of resources on people);

Agriculture 520.5, Crop Science (propagation);

Biology 621, Marine Science;

Social Science 451, Practical Social Studies: case study applications;

Geography 821, Introduction to Economic Geography.

Newfoundland

Geography Grade 9: farming problems, water resources, conservation);

World Geography 3202: crucial resources, water, natural resources and how they affect people);

World Problems 3204: "development of positive attitudes toward the problems of third world countries;

Canadian Economy 2103: resources, production and growth;

Canadian Issues 1201: case studies.