THE CITIZEN'S GUIDE TO BIOTECHNOLOGY

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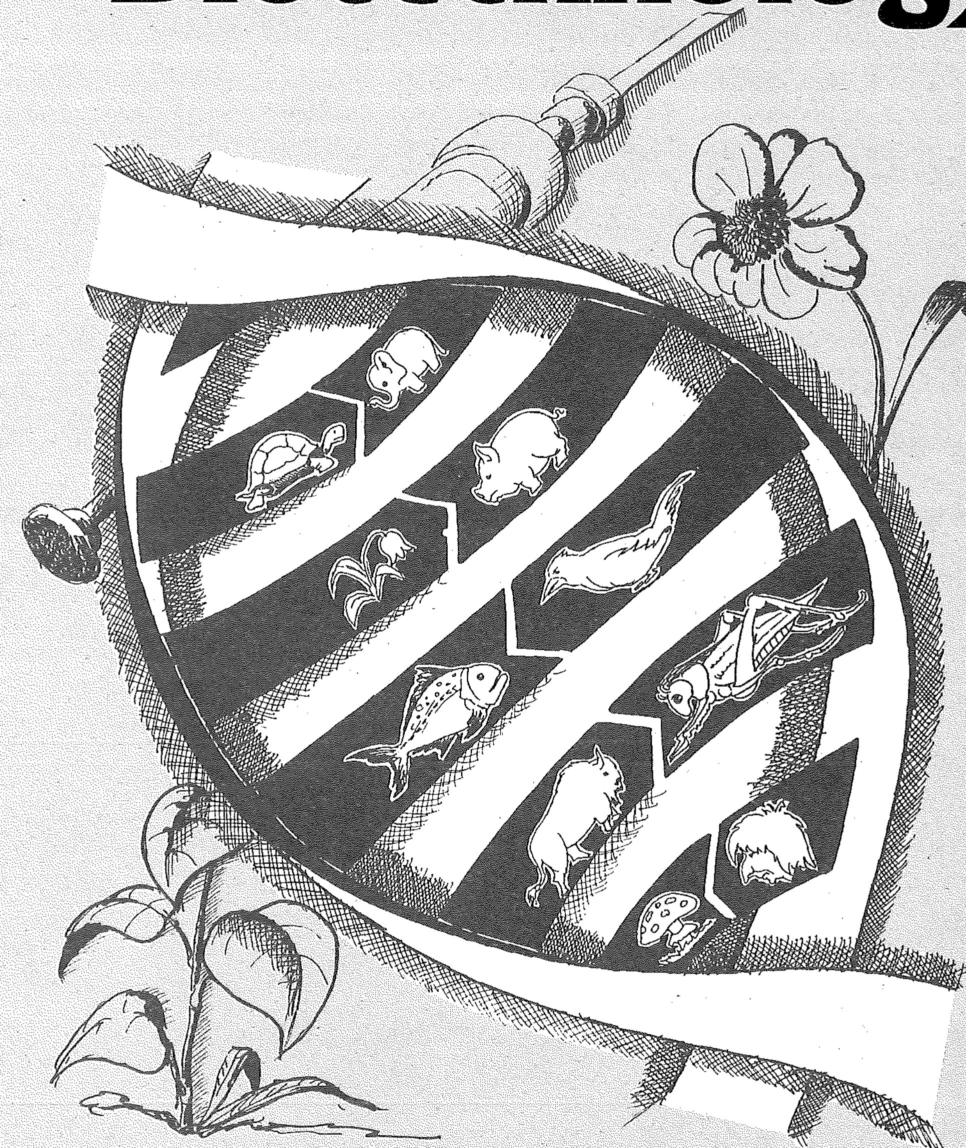

A Project of the
Canadian Institute for Environmental Law and Policy

The Citizen's Guide to Biotechnology

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About the Canadian Institute for Environmental Law and Policy

Founded in 1970, as the Canadian Environmental Law Research Foundation (CELRF), the Canadian Institute for Environmental Law and Policy (CIELAP) is an independent, not-for-profit professional research and educational institute committed to environmental law and policy analysis and reform. CIELAP is incorporated under the laws of the Province of Ontario and registered with Revenue Canada as a charity. Our registration number is 0380584-59.

CIELAP provides leadership in the development of environmental law and policy which promotes the public interest and the principles of sustainability, including the protection of the health and well-being of present and future generations, and of the natural environment.

CIELAP's Interest in Biotechnology

CIELAP has been involved with biotechnology issues for over ten years. We host conferences, publish reports and briefs, participate in consultations on regulating biotechnology products, prepare studies for government, and inform Canadians on the issues surrounding biotechnology. This citizen's guide aims to inform, raise questions and stimulate debate on a variety of concerns about biotechnology.

Dear Reader,

It was well over a year ago that CIELAP decided that there was a need for a plain language resource on the topic of biotechnology that could speak to persons ranging from students in high schools to community activists to ordinary citizens. Burkhard Mausberg, who was Project Officer with CIELAP in 1994, began the research and writing for the Citizen's Guide. When he left CIELAP in December 1994 to take up the position of Executive Director at the environmental coalition Great Lakes United, Paula Coutinho, an Environmental Youth Corps contract employee, took over. In February 1995, Maureen Press-Merkur, who had been working on another CIELAP project related to biotechnology, turned her skills and attention to the Citizen's Guide. I would like to sincerely thank Burkhard, Paula and Maureen for their contribution to the Citizen's Guide.

Many others have been involved in the production of this Citizen's Guide and they too deserve a big thank you. Penny Sanger and Brenda Rooney provided helpful comments on various drafts; Wes Murawski provided his artistic skills and produced many of the Guide's graphics; and, of course the CIELAP staff, in particular Mark Winfield, Director of Research, who supervised the research; and Greg Jenish, Project Officer with CIELAP who designed the final layout of the Guide.

None of the above mentions could have been made at all were it not for the support received from the funders of the project. CIELAP and the creators of the Citizen's Guide extend their gratitude to the Guide's funders: the Ontario Ministry of Environment and Energy, the Canadian Environmental Network's Biotechnology Caucus and the George Cedric Metcalf Charitable Foundation.

We hope that this guide will raise questions and stimulate debate on a variety of concerns about biotechnology. We welcome your comments.

Anne Mitchell
Executive Director

Toronto, May 1995

CHAPTER 1 Introduction to the Citizen's Guide

Did you know that genetic engineers have developed tomatoes that ripen slower, fish that grow faster, and hormones that increase milk production in cows? Did you know that over 1,700 tests of genetically engineered crops have occurred on Canadian soil?

Biotechnology is here and it's affecting every area of our lives. In this century, we have seen three major revolutions that have touched nearly every aspect of our lives: the chemical industry, the nuclear industry, and an explosion in the field of information and computers. The new science of biotechnology and its offshoot, genetic engineering, promise an equally profound effect on our lives. If the trend in biotechnology continues, the foods we eat, the medicines and health care we receive and the way we view and use our natural resources will never be the same.

If you are like most Canadians, you are both intrigued and concerned about the science of biotechnology and, in particular, aspects of genetic engineering. A recent poll found that most Canadians are "cautiously optimistic" about some of the benefits of biotechnology.[1] But they are also apprehensive because scientists have made discoveries in the past that have turned out to have disastrous consequences. Pesticides, for example, were developed to reduce the amount of food lost to insects. However, much of these chemicals remain in the soil and make their way into streams, rivers and lakes, affecting wildlife. Residues left on food may have long-term health effects of which, at present, we are unaware. Similar experiences have led some Canadians to the conclusion that "science and technology have made the world a riskier place to live".[2]

This Citizen's Guide explores the concerns about biotechnology and is intended to be thought-provoking as well as providing a starting point for discussion and debate. Scientists are speeding ahead with biotechnology, and our governments, both provincially and nationally, are spending enormous amounts of our tax dollars on this industry. But while they race forward, many fundamental issues have not been discussed or debated by

Historical Milestones in Genetic Engineering

Year	Event
1973	U.S. Scientists perform first genetic engineering experiment.
1977	The Canadian Medical Research Council announces laboratory safety guidelines for genetic engineering experiments.
1982	The commercial production of insulin via genetic engineering begins.
1982	First Canadian patent of a living organism is granted to Abitibi-Price.
1983	Canada's National Biotechnology Strategy to boost the Canadian biotechnology industry, is launched by the federal government.
1988	The first fourteen tests of genetically engineered crops occur on Canadian soil.
1990	Canada's Green Plan promises new regulations for biotechnology.
1994	Over 700 tests of genetically engineered crops occur on Canadian soil.
1995	The genetically engineered "Flavr Savr" Tomato is approved for sale in Canada.

Canadians, and remain unresolved.

In discussing biotechnology, we will first explain the difference between biotechnology and genetic engineering, then we will review some basic science. We'll untangle proteins, genes and chromosomes and explain why they are important and how industry is using biotechnology to create products. A glossary has been provided at the back of this guide for easy reference.

Emerging applications will also be explored, as well as ethical, environmental and social concerns arising from this technology. Finally, we will provide a few ideas about what you can do to become involved in the debate about biotechnology, how you can express your concerns to government officials, and where you can go for more information.

CHAPTER 2 Some Basic Science

Biotechnology is one of the oldest sciences known to humans. The term refers to taking any living organism and using it to produce something – using cells of yeast to make bread, beer, or wine, for example. The term is also used to describe the careful breeding of plants or animals to produce a particular, desired result. Everything from hothouse roses with unique colouring, to cows that give more meat or milk have been obtained through traditional biotechnologies. More recently, the practice of producing antibiotics or vaccines is also a form of biotechnology.

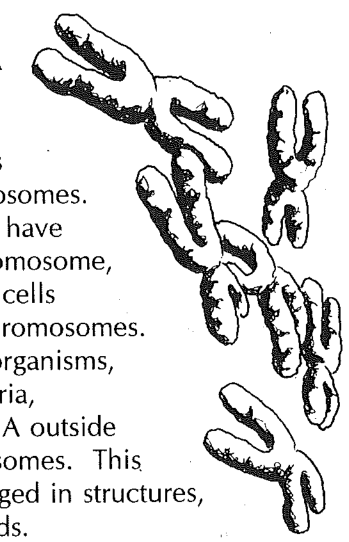
The relatively new science of genetic engineering is also part of biotechnology. This involves taking portions of cells – actual genes – and altering them in some way. In order to understand the implications of this new science, it is necessary to review some basic biology.

Genetics

It is no accident that we look like our parents. Our genetic inheritance comes from a special chemical called deoxyribonucleic acid (DNA). DNA is a string-like molecule which largely determines many cell functions.

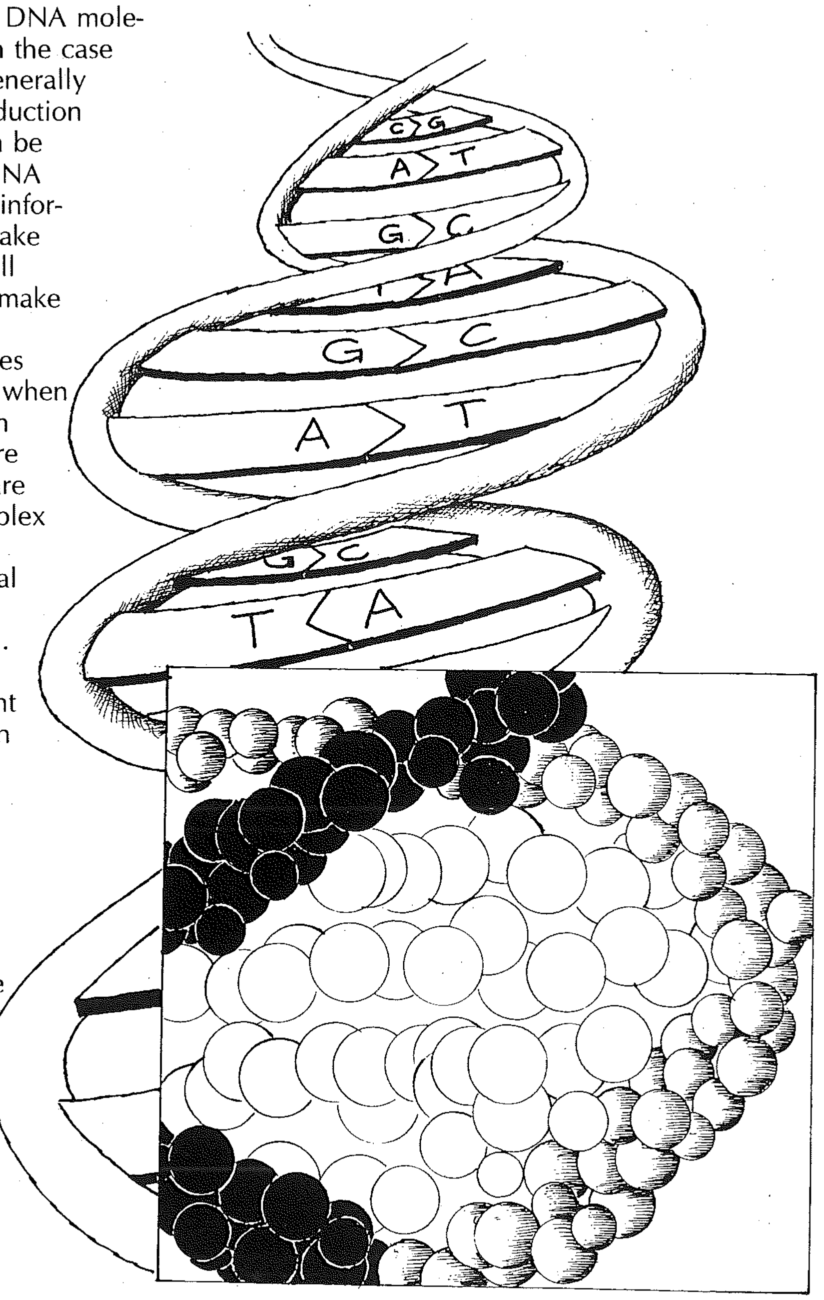
The cell is the basic building block of life. It is the smallest independent structure in organisms, able to grow and reproduce by itself. All organisms are made up of cells and there are many different types of cells. The cells in your heart, for instance, are not the same as those cells making up your liver.

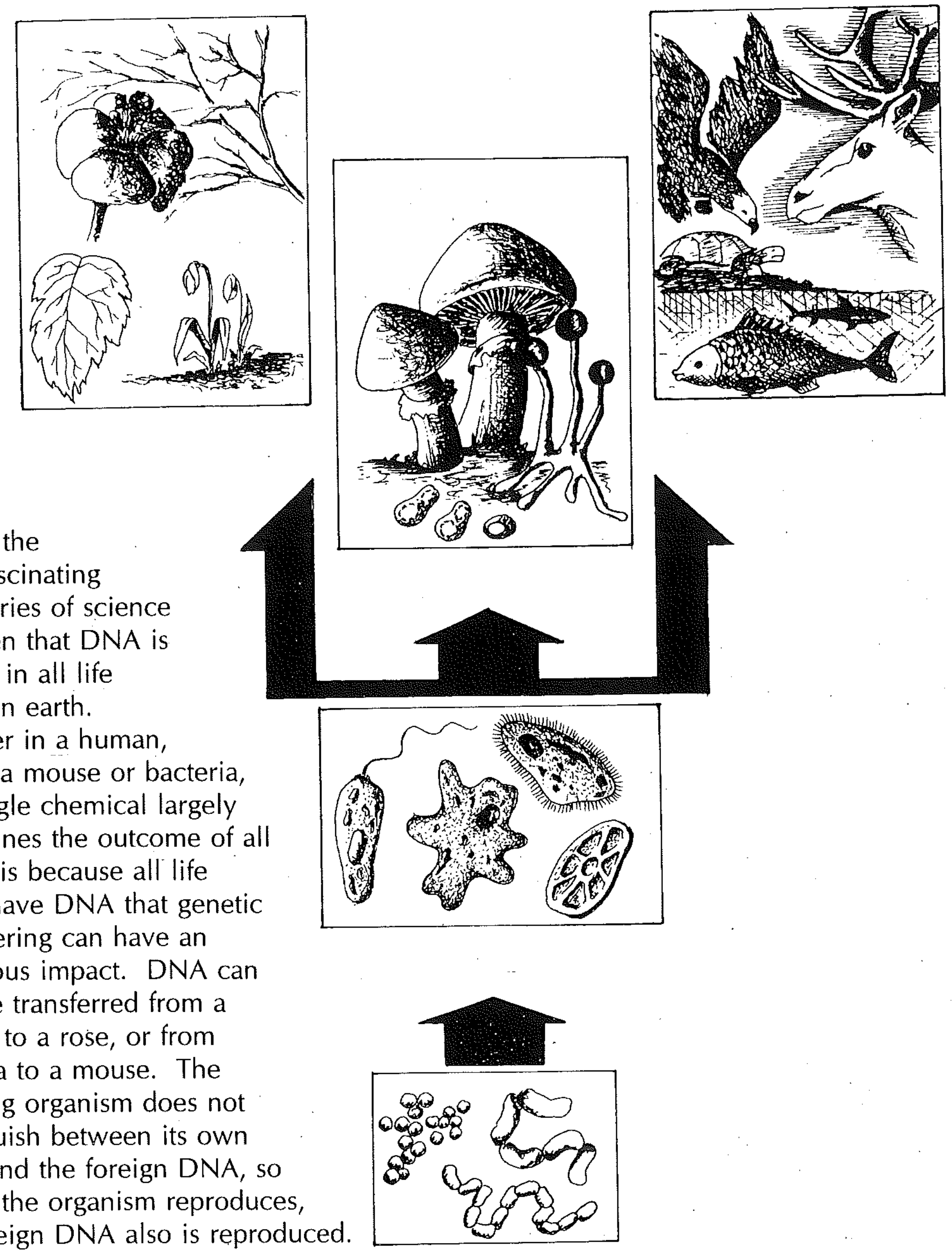
Every cell contains DNA which is organized into structures called chromosomes. Most bacteria have only one chromosome, while human cells contain 46 chromosomes. Some micro-organisms, such as bacteria, also have DNA outside their chromosomes. This DNA is arranged in structures, called plasmids.



The active portions of a DNA molecule are called genes. In the case of DNA, being active generally means ordering the production of a protein. A gene can be considered a string of DNA which contains enough information to tell cells to make a protein. It tells the cell both when and how to make the particular protein. It is worth noting that genes are able to do this only when certain conditions within the cell and organism are met, conditions which are controlled both by complex interactions within the organism and by external factors. Generally, one gene makes one protein.

Proteins are an important class of chemicals which control biochemical processes in cells. Indeed, proteins have been called the body's workhorse chemicals because they control so many functions and determine physical appearances, such as your hair colour, muscle tissue, and size. It is the combination of proteins that determine how organisms look and work.





One of the most fascinating discoveries of science has been that DNA is present in all life forms on earth. Whether in a human, a rose, a mouse or bacteria, this single chemical largely determines the outcome of all life. It is because all life forms have DNA that genetic engineering can have an enormous impact. DNA can now be transferred from a human to a rose, or from bacteria to a mouse. The resulting organism does not distinguish between its own DNA and the foreign DNA, so that as the organism reproduces, the foreign DNA also is reproduced.

2.1. Traditional Biotechnology

Prior to 1973, DNA from one species could not be inserted into another unrelated species. Instead, any changes in organisms had to be achieved by traditional techniques developed throughout the world over thousands of years. Selective breeding and more recently, mutagenesis, were used to change life and its processes.

Selective breeding could be described as a form of intentional evolution which has been vastly sped up. It involves choosing female and male organisms with particular, desirable traits and having them mate and reproduce. This is done with both plants and animals. Over many generations, this method of directed evolution can produce life-forms which are different from those normally found in nature.

Selective breeding has been used for centuries by peoples around the world to produce new and better types of a given crop or animal. Today's milk cow, for example, is a result of selective breeding: she is bigger and can produce more milk than her forerunner of only a few decades ago.

Over the past fifty years, scientists have been using a technique called mutagenesis with single-celled species. The DNA of micro-organisms is changed by applying heat, chemicals, or radiation, causing mutations (changes) in the organisms. The results of metagenesis, however, are unpredictable. The mutations might not affect the organisms and, even if the process is successful, it might not last. Similarly, these changes may not get passed on to future generations.

Products made from both these techniques have proven to be quite useful. However, with traditional biotechnology, only DNA from the same, or very closely related, species can be used. A new type of cow could only be bred from another cow. A fish could not be crossed with a tomato. This inability of different species to mix is commonly called the "species barrier" and has played an important part in evolution by creating a diversity of species, as well as accumulating genes within each species that favour their survival.

However, with genetic engineering, the species barrier has been broken. All the world's genes are now available to genetic engineers in whatever combinations may seem to be commercially useful: from fish to wheat, insects to roses, worms to humans. . . the number of potential genetic variations are seemingly endless.

2.2. Genetic Engineering

In 1973, Herbert Boyer, a researcher at

the University of California, and Stanley Cohen, a scientist with Stanford University, were the first to succeed in an experiment with genetic engineering. DNA sequences taken from a toad and a bacterium were combined, that is, "spliced" together and placed into a living bacterial cell. There, the toad DNA survived in a completely foreign environment.[3] Since this success, several different methods have been developed to splice DNA, insert DNA, and even artificially make DNA.

2.3. The Difference between Traditional Biotechnology and Genetic Engineering

The implications of these new techniques have been widely recognized since the Boyer and Cohen experiment. Compared with traditional biotechnology techniques, genetic engineering differs in several substantial ways. The overall implication of genetic engineering is that life can be designed with very specific characteristics. What is "natural" or "unnatural" is becoming indistinguishable.

Traditional Biotechnology	Genetic Engineering
Only organisms of the same species can be bred together. Only naturally-occurring, within-species DNA combinations are possible. Thus, the vast majority of the organisms created are those which could or already do exist naturally.	The DNA of organisms from different species can be combined (cross-species combination). Thus, "new" organisms can be produced which, because they possess traits not normally found within that species, do not exist naturally.
The variety of traits that can be bred for is limited to the traits that naturally exist within that species.	DNA from different species can be combined. The variety of traits that can be bred for is almost unlimited.
Traditional breeding does not have the same degree of precision, accuracy and predictability as genetic engineering. Sometimes unexpected and even undesirable results are obtained.	Although greater precision is sometimes possible when introducing traits to an organism through the transfer of specific genes, this method can also produce results which are unexpected and even undesirable.
Usually, many generations of selective breeding are required to obtain the desired results, a process which can take several years.	This method for introducing traits into a given species allows the desired product to be obtained much more quickly.

CHAPTER 3

What Has Canada Done in the Field of Genetic Engineering?

What are Canadian genetic engineers doing? Quite a lot. Researchers are focusing on areas where the Canadian economy has traditionally been quite strong - agriculture and resource industries - as well as health care. Indeed, in May of 1983, the federal government claimed that biotechnology, including genetic engineering, is a "...national priority for economic development,"[4] and it has since spent over $1 billion of public funds supporting and promoting this industry.

3.1 Biotechnology in Canada: Research and Applications

The following section provides an overall picture of biotechnology as it is being researched and in some cases, applied in Canada and elsewhere in the world.

Health Applications

Many health-related uses of biotechnology are currently being pursued. Four main research and application areas are:

- diagnosis
- drug treatments
- gene therapy
- genetic testing

Diagnosis and Treatment

Diagnosis of diseases and other physical conditions is one area in which biotechnology is already being applied and applications will undoubtedly increase. Researchers are attempting to identify genes associated with diseases,[5] and to develop treatments that, in part, rely on the body's natural ability to fight illnesses.[6]

Genetic screening is currently being done on individuals likely to have inherited a gene associated with an illness or other physical condition, or to screen developing embryos in the early stages of pregnancy. So far, the screening of individuals is usually done to alert them that they may pass on an inherited disease to their children,[7] while embryos are tested to see if they possess genes which may cause disease.

Embryos conceived through *in vitro* fertilization, that is, fertilization that has taken place outside the womb, are routinely screened prior to implantation into the mother. Only embryos which are free of genes associated with diseases or other physical conditions are implanted.[8]

As well, embryos already developing in natural pregnancies are tested for the presence of genetic diseases. Since no treatment is yet available for these conditions, this is useful only to decide whether to continue with a pregnancy or have it terminated.[9]

The genetic screening of embryos is viewed as controversial by the disabled community and women's groups, among others. Genes alone can never predict with certainty if an individual will develop a condition[10], or how severely it might be experienced. Others fear that the disabled may suffer in a society which regards certain embryos as "defective" and therefore expendable.

Additionally, while genes may exert a strong influence in causing certain disorders, in the majority of cases genes must interact with a variety of other factors before any condition becomes manifested. These disorders, referred to as multi-factorial, are much more common and include diabetes, multiple sclerosis, asthma, coronary heart disease, schizophrenia, manic depressive disorder, epilepsy and hypertension.[11]

Another important concern is the ethical and social question of who decides which genes are to be considered "defective". Although it is possible to identify diseases as being the target of research and clinical practice, it is also possible that other traits such as hair colour, baldness, or height, may come to be identified as "undesirable". Treatments for these genes may be instituted as well.

Drug Treatments

Canadian biopharmaceutical companies are currently developing and testing drugs to help treat a variety of diseases, such as osteoporosis, cancer, AIDS and hepatitis B.[12]

Aside from the development of new drugs, genetic engineering potentially allows for the unlimited production of drugs which are available in natural forms, but are difficult to produce in large quantities. This would eliminate the use of animals and provide a more steady and adequate supply of these drugs.

An example of a drug produced in this way is synthetic insulin. This substance, used to treat diabetics, was originally extracted from animal sources. Since the early 1980's, however, insulin has been produced using recombinant technology. This form of genetic engineering places the human insulin gene into bacteria, resulting in an insulin-making organism which can be replicated to produce large quantities of human insulin.[13]

However, the ease with which these substances are being produced has led to controversy. In addition to insulin, synthetic human growth hormone, or HGH, is being produced using similar methods. Originally developed to increase the stature of children who are diagnosed with dwarfism, this drug is currently being used to "treat" children who are merely somewhat shorter than average.[14]

Gene Therapy

As mentioned above, some genes which are associated with disease can be identified using biotechnology. The technology to alter these genes, and thereby cure the disease, is called gene therapy.

Two applications of gene therapy are being pursued: somatic cell therapy and germ cell therapy. Altering somatic cells, or body cells, means making changes that will only last for an individual's lifetime. The treatment of germ cells, or reproductive cells, entails altering the genes so that the changes are incorporated into every cell of the developing human. Not only is the entire genetic makeup of the new individual altered, but that of all of their descendants as well.

Many people question the wisdom of using germ line gene therapy. Individuals considering somatic cell therapy are often facing life-threatening illnesses where the choice between certain death from the disease and possible death from the treatment leads them to opt for the treatment. The same cannot be said of germ line therapy.

While both treatments could cause unintended and devastating effects, such as cancer, with germ cell therapy the effect may not show up for several generations.[15] In fact, the Royal Commission on New Reproductive Technologies, a working group commissioned by the Canadian government to report on developments related to genetic and new reproductive

SYLVIA

technologies, has called for a total ban on germ cell gene therapy.[16]

Agriculture and Food

The agricultural sector is by far one of the busiest areas of biotechnology activities in Canada, and indeed worldwide. Currently research is being done to genetically alter both crop plants and farm animals, with the major portion of research focusing on crop plants.

Crops

Genetically engineered crops are being extensively tested here in Canada. Since 1988, the number of tests carried out per year has increased from 14 to over 700 in 1994.

Field-Tests by Province (1988-1994)

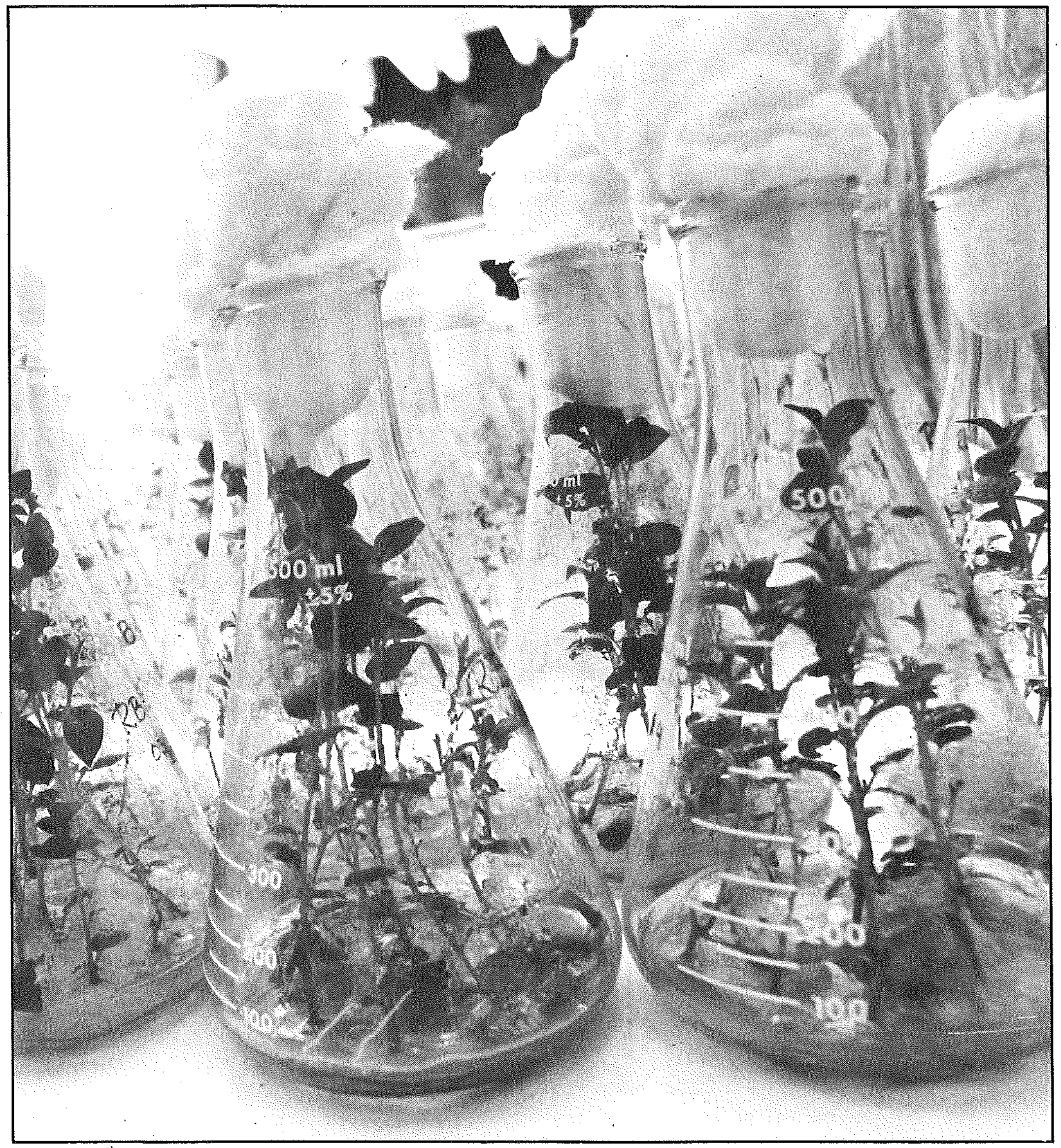
Newfoundland	0
Nova Scotia	0
Prince Edward Island	24
New Brunswick	32
Quebec	3
Ontario	236
Manitoba	349
Saskatchewan	955
Alberta	384
British Columbia	16
Total	1999

Three main types of changes are being sought through the engineering of crops: herbicide tolerance; resistance to various stresses; and the development of specific characteristics.

According to government statistics, more than 75 percent of Canadian research over the past seven years has been focused on making crops tolerant to herbicides, that is, chemical weed-killers.[17] This tolerance enables crops to survive the specific herbicide to which they have been made resistant while the weeds around them die. Thus, farmers can use stronger herbicides to kill weeds which have become resistant to other herbicides.[18] Stress resistance is also being researched so that crops can be grown in conditions which they could not otherwise tolerate. Such conditions include drought, cold, disease and insects. The development of these types of crops could be of benefit because it could increase productivity and expand the areas in which the crops could be planted.

Genetic engineering is also being done on crops to make them more commercially valuable. The "Flavr Savr" tomato, for example, developed by the American company Calgene, has had its "aging" gene altered to give it a longer shelf-life.

By far the most engineered crop in Canada is canola, a crop with an annual export market of $1.5 billion.[19] It is a form of rapeseed and is used for the



Potato plantlets growing in beakers. The plants were cultured from virus-free tissue. This process does not involve moving genetic material from one plant to another. Courtesy of Oregon State University.

production of vegetable oils and oils used in various industrial processes. It is being engineered mainly for herbicide resistance as well as for qualities which would make it a valuable industrial lubricant, and to give it a longer life when used as an oil in fast food fryers.[20]

Animals

Genetic engineering of farm animals is occurring in the following areas:

- To treat animal disease. Researchers are using genetic engineering to develop diagnostic tools to detect animal diseases, and vaccines to fight these diseases.[21]
- To enhance selective breeding and increase reproduction. One way this can now be done with cows is by splitting the embryos developed from specially chosen, high quality cows, to create several new cows from a single fertilized egg.
- To genetically engineer animals for specific qualities, such as increasing size or leanness of the animal, or to alter other characteristics such as disease resistance. This is a costly and time-consuming method which has low success rates and often produces unexpected and undesirable results.[22] Pigs genetically engineered to be bigger and leaner, for example, have suffered from various painful conditions, such as arthritis, diabetes, breathing difficulties and increased disease susceptibility.[23]

The Transgenic Diner

A Dinner of Transgenic Food
(real combinations that are now available)[24]

Soup du Jour
Flavr Savr Tomato Soup
Tomatoes that have stayed fresher while stored longer!

Appetizers

Spiced Potatoes with Waxmoth genes - no bruises on these potatoes!
Juice of Tomatoes with Flounder gene - freeze 'em and they still taste fresh!

Entrée

Blackened Catfish with Trout gene - grown faster to reach your table sooner!
Scalloped Potatoes with Chicken gene - guaranteed disease free!
Cornbread with Firefly gene - no extra cost marker genes!

Dessert

Rice Pudding with Pea gene - stays fresh longer!

Beverage

Milk from cows treated with recombinant Bovine Growth Hormone - Bessie never gave so much milk!

- To increase productivity by the administration of a genetically engineered pharmaceutical. Recombinant bovine growth hormone (rBGH), for example, has been developed to increase milk production in cows.

Fisheries

Since the recent collapse of the east-coast fisheries, the use of bio-engineered fish in fish-farming has become an attractive means to increase fish production. The federal government has identified aquaculture, or fish-farming, as an important sector of economic development for Canada.[25]

Two broad categories of genetic engineering research are being pursued in this area:

- Increased growth and reproduction of fish. Government scientists in West Vancouver, for example, have developed genetically engineered coho salmon which grow ten times faster than the normal rate in their first year. That is, the fish do not grow any bigger than they would otherwise, they simply reach their full size more quickly.[26]

- Diagnosis and treatment of diseases in fish. Antibodies are being developed, for example, to perform tests which detect the presence of disease in fish populations.[27]

Fisheries and Oceans Canada

Pest Control

Aside from using genetic engineering to develop pest-resistant crops, scientists are also developing biopesticides. These are "natural" pesticides, that is, micro-organisms such as bacteria which can be sprayed on crops to kill particular insects. The biopesticides can then replace chemical pesticides to help control pest insects in a field.

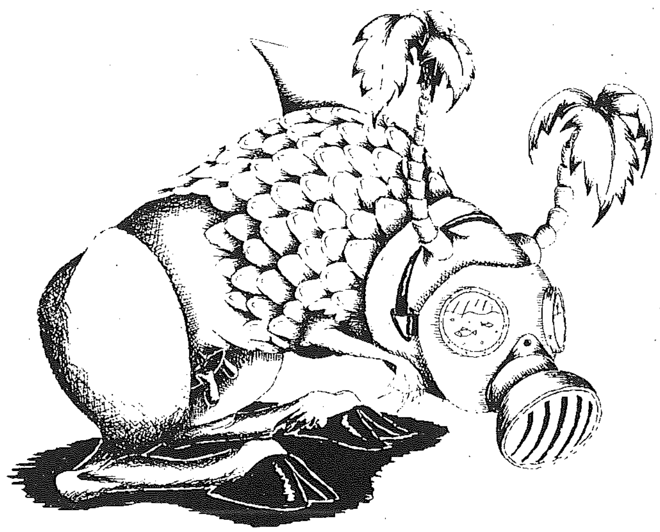
An example of a biopesticide is the bacteria, *Bacillus thuringiensis (Bt)*. This bacteria produces a toxin which has proven effective in killing mosquito and black fly larvae. It has been used successfully against both pests in Africa, Germany, and in parts of the U.S. As of 1989, there was commercial interest in developing strains of this bacteria for use against agricultural pests such as the Colorado potato beetle, as well as forest pests such as the spruce budworm and the gypsy moth.[28 29]

Industrial Applications

Mining and Petrochemicals

Research in the mining and petrochemical fields can be generally divided into three categories:

(1) Enhanced oil, gas and metal recovery. Micro-organisms may be used, for example, to indirectly help capture the remaining oil and gas in abandoned wells or to leach minerals such as copper, nickel and uranium from ores in concentrations that could not be economically extracted using ordinary methods.[30]



(2) Desulfurization of fossil fuels. It may be possible to use micro-organisms to remove sulphur, which produces pollution when fuels are burned, from coal and crude oil. The micro-organisms would "eat" the sulphur compounds and convert them into products that could be easily removed.[31]

(3) Fuel production. Researchers are working on methods to produce ethanol or methane from plants and micro-organisms.

So far, no genetically engineered organisms have been used commercially in Canada in these areas, although research is ongoing.

Waste Water Treatment

New biotechnology products such as micro-organisms may be used to speed up processes of degrading and removing toxic substances from sludge at waste water treatment facilities. Two Canadian research institutes are investigating the use of such technology for the treatment of industrial and municipal waste water.[32]

Bioremediation

The use of both genetically engineered and naturally occurring micro-organisms as a method of cleaning up pollution is emerging as a major potential application of biotechnology.[33] One possible application may be the use of micro-organisms to clean up polluted sites by making hazardous wastes or organic pollutants such as polychlorinated biphenyls (PCBs) less toxic. This approach could be used for the clean-up of oil and other chemical spills.[34]

Forestry

Given that the Canadian forest industry sold $37.6 billion of forest products in 1993,[35] it is not surprising that Canada has one of the most advanced research programs of forest biotechnology in the world.[36] In fact, scientists at the National Research Council and at Forestry Canada were the first to develop techniques to genetically engineer trees.

Biotechnology research in the forestry sector can be divided into two general categories:

(1) Pulp and paper production. Research is being done on the use of micro-organisms for bleaching paper, for degradation of tough wood components, for wastewater treatment, and for wood protection.[37]

(2) Increased tree reproduction. Canadian researchers, for example, are engineering faster-growing trees, especially conifer species, to re-generate forests that have been clear-cut.[38]

The potential economic benefits of producing fast-growing trees and effective biopesticides are tremendous. Both applications could result in a dramatic increase in yields of forest products. Nevertheless, due to the long life-spans of trees, commercial applications are at least some three to five years away.[39]

Summary

Canada's reliance on natural resources in its economy provides the main stimulus for biotechnology activities. And some of the products of biotechnological research are now leaving the laboratories and starting to enter the market. What are some of the main concerns about such activity? Is the science fully developed to prevent ecological damages and harm to the health of the public? What will be the long-term impacts? What information about any of this is available to the public?

CHAPTER 4 Concerns About Genetic Engineering

The biotechnological revolution has tremendous power and therefore gives rise to enormous social, environmental and ethical issues. While it is impossible to discuss all of the concerns in depth, some of the issues will be briefly surveyed below.

4.1. Ethical Dilemmas

The ethical questions raised by the emergence of genetic engineering and its products boggle the mind. Just consider:

- Is it right to manipulate the blueprint of life of either humans or other species?
- In making genetic alterations in humans, how do we decide what is in need of improvement? Who decides what is normal?
- Who owns genetic information? For what purposes? Is ownership of genetic information - of reproduction and life itself - right? What are the implications of this kind of ownership?
- Is it right to use animals as bioreactors to produce drugs or chemicals? Or to alter the genetic makeup of food and game animals - regardless of the cost to them - to produce in them certain qualities which we desire?
- Do we want, or need, genetically engineered food?

These questions have never been answered or even considered by the Canadian government. Little attention has been given to the ethical issues involved with the use of biotechnology. Yet the technology continues to race forward and more and more genetically engineered products are being developed.

The first step is to ask ourselves whether we have adequate information. If not, we should ask ourselves what information we need, whether we have difficulty getting it and, if so, why? When we have sufficient information, we can then ask:

The Right Questions About Technology

- What is the purpose of the technology? Does it address a legitimate need? If so, does it address the cause of the problem or just the symptoms?
- Is this technology the only way to solve a given problem or are there alternatives? What are the benefits and disadvantages of each?
- Does it improve the quality of life for humans and animals?
- What are the environmental impacts? Does the technology reduce biodiversity? Does it detract from or contribute to environmentally sustainable development? Does it increase or reduce use of non-renewable resources and harmful substances? Does it generate harmful waste either in its production or use?
- Is it safe for humans today and for our descendants?
- Does it create undue reliance on one product, thereby increasing dependence on large corporations and discouraging the use of alternatives?
- Does this technology have indirect environmental, economic, or social impacts, either locally or globally?
- Does the technology raise ethical/moral concerns?
- Who motivated the development of this technology and why? Who would benefit and who would lose the most from the development, manufacture, possible patenting, and use of this technology?
- Was this technology developed with citizen participation and/or oversight? To what degree has the public paid for development of this technology? How much will we benefit?

Adapted from: *At the Crossroads, July 1992.*

4.2. Benefits of Genetic Engineering: Real or Imaginary?

The biotechnology industry and governments have been promoting the potential benefits of genetic engineering for a long time. Almost all of their statements emphasize potential advantages: ending world hunger, increasing industrial efficiency, fighting disease, cleaning up the environment, and enhancing the productivity of forests, fisheries and farms. According to one industry specialist, biotechnology is "the story of improved food safety and food quality, lower cost food, improved human health, new jobs, products. . .[made] in primarily rural communities, decreased subsidies, decreased environmental problems, and increased sustainability."[40]

However, in taking a closer look at the applications being pursued by genetic engineers, we can see that many of these benefits are less straightforward than they first appear. Biotechnology often treats only the symptoms of much deeper problems, primarily those resulting from unsustainable development. Applications may appear to solve a problem, but as it has addressed the symptoms and not the causes, other problems will soon appear. The following serves to illustrate these problems.

Herbicide-Tolerant Crops

As seen in Chapter 3, over 75 percent of the genetically engineered crops which have been tested in Canada have been engineered to be resistant to herbicides. Indeed, almost 50 percent of the agricultural biotechnology industry's resources are directed toward herbicide-tolerance.[41]

Field Tests of Genetically Engineered Crops in Canada

Fungal resistance	2
Genetic research	1
Generation of mutants	2
Herbicide tolerance	1691
Insect resistance	82
Male sterility / restoration	212
Modified oil composition	103
Nutritional change	32
Pharmaceutical	1
Stress tolerance	25
Virus resistance	35
Other	2

A herbicide tolerant crop will be able to withstand the application of a particular herbicide while the weeds around it die. This would make herbicide-tolerant crops seem like a good development for weed control and farming in general. But critics argue that herbicide-tolerant crops do not address the primary cause of the weed problem: a lack of environmentally sustainable agricultural practices. Their opinion is based on the following:

- The use of herbicide-tolerant crops may increase the total amount of herbicides used. As only the weeds and not the crops will be killed by the herbicides, farmers are free to use either larger amounts or more poisonous varieties of herbicides. In fact, many of the herbicides for which crop tolerance is being sought are older, more toxic and remain in the environment longer than herbicides currently in use. Only herbicide-tolerant crops could survive exposure to such herbicides; crops which have not been genetically engineered would die.[42]

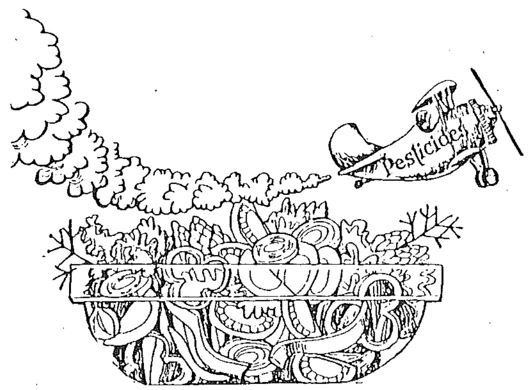
  The use of greater amounts of more toxic herbicides will increase damage to the environment: more chemicals mean more residues in the soil, in groundwater, and in streams, ponds or lakes where there is run-off from farm lands. Herbicide residues on crops may also pose serious health risks to humans, farms animals, and wildlife.

- The use of herbicide-tolerant crops will entrench a dependence on energy-intensive agricultural methods, primarily a reliance on agri-chemicals and intensive mechanical treatment of the soil. These strategies do not address the underlying causes of weed proliferation. Monoculture, the practice of growing a single crop over the same, large area year after year allows weeds to become well-established in the same area. As long as this practice continues, the weed problem will persist, and so too will the need to use herbicides.

- A more intense use of herbicides will create selective pressures which will lead to herbicide-tolerant weeds. Numerous cases have been observed in which weeds have developed resistance to the herbicides which were being used. For example, 55 species of weeds are now resistant to the triazine group of herbicides in the U.S.[43]

An alternative to this type of technology is sustainable agriculture, which relies less on technology and more on natural processes. Sustainable practices allow the land to naturally maintain its health and productivity. In this case, farmers could adopt farming methods which would naturally eliminate the weed problem, such as mixed farming (growing several different crops) and frequent crop rotation.

The following example clearly illustrates the advantages that sustainable agriculture has over high levels of technology for



Courtesy of Carol Simpson / NCAMP

weed control and increased agricultural productivity.

In 1945, the percentage of corn lost to insects was, on average, 3.5 per cent. Insecticides were not widely used at that time. Since then, the use of insecticides has increased over a thousand-fold. Interestingly, crop losses to insects have also increased, nearly four times from 3.5% to 12%. Increased insecticide use has not been accompanied by a decreased insect problem, but rather, by an increase. Why?

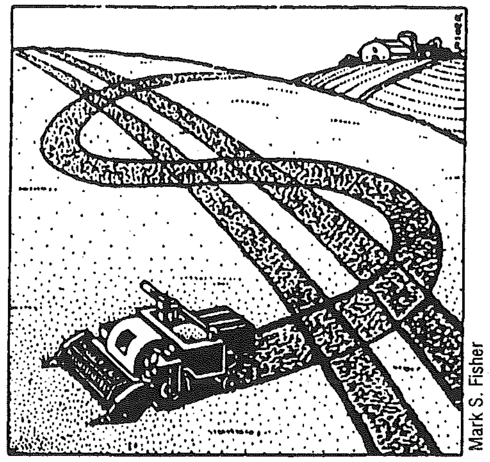
At the end of the Second World War, nearly all corn crops were rotated annually with soybeans, wheat or oats. Since then, the practice of rotating crops has been replaced with continuous corn cropping. This has intensified insect, weed and disease problems, requiring increased use of fungicides and herbicides.[44]

The use of agricultural biotechnology applications, such as herbicide-tolerant crops, not only fails to contribute to sustainable agriculture and long-term agricultural productivity, it may actually undermine efforts to farm sustainably. Time, effort and money will be directed towards biotechnological solutions and away from research and promotion of sustainable practices.

Federal expenditures from a single year (1991-1992) demonstrate this. Funding of biotechnology research for agricultural applications alone was over $26 million.[45] However, total funding for the Pest Management Alternatives Office (PMAO), the only clearly identifiable program sponsored by the federal government to support research on sustainable agricultural practices, has amounted to less than $2½ million since the program began in November of 1992.[46]

Who is in Control?

Another issue which arises from the development and sale of biotechnology products is industry control over farmers and the food production process. Through the development and sale of a series of interlocking products, such as



herbicides and herbicide tolerant seeds, biotechnology firms hope farmers will become increasingly dependant on their products in order to maintain competitive production. This will ensure a captive market for those products, resulting in increased profits for the biotechnology companies.

Most herbicide-tolerant crops are designed to be used in combination with specific herbicides, usually those manufactured by the same company that is manufacturing and selling the seeds. Monsanto, for example, is seeking approval for commercial production of canola which has been genetically engineered to be tolerant to its herbicide, 'Round Up'. In effect, companies are offering "a tailored package of their many products and services to customers and farmers on a one-stop shopping basis."[47] As the President of the American biotechnology company, Calgene, has stated:

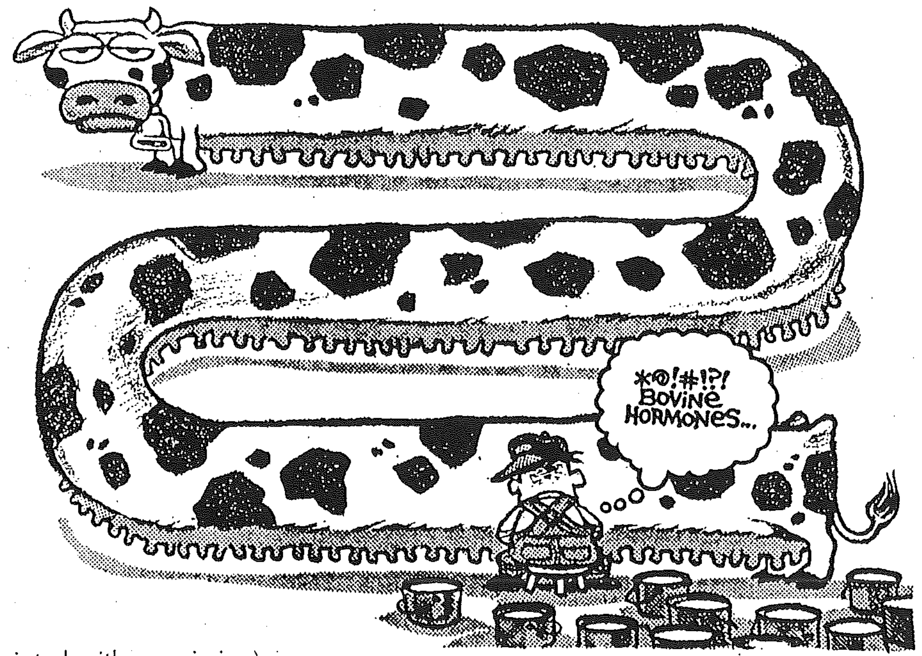
> "If you have herbicide tolerance, you're going to expand market share [for that herbicide]. If you don't, you're going to lose."

The desire of agri-business companies to gain control over the food production process, a control which will be aided by the development of biotechnology applications, is best summed up by the following words of the Vice-President of this same company:

> "Our objective is to control production with our partners from the production of foundation seed to the sale of the oil to our customers. *We want complete control*. . . The way you capture value added is selling oil -- value-added oil at a premium to customers, period. So we and our partners *will maintain complete control of the process*. [emphasis added]."[48]

Genetically Engineered Milk

Bovine growth hormone (BGH) controls several functions in cows, including that of milk production. Scientists can now produce BGH in large quantities through genetic engineering. The genetically engineered hormone, recombinant BGH, or rBGH, is injected into cows and increases their milk production by 10 to 25%.[49] Using rBGH may at first appear to be beneficial, but this application of genetic engineering could lead to many problems:



(printed with permission)

- Monsanto, the company which developed rBGH, warns on its product label that use of rBGH will result in significant increases in mastitis, an inflammation of the cow's mammary glands, reduced birth weight in calves, reduced immune defenses, and could lead to decreased fertility.
- In order to withstand the illnesses resulting from rBGH, the rBGH-treated cows must be treated with antibiotics which will then enter the

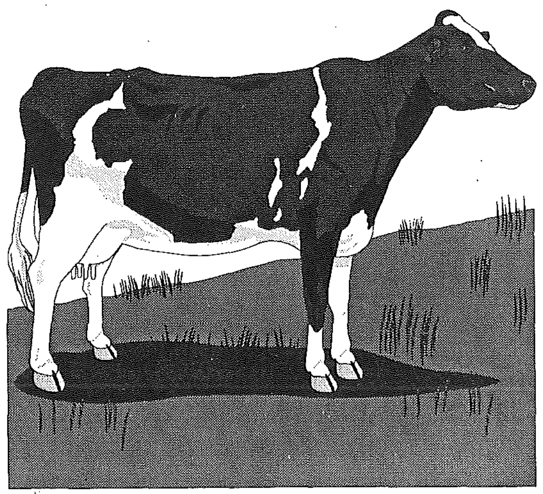
cows' milk. Since, by Canadian law, milk carrying antibiotics may not enter the milk pool, farmers may have to throw away a lot of their cows' milk.[50] Between the cost of the rBGH, the antibiotics and the wasted, unsalable milk, using rBGH may not be so profitable for farmers after all.

- If dairy farmers in Canada were to use rBGH, the country's milk production could increase by up to 20 percent. This would flood an already well-supplied market and almost certainly result in dairy farm closures. Since rBGH went on sale in the U.S. in February of 1994, farmers have suffered a drop in the price of milk of almost 12.5%, although this decrease has not yet been passed along to the consumer. American farmers with 50 to 55 cows may have already lost as much as $10,000 in a single year.[51]

- Studies in Canada have shown that consumers do not want farmers to use rBGH. There has been controversy both here and in the U.S. when milk from cows being used in rBGH trials entered the general milk pool.[52] Canadians have indicated that they are very concerned about the safety of milk from rBGH-treated cows, and 96% of those surveyed stated that they want this milk labelled.[53]

Why is rBGH being promoted? It certainly is not needed to enhance the productivity of dairy farms which are already providing all the milk which the Canadian market can consume. Nor does it help to decrease the burden which dairy farms place on the environment. In fact, it could be seen to worsen the impact. Cows on rBGH cannot graze, a feeding method which allows the land or pasture on which they feed to have a "rest" from cultivated crops. Instead, the cows must be fed special, high energy grains which are produced at a higher cost to the land.[54]

What then, is the purpose of rBGH? Biotechnology companies are estimated to have spent US$1.5 billion in developing rBGH,[55] and the potential annual profit to Monsanto from rBGH sales is US$300 to $500 million in the U.S. alone.[56]



Other Applications

Aside from the two uses of genetic engineering just discussed, critics have also questioned other proposed applications. Scientists, for example, are developing fast-growing trees to be grown on clear-cut areas. These trees will regenerate the area quickly, presumably in preparation for the next clear-cut.[57]

The ability to regenerate deforested areas more quickly may initially seem like a good application of biotechnology. By harvesting faster-growing trees, fewer areas will need to be clear-cut to obtain the same amount of wood. Thus, fewer areas will suffer from the environmental degradation and loss of biodiversity that occurs whenever an area is completely logged.

This application fails to address, however, the underlying cause of these problems: unsustainable forest management practices.

The development of faster-growing trees pays little regard to the slow and intricate process of soil formation. Genetically engineered tress could very well extract nutrients from a soil at a far greater rate than they can be replenished. In short order, the soil could be left depleted and sterile.

If forests were logged in a sustainable manner, problems with a general loss of biodiversity and related environmental degradation would begin to decrease. But the destructive practice of clear-cutting, which this application encourages, will continue to create problems in the long-term.

The development of fish that mature more quickly seems like a similar misplaced application of biotechnology. This might provide increased fish stocks for a declining fishing industry in the immediate future, but it does not address the underlying cause of the declining fish population: a federal policy of harvesting too many fish,[58] coupled with environmental degradation. Over-fishing, polluted waters, and damaged or destroyed fish habitats and feeding grounds have caused declines in fish populations which threaten the fishing industry today. Adequately combating these problems requires action. Actions, such as establishing and enforcing regulations that ensure sustainable management of the natural fish population and its habitat, would help. The use of genetically engineered, faster-growing fish, designed to survive only in fish-farms, only encourages the continuation of unsustainable practices.

Biotechnology: Concerns of People of the Third World

Multinational corporations based in the west are using genetic engineering to appropriate plant varieties from the Third World, gathering genetic materials and information in order to design crop species. These are designed to grow in any controlled environment or region in the world, thereby eliminating exclusivity of these crops to their area of origin. This new ability to grow the crops anywhere creates foreign competition for those crops.

Modified crop species are often designed to be high yielding (producing a larger volume of crops) than traditional crop species. High yields of crops only occur, however, if certain conditions are met. This often results in a dependency by farmers on expensive and harmful fertilizers and pesticides, as well as an increased use of irrigation systems which are needed to grow the modified crops. The increased level of international trade and competition between farmers who can afford to grow engineered crops are forcing poorer farmers to leave their farms and migrate to already-overpopulated urban centres.

Companies, when appropriating genetic information, often place a patent on the crop species to prevent other researchers from conducting any experiments and from obtaining any profits on the patented plant. The patents also prohibit farmers and other individuals from using the plant, unless they pay royalties. Farmers are slowly losing their livelihood to the multinationals who own the patents or can afford to pay royalties for them.

Multinationals are not only producing the genetically engineered crops but are also selling them to farmers who must borrow funds from various lending agencies to buy them. These engineered crops are creating a one-crop dependency which is leading to the loss of traditional farming and biodiversity.

Traditional farming involves planting and cultivating a variety of crop species. In Bangladesh, over 7,000 varieties of rice used to be grown, today farmers plant and cultivate only one rice variety. In addition to this severe loss in biodiversity, this leaves Bangladesh in an extremely vulnerable social and economic position to any condition that could adversely affect the crop. Because of its genetic uniformity, a single disease or pest could, in a single growing season, destroy the entire country's crop.

Biotechnology as it presently stands will have only adverse effects on peoples of the Third World. In order for biotechnology to be a beneficial part of "development" in the Third World, it must undergo serious evaluation and include, in its development and implementation, participation of the people who will be effected by its applications.

Source: The Development Education Centre, January 1995

Summary

Claims about the benefits of biotechnology by governments and proponents need to be examined carefully. We must consider that many of the applications of biotechnology are designed to treat symptoms of problems, rather than their causes. Is this the best approach?

4.3. Environmental Concerns

Biotechnology products used in agriculture, mining and petrochemical processing, waste water treatment, bioremediation, forestry and fisheries, present a number of special environmental and health risks which distinguish them from traditional technologies used in these fields. Two major areas of concern have been identified:

(a) Many biotechnology products include life-forms which can reproduce. Once released into the environment, they can spread, mutate and transfer genetic material. For this reason, biotechnology products and their genetic material will be difficult, if not impossible, to control.

(b) The technologies employed in the development of many new biotechnology products have only emerged over the last twenty years, especially recombinant DNA and cell fusion technologies. It is difficult to evaluate such products for potential environmental damage. In fact, the scientific literature reflects wide concerns regarding the lack of adequate information and methods to properly assess the environmental and health effects of the products of biotechnology.[59]

The issue most often mentioned in relation to genetically engineered species is the potential for environmental damage. The nature of the effect these species can have on the environment depends on complex interactions between genes and cells inside the engineered organism, as well as interactions between the organism and its environment.

In general, scientists believe that genetically engineered species may be less predictable than those developed by traditional techniques.[60] As of yet, there are no methods available to accurately evaluate the effects a new species will have on its environment. This lack of predictability and knowledge about the potential impact of engineered species suggests that we should be cautious about releasing such species into the environment.

Such caution is especially important because once the species are released into the environment, they can reproduce, spread and mutate and transfer their genetic material. Once released, control of these species will be difficult, if not impossible.

What are the Environmental Risks?

Despite the difficulty in assessing the potential impact of genetically engineered species on the environment, scientists have suggested that the following reactions might occur, based on what they have observed in similar situations with naturally-occurring species:

- the creation of new pests: a crop which has been genetically engineered to be salt-tolerant, for example, could escape cultivated fields and invade estuaries.

- an increase in the effects of existing pests: crop plants, for example, are capable of transferring genes over relatively long distances to related plants, some of which may be weeds.[61] Thus, traits which may be desirable in a crop plant, such as tolerance to herbicides or drought, could be transferred to weeds, making them even more difficult to control.

  The impact of what biologists call "natural selection" could also worsen the impact of existing pests. Pesticide use provides an excellent example of this. Pesticides may work effectively for a period of time, but a certain percentage of insects will develop resistances to the chemicals. As they reproduce, these insects produce an entire population that is pesticide-resistant. Numerous cases of this evolutionary process have been recorded.[62]

- harm to non-target species: genetically engineered organisms may also cause damage to other species. For instance, viruses or micro-organisms engineered to kill specific pests could also infect beneficial insects.

- disruption of natural systems and processes: disruptions could range from the replacement of a few native species to a complete change in the types of species which inhabit an area.

  The introduction of genetically engineered organisms may also cause disruptions in ecosystem processes in forests such as nutrient cycles or weather patterns. Such effects are usually very difficult to predict for an engineered species because of the number of possible interactions between the engineered species, surrounding species and various elements in the surrounding environment.

- loss of biodiversity: the term biodiversity refers to the number of species, as well as variations within species, which thrive in any given area. A loss of biodiversity could severely impair the ability of a given environment or species to successfully respond to sudden stresses, such as drought or disease. Low biodiversity could be likened to having few skills when looking for a new job in a rapidly changing job market.

- failed bioremediation: the use of naturally occurring or genetically engineered micro-organisms to clean up polluted sites may not be as beneficial as it might at first appear. While the micro-organisms may break down and thus eliminate some toxic substances, microbial degradation may create other toxins as a byproduct of this process. The microbial degradation of trichloroethylene (TCE) and tetrachloroethylene (PCE), for example, produces an even more toxic substance, vinyl chloride.[63]

- squandering valuable biological resources: the bacteria *Bacillus thuringiensis (Bt)* is currently used as a natural pesticide. Researchers, however, are genetically engineering several crops with *Bt*. This may speed up the process by which large numbers of insects adapt and become resistant to *Bt*, making the bacteria ineffective.

What do we really know about genetically engineered products?

Consider the following quotes from various scientists and writers:

> "Unfortunately, when dealing with the potential risks to biological systems, the existing data base is meager and the predictive ability of the ecological sciences is almost nil."[64]

> "Insufficient data exist to forecast environmental problems and pest outbreaks resulting from the release of genetically engineered organisms. Based on the data presented, we expect some environmental problems to occur..."[65]

> "There is no dispute that engineered organisms as a group will possess a higher degree of genetic novelty than .... naturally occurring organisms and that our environmental experience with such organisms is virtually nil."[66]

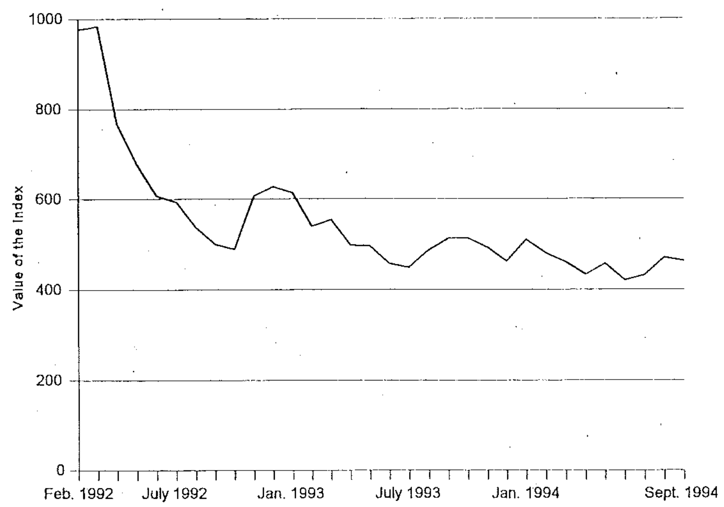
Science cannot accurately predict environmental risks. But scientific uncertainty is not new to the field of genetic engineering. From the early laboratory beginnings, molecular biologists were uncertain about the consequences of their activities.[67] They did not know what to expect from newly engineered organisms: if and how they would survive, if they would reproduce, how they would express their newly acquired traits, or how dangerous such organisms would be in a laboratory environment. This uncertainty is spreading from the lab to the fields and remains one of the more frightening elements of genetic engineering.

4.4 Economic Issues

Economists predict, based on performances so far, that biotechnology companies will continue to grow. Canadian biotechnology companies earned $550 million in sales in 1993, while their U.S. counterparts sold some US$7 billion dollars of biotechnology products.[68] Some analysts predict that by the year 2000, the North-American market for biotechnology products will reach US$100 billion.[69]

When we look at the TSE biotech index we can see, however, that it has been declining since it first started in February of 1992. In the U.S. some biotechnology stocks have dropped as much as 93% in a single year.[70] This would seem contrary to both the profitable performances exhibited thus far by biotech companies and the promising predictions made for the future. What explanation lies behind this apparent contradiction?

Although the biotech companies seem to have made profits in sales, they have also



Biotechnology Index of the Toronto Stock Exchange

spent a lot of money on the research and development of new products. In fact, for many companies the expenses have outweighed the profits. According to one source: "... all but one of the leading Canadian public biotechnology companies have yet to...have a positive net income."[71]

Due to this, investments in the biotechnology industry have fallen off. The only way for biotechnology companies to begin to recover is through large scale sales of products. Many of these companies are anxious, therefore, to get almost any product on to the market which can generate a profit.

In Canada, these financial pressures have led the industry to lobby Canadian governments for access to public funds to facilitate the research, development and commercialization of products. The biotechnology industry has already received well over $1 billion from the Canadian government and the industry-based Biotechnology Council of Ontario (BCO) is currently asking the provincial government for tens of millions more.[72]

The need of the industry to generate profits from products has also led it to pressure governments for "favourable" regulatory conditions for product approval. An example of this is again provided by the BCO report. The Council emphasized the importance of *balancing* the needs of the industry against the safety

The National Biotechnology Strategy and Federal Expenditures on Biotechnology

Since 1983, federal activity related to biotechnology seems to indicate that biotechnology has, indeed, become a national priority for economic development. One obvious indication of this has been the government's establishment in 1983 of the National Biotechnology Strategy, or NBS. The main objectives of the strategy have been:

- to identify areas where biotechnology could benefit Canadian businesses and the public;
- to ensure a number of people are trained as potential employees in the field;
- to support communication among researchers in various disciplines as well as the industry; and
- to attract biotechnology companies to Canada.

To help meet these objectives, the government set up the National Biotechnology Strategy Fund. Money from this fund is distributed annually to various government departments and agencies for activities related to biotechnology. So far, government spending on biotechnology through this fund alone has been on the order of $110-$120 million. The NBS plans to spend an additional $30 million over the next two years.

The government has generously promoted biotechnology outside of the NBS Fund as well. Additional expenditures have risen steadily from around $10 million in 1982-1983 to over $200 million in 1991-1992. The total amount of federal taxpayers' money spent so far, including NBS expenditures, comes to well over $1 billion.

of the public and the protection of the environment.[73] These statements seem to imply that the biotechnology industry wants the government to be less stringent with regulations so that products will be approved more easily for commercialization.

Impact on Universities and Public Interest Research

The research and development of biotechnology applications raises important economic issues regarding universities and research done for public benefit.

One issue regards the assessment of the potential ecological, health-related, ethical, social, and economic impacts of biotechnology applications. This type of public-interest research has traditionally been done at universities. Because of recent funding changes, however, this is beginning to change. In the past, universities received their funding for research projects from the government. Now, however, they are often required to have private funding for a project in order to receive money from the government for it. As a result, more and more university research is being directed towards finding commercial applications of biotechnology. With biotechnology companies providing the private funding, fewer and fewer resources and researchers are available to conduct much-needed public interest research into the impacts of biotechnology on the environment and human health.

In addition, there is the question of public subsidization of biotechnology companies' research. As noted earlier, research for the development of products for biotech companies is being done increasingly at universities. While some of the funding for this research does come from the companies, much of the cost is covered by the university which is supported by public tax dollars.

An example of this is provided by Centres of Excellence, research centres which have been established at universities and teaching hospitals across the country. As partnerships of government, industry and research institutions, these centres are at least partly publicly funded and should, therefore, be conducting research for the benefit of the public. They are, however, under pressure to provide research and development benefits to their corporate, or industry partners.[74]

Finally, the issue arises of "ownership" of the findings of industry-sponsored university research. Traditionally, university research findings have been published and thereby made accessible to the public. This practice is in keeping with universities' traditional mandate: to create and disseminate knowledge for public benefit. The findings of industry-sponsored research, however, are often not made public or are only made available after some kind of ownership

protection has been acquired, at which time a special license must be purchased in order to have access to the findings. This happens because the results of such research are typically techniques or products to be used or marketed by the sponsoring biotech company and this information is therefore regarded as "trade secrets".

This phenomenon raises at least two important questions. First, should universities as publicly funded institutions be conducting research for the development of marketable applications? Such research is clearly not creating and disseminating knowledge for the public benefit. Second, when such research does occur, who should "own" the findings - the university? the individual researchers? or the sponsoring biotech company?

4.5. Who owns Genetic Engineering and its Products?

Patent protection on living organisms raises a number of disturbing questions. Can someone actually own or appropriate the blueprint of life? Is genetic material from plants, animals or humans a public or private resource? How does one define a "novel life form" and give it patent protection?

What is a Patent?

A patent is basically a contract between an inventor and society. The inventor makes information about the invention public, and in turn society grants the inventor the exclusive right to profit from the invention for a certain amount of time, usually 15 to 20 years. By conferring on an inventor the right to exclude others from profiting from an invention for a certain period of time, patents are meant to promote innovative research.

To receive a patent, the invention must meet three specific eligibility criteria:

- novelty - the invention must be new;
- utility - the invention must be useful; and
- non-obviousness - the invention must represent a real advance which might not have been achieved without the inventor's creative insight.[75]

What are the Concerns about Patenting Genetically Engineered Life?

There have been a variety of concerns expressed about patenting living organisms. The following two case studies may serve as an illustrations of some of these concerns.

The first patent for a living organism was given in the U.S. in 1873 to Louis Pastor. He received a patent on some yeast strains that were "free from organic germs." Institutionalized mechanisms for protecting plant varieties did not begin until the 1930's. In 1980, genetically engineered microorganisms became patentable according to US Supreme Court law. Five years later the US Patent & Trademark Office ruled that plants previously protected only by plant breeders' rights, qualified for consideration under industrial patent laws. Two years later in 1987 the same office ruled that patents could also be obtained on genetically engineered animals.

Patent Problem Woes: Case Study 1

In October of 1992 the American Patent Office set a precedent by granting a full species patent to the firm Agracetus Inc. for cotton. Sixteen months later, this same American company was granted a similar patent by the European Patent Office for soybeans. These patents gave Agracetus' parent company, the transnational chemical company W.R. Grace, full control over the techniques used to genetically alter these plants as well as all genetically-transformed cotton or soybean varieties. The significance of this is that *all* genetically altered cotton or soybean plants were considered the "intellectual property" of W.R. Grace, regardless of what any other company might have done to develop additional techniques to alter the plants. According to Dr. Geoffrey Hawtin, Director-General of the International Plant Genetic Resources Institute:

> "The granting of patents covering all genetically engineered varieties of a species. . .puts in the hands of a single inventor the possibility to control what we grow on our farms and in our gardens. At a stroke of a pen the research of countless farmers and scientists has potentially been negated in a single, legal act of economic high jack."[76]

The initial granting of these patents on cotton alarmed researchers, farmers, governments, and biotechnology industries and businesses around the world. First of all, these patents effectively stop any further biotechnology research and development of patented crops. No time or money can be invested in product research and development if the company can not profit. A likely result of this decreased research will be that fewer improvements will be made to these important crops. Farmers will be adversely affected by patents because they are prohibited from saving any seeds from genetically engineered crops at harvest time. This ancient practice ensures that farmers will have seeds for replanting. By being forced to sell the entire crop, these same farmers must buy seeds for the

following growing season; a considerable hardship in many developing countries.[77]

As of December 1994, the American cotton patent was revoked. Various groups are fighting to have the patent revoked in Europe as well.

The Human Genome Project: Case Study 2

In 1988 the Human Genome Organization was launched as a 15-year, internationally cooperative effort to map and decipher the 100,000 genes and 3 billion chemical compounds that form the complete genetic instructions for a human being. At that time, the proposed cost of the project was estimated to be in the range of US $3 billion.

Corporations stand to profit from this project when any genes are identified which might be of medical or biological importance. Once a valuable gene is located and isolated, genome companies can mass-produce it using the techniques of biotechnology. Although no single product has yet come to the market from this research, patent claims on genes and gene fragments are being made at an astonishing rate.

During 1991 and 1992, two researchers for the lead agency in the project, the US National Institutes of Health, filed for patents on nearly 7,000 partial DNA sequences for human genes. These patent claims, however, were rejected by the US Patent and Trademark Office for failing to meet the standard patent criteria; they were judged as not useful, not new, and too obvious.

"I never imagined people would patent plants and animals. It's fundamentally immoral, contrary to the Guaymi view of nature, and our place in it. To patent human material...to take human DNA and patent its products... that violates the integrity of life itself, and our deepest sense of morality.'"

Isidro Acosta, President of the Guaymi General Congress.

The US Patent Office had granted previous applications for patents on human genes, but only for those whose full sequences and functions were known. The NIH application, however, was for patents on only partially characterized genes, where no biological function had been identified. This ruling by the US Patent and Trademark Office is controversial and has not stopped private corporations from continuing to file for patents on partial sequences, although none have yet been granted.

In February of 1994, the National Institute of Health in the U.S. announced that is was dropping all efforts to patent human gene segments, as did the British Medical Research Council.[78]

> Jeremy Rifkin, founder of the American Foundation on Economic Trends has commented:
>
> *In one regulatory stroke, the U.S. Patent Office reduced the entire animal kingdom to the lowly status of a commercial commodity indistinguishable from microwave ovens. They're patentable products. And they gave away the entire gene pool – from eggs to insects – to the private sector. To the multinationals. To the genetic engineering corporations. To the researchers who patent the products. To the pharmaceutical and chemical companies. Did you and I debate this question?*

Another important issue which arises out of these and other patent claims is the recognition of, and compensation for, previous work that contributed to the development of the patented products. The starting material for genetically engineered food crops is generally taken from publicly available collections of plants, seeds and plant parts that have been collected from around the world. A good portion of these collections may be comprised of plants or organisms that have been developed by indigenous peoples over many generations. The knowledge of these people has therefore contributed greatly to the development of products, biopharmaceuticals being the most common example, which when patented, earn substantial amounts of money. Indigenous people receive no compensation for their contributions other than, perhaps, the opportunity to buy expensive, genetically engineered seeds or products which were developed from their knowledge and taken from their lands.[79]

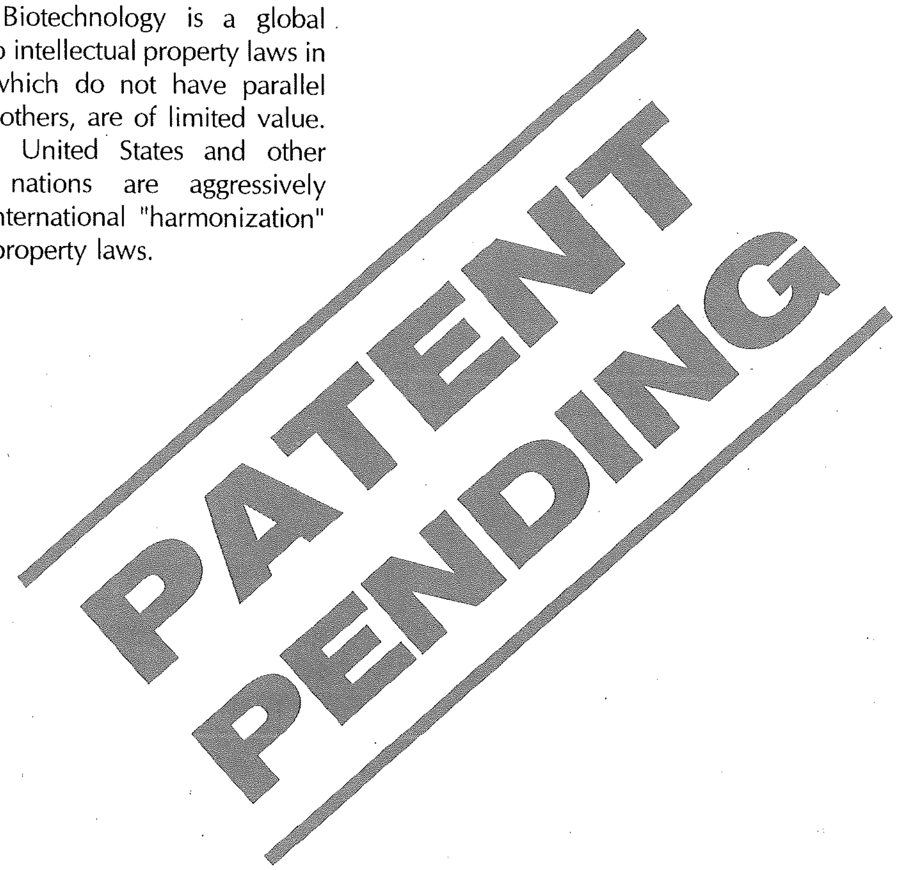
What is the Current Status of Patents in Canada?

In 1982, A Canadian pulp and paper company, Abitibi-Price, received the first Canadian patent for a living organism, a culture of fungal species adapted to biodegrade a chemical waste.[80] It is worth noting that the patent claim for the fungal culture was initially rejected on the grounds that living organisms were not considered patentable subject matter. The rejection was later overturned.[81] From then on, patents have been available for all types of micro-organisms, including commonly known ones such as yeasts, molds, bacteria, and viruses.

The situation is different with plants and animals, which Canadian law considers to be a higher life-form and therefore cannot be patented. However, as a result of the TRIPS agreement (Trade Related Aspects of Intellectual Property) which was signed at the Uruguay round of the General Agreement on Tariffs and Trade (GATT), all participating GATT countries, including

Canada, are required to adopt minimum intellectual property standards for plants and micro-organisms over the next five to fifteen years.

While each government has been given room for flexibility in designing the plant patent laws, the fact remains that under the terms of this agreement Canada must begin to allow patenting of plants.[82] Although GATT member countries are not required to allow patenting of animals, it is entirely conceivable that this requirement will not be far behind. Biotechnology is a global industry, and so intellectual property laws in one country which do not have parallel recognition in others, are of limited value. Therefore, the United States and other industrialized nations are aggressively lobbying for international "harmonization" of intellectual property laws.



CHAPTER 5

The Regulation of Genetic Engineering and it Products

A recent survey conducted by Optima Consultants and funded by Industry Canada, found that 42% of all those interviewed felt that "science and technology have made the world a riskier place to live" and 41% of respondents stated that Canadians should not "accept some risks from biotech developments [even] if it strengthens the economy".[83]

Canadians surveyed felt that public participation in decisions about biotechnology is extremely important: 71% felt that the government should "conduct a public information campaign about biotechnology", while 81% of those interviewed stated that the government should "consult the public on regulating biotech products and uses".[84]

It is clear that Canadians want to be involved in decision-making about biotechnology. This is justified for at least two reasons:

(1) Canadians will bear the risks associated with the use of biotechnology. These risks include the health-related risks involved with the personal purchase and use of biotechnology products, and the larger economic, environmental, social, and ethical risks associated with both personal use and commercial use of biotechnology.

(2) Canadians help to fund the development of biotechnology through their tax dollars which support various research programs and the National Biotechnology Strategy (NBS).

Governments and businesses have offered limited avenues for public participation which have been widely criticized as being fragmentary and incomplete. Indeed, many non-governmental organizations argue that citizens have not been able to stop a single environmental release of bio-genetic products.

In fact, the federal government is in an awkward position as both promoter and regulator of biotechnology applications, particularly in agriculture. In 1991, for example, Agriculture Canada field-tested more genetically-engineered crops than private industry.

Additionally, there is no assurance that commercial food-products arising from biotechnology will be labelled as products of genetic engineering. Monsanto, the company which produces the growth hormone designed to increase milk production in cows, has successfully argued to the U.S. Food and Drug Administration that milk containing rBGH is not substantially different from other milk, and therefore should not be labelled.

With the range of applications being developed, there is virtually no aspect of human activity which will not be affected by the modern age of biotechnology. Therefore, it is impossible to list all regulatory aspects for all products of this new industry. Instead, this section will examine the overall principles used for regulating bio-genetic products.

Canadians have some very strong opinions about the biotechnology industry and government regulation. The following is drawn from a survey conducted in 1994:

Level of Agreement With Statements Regarding Governments' Role in Biotechnology

	Agree %	Neutral %	Disagree %
Protect the safety of workers in biotech industries	87	8	5
Determine the safety of biotech products	87	8	4
Enforce regulations on activities in biotech	84	10	5
Consult the public on regulating biotech products and uses	81	13	5
Conduct a public information campaign about biotechnology	77	14	9
Assess the benefits of biotech	76	16	7
Be involved in the ethical aspects of biotechnology	75	16	8
Educate the public by offering seminars on biotechnology	74	16	9
Financially support biotech research in companies	37	33	29
Develop biotech products for commercial purposes	33	28	37

Source: Optima Consultants: Understanding The Consumer Interest In The New Biotechnology Industry. Nov 1994.

Which Level of Government has Control?

Since the Constitution does not address genetic engineering and biotechnology, both the provincial and federal governments have certain responsibilities over genetic engineering. The federal government is generally responsible for the *control and licensing* of biotechnology products, while the provincial focus is on the safe *application and use* of such products.[85]

Because of the overlap among the governments and departments, there are approximately 17 different federal and 46 provincial agencies which have some regulatory mandate over biotechnology.[86]

In December of 1990, the Government of Canada released its "Green Plan" outlining its environmental agenda for upcoming years. In this plan the federal government committed itself to a national regulatory regime to address the environmental risks of the biotechnology industry. This national regulatory regime was to include both national standards and codes of practice to prevent problems arising from accidental or deliberate releases of genetically-engineered micro-organisms, and regulations requiring notification of new products of biotechnology prior to their environmental release or introduction to the market.[87] The federal government set 1995 as the deadline to fulfil these obligations.

Here is an outline of the regulatory regime which the government promised in its Green Plan. In summary, regulatory activity occurs at the federal level and is based on four principles:

(1) the use of existing laws and regulations rather than the development of new ones;

(2) the regulation of each product separately;

(3) the use of a risk-assessment approach; and

(4) leaving all decisions regarding the value or need for products to the marketplace.

Critics say this approach of safeguarding Canadians from genetic engineering is fundamentally flawed for a number of reasons including:

- most of the laws which the government proposes to use to regulate biotechnology products were drafted long before the emergence of genetic engineering techniques and make no provision for dealing with its products;

- many of the laws under which the government proposes to regulate biotechnology products, such as the *Seeds Act*, contain no clear legal authority for the evaluation of potential impacts on human health or the environment;[88]

News Release

Federal Government Agrees on New Regulatory Framework for Biotechnology

OTTAWA, Jan. 11, 1993 – Federal regulatory departments have agreed on principles for a more efficient and effective regulatory framework for Canadian biotechnology.

These principles will ensure the practical benefits of biotechnology products and processes are balanced against the need to protect the environment, human health and safety. They will be the basis of a federal regulatory framework for biotechnology that:

- maintains Canada's high standards for the protection of the health of workers, the general public and the environment;
- uses existing legislation and regulatory institutions to clarify responsibilities and avoid duplication;
- continues to develop clear guidelines for evaluation of products of biotechnology which are in harmony with national priorities and international standards;
- provides for a sound scientific database on which to assess risk and evaluate products;
- ensures [that] both the development and enforcement of Canadian biotechnology regulations are open and include consultations; and
- contributes to the prosperity and well-being of Canadians by fostering a favourable climate for investment, development, innovation and adoption of sustainable Canadian biotechnology products and processes.

The goal of the regulatory framework is to minimize environmental risks while fostering competitiveness through timely introduction of biotechnology products to the marketplace.[89]

- the evaluative criteria which the government proposes to use have a very narrow scope; they are focused on issues of efficacy and the direct effects of products on human health and the environment. Questions regarding cumulative effects of commercial scale use are excluded, as are any issues related to the value or of purpose biotechnology products; and
- the existing laws provide for little or no citizen participation in the decision-making processes.

In addition, many have been critical of the government's use of a risk-assessment approach rather than a precautionary, or risk-prevention approach to the regulation of biotechnology products. Risk-assessment and precautionary approaches to regulation are fundamentally different and have very different implications.

A risk-assessment approach assumes that products are "innocent until proven guilty." Regulatory action cannot be taken unless there is firm proof of a potential to cause harm to human health and the environment. A precautionary model, on the other hand, considers an activity "guilty until proven innocent." Activities must be shown to be safe before they can proceed.

CHAPTER 6

What Should be done about Genetic Engineering and its Products?

The federal government's framework for the regulation of biotechnology has been criticized by many environmental, agricultural, labour, public health, social justice and animal welfare organizations. These groups have been particularly concerned about to aspects about the framework: 1) the federal government's use of a risk assessment, as opposed to a precautionary approach in the regulation of biotechnology; and 2) the failure of the regulatory system to consider the long-term environmental, health, ethical, social and economic implications of emerging biotechnology products.

The critics have argued that the following principles should guide Canada's laws and policies regarding biotechnology:

Environmental Sustainability

The regulation of biotechnology must favour sustainable and ecologically-sound industrial and agricultural practices. It could do so by containing certain criteria that products or processes would have to meet before they could be developed and/or marketed. These criteria would require that products and processes contribute to environmentally sustainable practices and that they address the causes and not just the symptoms of problems related to industry, agriculture, or the environment in general.

Protection of Biodiversity

The use of genetically engineered organisms and processes must not destroy or endanger biodiversity.

Promotion of Socio-Economic Equity

The regulation of biotechnology and its products should not enable one party to benefit at the expense of another. Instead, it should encourage equitable gain for all parties involved, on both local and global levels. The regulations should not allow the development and marketing of biotechnology that creates a dependency situation between the consumer and the supplier in which alternative products or practices are eliminated.

Protection of Animal Welfare

The well-being of animals must not be

compromised by research or applications of biotechnology. For example, biotechnology applications which make livestock produce more or grow leaner but cause the animals to experience discomfort or pain should not be allowed.

Reforming Canada's Biotechnology Regulations

In September 1994 a coalition of more than fifty environmental, labour and public health organizations proposed major revisions to the federal government's approach to the regulation of biotechnology products, as part of their submission to the House of Commons Standing Committee on Environment and Sustainable Development, regarding the review of the *Canadian Environmental Protection Act*.[90] The coalition recommended that biotechnology be evaluated in light of the following questions:

- What are the product's biological and ecological characteristics? What are the product's direct, indirect, long-term, and cumulative effects on human health and on the environment, including its impact on biodiversity? If this information is not available or if there is uncertainty about what is known, then the product should not be allowed to enter the environment.

- What is the purpose of the product? Is it really necessary, does it address legitimate needs? Or does it address the symptoms instead of the causes of a problem?

- How effectively does it work? Does it do what it says it's going to do?

- Are there alternatives to the proposed product available which are not based on biotechnology, and which are, cheaper, safer and more effective?

In addition, the coalition proposed that the public be given opportunities to participate in decision-making about biotechnology. This could occur by making sure that people are informed of tests in their communities, that they have access to the information used to evaluate biotechnology products, that they can participate directly in evaluating and approving products, and that they can appeal decisions with which they do not agree. Finally, the coalition argued that biotechnology companies should be held fully responsible for any damage caused by engineered products.

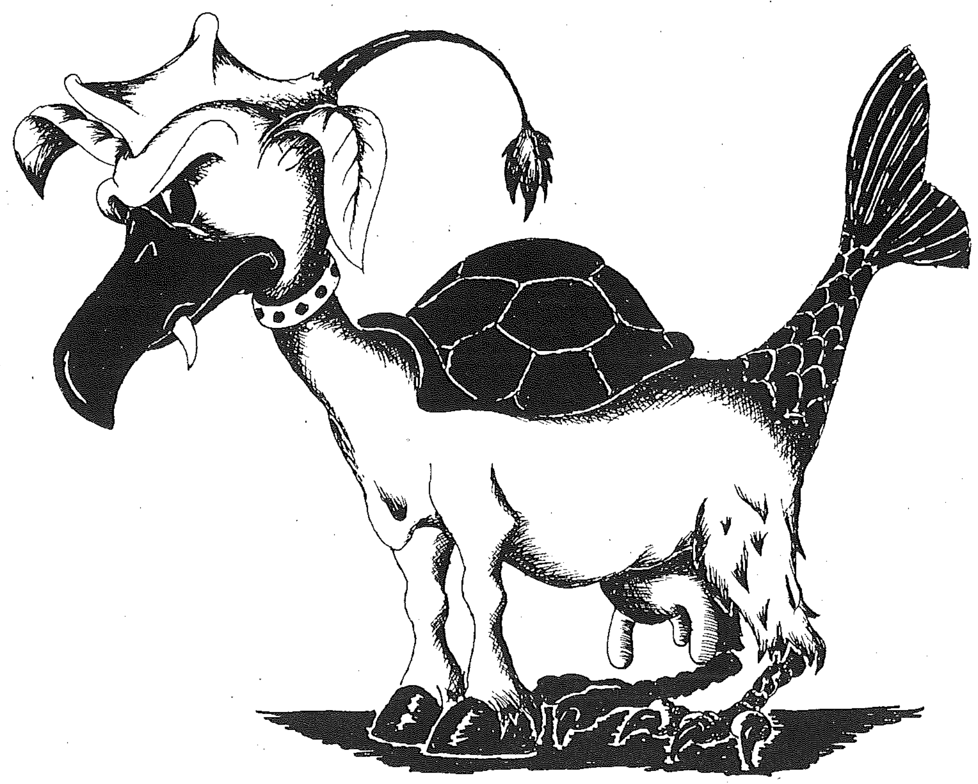
The House of Commons Standing Committee on Environment and Sustainable Development is expected to table its report on the reform of the *Canadian Environmental Protection Act* in June 1995. The Act may be amended as a result of the Committee's report.

An Overview of Federal Laws and Agencies for Biotechnology*

Biotechnology Products/Organisms	Relevant Laws and Regulations	Applicable Agencies
Animal pathogens, veterinary biologics, animal products and byproducts	*Health of Animals Act* and Regulations	Agriculture Canada
Feeds and feed additives	*Feeds Act* and Regulations	Agriculture Canada
Fertilizers / supplements	*Fertilizers Act* and Regulations	Agriculture Canada
Foods and food additives	*Food and Drugs Act* and Regulations	Health and Welfare Canada
Medical devices	*Food and Drugs Act* and Regulations	Health and Welfare Canada
Pest control agents	*Pest Control Products Act* and Regulations	Agriculture Canada, Health and Welfare Canada
Food and drugs	*Foods and Drugs Act* and Regulations	Health and Welfare Canada
Plant pests	*Plant Protection Act* and Regulations	Agriculture Canada
Plants / seeds	*Seeds Act* and Regulations	Agriculture Canada
Consumer products	*Hazardous Products Act* and regulations; *Consumer Protection Act*	Health and Welfare Canada, Consumer and Corporate Affairs
Chemical products	*Canadian Environmental Protection Act* and Regulations	Environment Canada, Health and Welfare Canada
Other Products (pollution control, mineral leaching, chemical residue destruction, waste disposal, novel uses not elsewhere covered)	*Canadian Environmental Protection Act* and Regulations	Environment Canada, Health and Welfare Canada

* Adapted from: Government of Canada, Bio-Tech Regulations - A User's Guide (Ottawa: Industry, Science and Technology Canada, Agriculture Canada, Environment Canada, Health and Welfare Canada, Labour Canada, 1991)

What happens if....?

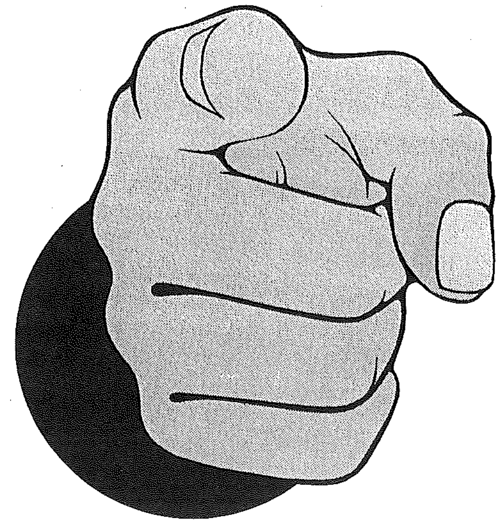


What happens if genetically engineered products in the environment or in work areas cause damage? Who is responsible, who pays, how much, who decides?

If we can say who or what caused the harm, but it was perfectly legal to use or release the genetically engineered product, who would be considered responsible? Who would be held accountable, and to what degree, if the engineered organism mutated and then caused damage? If the organism was released in one country but caused damage in another, who would be held responsible then?

CHAPTER 7

What Can You Do?



If certain aspects of genetic engineering are giving you the shivers, there are a number of things you can do. First, inform yourself. Read some of the materials listed below. Tell your friends and family. Then become active and get involved.

Tell your grocery store that you won't buy food that is genetically engineered. Tell the dairy farm association that you don't want them to use the hormone BGH. You can contact the Dairy Farmers of Canada to find out where your milk comes from, at:

75 Albert Street, Suite 1101,
Ottawa, Ontario, K1P 5E7
(613) 236-9997

Ask that no genetically engineered food be included in the products that they sell.

Write your federal MPs and Ministers. Tell them you want stringent laws to regulate genetic engineering. Also, ask them to make sure that all food that is genetically engineered be labelled as such.

Here is a sample letter to Jean Chrétien:

The Right Honourable Jean Chrétien
Prime Minister
House of Commons
Ottawa, Ontario
K1A 0A6

Dear Mr. Chrétien:

As a Canadian taxpayer, I am writing to express concern about the regulation of genetic engineering and the labelling of genetically engineered foods.

While genetic engineering may offer some potential to benefit our lives, there are many social, ethical, economic and environmental issues which must first be considered. I am requesting, therefore, that the Canadian government impose stringent laws to regulate biotechnology in order that these issues be wisely dealt with.

I would also like to request that laws be established for the labelling of food that has been genetically engineered, should such products enter the market. As consumers, we should have the right to choose whether or not to purchase such products. This choice can only be made if genetically engineered foods are clearly labelled.

I look forward to your response.

Sincerely,

Copy the letter to the relevant government ministers:

The Honourable Sheila Copps
Deputy Prime Minister and Minister of the Environment
Room 509-S, Centre Block
House of Commons
Ottawa, ON K1A 0A6

The Honourable Ralph Goodale
Minister of Agriculture and Agri-Food
Room 175, East Block
House of Commons
Ottawa, ON K1A 0A6

The Honourable John Manley
Minister of Industry
Room 356, Confederation
House of Commons
Ottawa, ON K1A 0A6

The Honourable Diane Marleau
Minister of Health
Room 256, Confederation
House of Commons
Ottawa, ON K1A 0A6

Write to the agencies listed below. Ask for information, input into the decisions to be made, and how the agencies will address your concerns.

<u>Agriculture and Agri-Food Canada</u>

Veterinary Biologics: Associate Director, Veterinary Biologics and Biotechnology, Animal Health Division, Health of Animals Directorate, Agriculture and Agri-Food Canada, 3851 Fallowfield Road, Nepean, Ontario, K2H 8P9.

Livestock Feeds and Fertilizers: Feed or Fertilizer Section, Plant Products Division, Animal and Plant Health Directorate, Agriculture and Agri-Food Canada, 59 Camelot Drive, Nepean, Ontario, K1A 0Y9.

Pest Control Products: Pesticide Directorate, Agriculture and Agri-Food Canada, 2323 Riverside Drive, SBI Building, Ottawa, Ontario, K1A 0C6.

Plants and Crops: Seed Section/Plant Products Division, Animal and Plant Health Directorate, Agriculture and Agri-Food Canada, 59 Camelot Drive, Nepean, Ontario, K1A 0Y9.

Health Canada

Drugs and Cosmetics: Chief, Drug Regulatory Affairs Division, Drugs Directorate, Room 139, Health Protection Building, Health Canada, Ottawa, Ontario, K1A 0L2.

Food and Food Additives: Chief, Food Regulatory, International and Interagency Affairs Division, Food Directorate, Health Protection Building, Health Canada, Ottawa, Ontario, K1A 0L2.

Medical Devices: Chief, Legislative and Regulatory Processes, Environmental Health Directorate, Environmental Health Centre, Health Canada, Ottawa, Ontario, K1A 0L2.

Environment Canada

All Products not Covered by other Departments: Chief, Biotechnology Centre, Commercial Chemicals Division, Environment Canada, 351 St. Joseph Blvd., Ottawa, Ontario, K1A 0H3.

Here is a sample letter to the Department of Agriculture and Agri-Food Canada:

(Again, make sure your MP and the Minister of Agri-Food and Agriculture gets a copy of your letter.)

Director
Seed Section
Plant Products Division
Animal and Plant Health Directorate
Agriculture and Agri-Food Canada
59 Camelot Drive
Nepean, Ontario
K1A 0Y9

To whom it may concern:

I am writing in regards to the use of biotechnology in the production of seeds and plants for agricultural use. I am concerned about the negative effects which genetically engineered crops might have on the environment, the economic welfare of farmers, and the health of humans and animals who consume these crops. Consequently, I would like to request the following:

First, I would like to receive any information you have on genetically engineered crops in Canada. I would like to be kept updated on both the development of new crops and the field-testing of these crops. As well, I would like to be informed of changes in the regulations which govern the development, marketing and use of these crops;

Second, I would like to know how I can partake in the decision-making process with respect to these issues. As a concerned Canadian, I would like to have the opportunity to participate in decisions which will affect the environment, the economy and the food that comes to my table.

Please send any information to the above address. I look forward to receiving your reply.

Sincerely,

CHAPTER 8

Where to go for More Information

There are a number of good books which are available through a library or book store. Also, various groups and organizations have information about genetic engineering. Here is a selection of resource materials you can look for and organizations you can contact.

Printed Materials

B. Belcher and Geoffrey Hawtin. *A Patent on Life: Ownership of Plant and Animal Research,* (Ottawa: International Development Research Centre, 1991).

The Crucible Group. *People, Plants and Patents: The Impact of Intellectual Property on Trade, Plant Biodiversity, and Rural Society,* (Ottawa: International Development Research Centre, 1994).

J. Doyle. *Altered Harvest,* (Toronto: Penguin, 1985).

M. Fox. *Super Pigs and Wondercorn: The Brave New World of Biotechnology,* (New York: Lyons & Burford, 1992).

R. Goldburg, J. Rissler, H. Shand, and C. Hassebrook. *Biotechnology's Bitter Harvest: Herbicide-Tolerant Crops and the Threat to Sustainable Agriculture,* (Washington, D.C.: Biotechnology Working Group, 1990).

A. Kimbrell. *The Human Body Shop: The Engineering and Marketing of Life,* (San Francisco: Harper Collins Publishers, 1993).

B. Kneen. *From Land to Mouth: Understanding the Food System,* (Toronto: NC Press Limited, 1993, Second Edition).

M. Lappe. *The Broken Code: The Exploitation of DNA,* (San Francisco: Sierra Club Books, 1984).

M. Mellon and Jane Rissler. *Perils Amidst the Promise: Ecological Risks of Transgenic Crops in a Global Market,* (Cambridge, MA: Union of Concerned Scientists, 1993).

Science Council of Canada. *Genetics in Canadian Health Care,* (Ottawa: The Publications Office/Science Council of Canada, 1991).

Vandana Shiva, *Monocultures of the Mind: Perspectives on Biodiversity and Biotechnology,* (London: Zed Boods, 1993).

E. and A. Stwertka. *Genetic Engineering,* (Toronto: Franklin Watts, 1989).

D. Suzuki and P. Knudtson. *Genethics: The Ethics of Engineering Life,* (Toronto: Stoddart, 1988).

Vermont Biotechnology Working Group. *Biotechnology: An Activists' Handbook,* (Vermont: VBWG, 1991). Available by sending $2 to Rural Vermont, 15 Barre Street, Montpelier, VT, 05602, U.S.A.

The Ramshorn is a newsletter looking at food policy issues with many articles on genetic engineering. Brewster Kneen, 125 Highfield Rd., Toronto, Ontario, M4L 2T9, (416) 469-8414.

Organizations

The Alliance For Public Wildlife has information on the use of biotechnology in game-ranching. 2428 Capitol Hill Crescent NW, Calgary, Alberta, T2M 4C2, (403) 289-5740, fax: (403) 284-5928.

The Biotechnology Caucus of the Canadian Environmental Network. The Biotechnology is a collection of groups including farmers, environmentalists, unionists, lawyers, animal welfare activists, and others, interested in genetic engineering. Canadian Environmental Network, P.O. Box 1289, Station B, Ottawa, Ontario, K1P 5R3, (613) 563-2078.

The Canadian Environmental Law Association (CELA) in Toronto has a public library which contains information on various aspects of biotechnology. CELA, 517 College Street, Suite 401, Toronto, Ontario, M6G 4A2, (416) 960-2284, fax: (416) 960-9392.

The Consumers' Association of Canada/Alberta - National Food Committee has information on recombinant bovine growth hormone (rBGH). 7403-15th Avenue, Edmonton, Alberta, T6K 2T3, (403) 462-1129.

The Council of Canadians, which monitors federal government policy and the activities of transnational corporations, has information on rBGH. 904-251 Laurier Avenue, West Ottawa, Ontario, K1P 5J6, (613) 233-2773, fax: (613) 233-6776.

The Environmental Law Centre in Edmonton also has information on the legal issues surrounding biotechnology. 10350-124th St. Suite 201, Edmonton, Alberta, T5N 3V9, (403) 482-4891.

The Feminist Alliance on New Genetic and Reproductive Technologies. This organization has information on issues surrounding the use of biotechnology / genetic engineering for reproductive purposes. 150 Montgomery Avenue, Toronto, Ontario, M4R 1E2, (416) 537-4991.

The Humane Society of Canada is concerned about the welfare of animals in Canada Their work often involves using biotechnology on animals. 347 Bay Street, Suite 806, Toronto, Ontario, M5H 2R7, (416) 368-0405.

The Organic Growers of Canada also have information on genetic engineering and its role in organic food production. P.O. Box 6408, Station J, Ottawa, Ontario, K2A 3Y6.

The National Farmers Union. The Union, which works specifically for agricultural policies, has information on rBGH. Box 450 Douglas, Ontario, K0J 1S0, (613) 649-2733, fax: (613) 649-2709; or 250C 2nd Avenue South, Saskatoon, Saskatchewan, S7K 2M1, (306) 652-9465, fax: (306) 664-6226.

The Rural Advancement Foundation International (RAFI) has information on the patenting issues surrounding biotechnology. Suite 504, 71 Bank St., Ottawa, Ontario, K1P 5N2, (613) 567-6880, fax: (613) 567-6884, E-mail: Web:rafican.

The Tatonka Foundation has information on biotechnology and appropriate technologies. Contact: Mia Benjamin-Robinson, 10741 71st Avenue, Edmonton, Alberta, T6E 0X5, (403) 436-6738.

The Toronto Food Policy Council maintains files on agricultural aspects of biotechnology, with a particular emphasis on rBGH. 277 Victoria Street, Room 203, Toronto, Ontario, M5B 1W1, (416) 392-1107, fax: (416) 392-1357, E-mail: fpc@web.

Union of Concerned Scientists. 26 Church Street, Cambridge, Massachusetts, USA, 02238, (617) 547-5552 or 1616 P Street NW, Suite 310, Washington, DC, USA, 20036, (202) 332-0900.

Videos

The New Creation

This video produced by the Humane Society of the United States, explores the ethical, economic and environmental ramifications of genetic engineering biotechnology, as well as the risks and benefits of applying this technology in agriculture and medicine. It can be purchased for US$ 20 from the Humane Society of the United States, 2100 L Street, NW, Washington, DC, USA, 20037.

Seeds of Change

This film produced by the International Development Research Council can be purchased for $22 from Carlton Productions, P.O. Box 5813, Maryville Depot, Ottawa, Ontario, K2C 3G6.

The following films are produced by the National Film Board of Canada (NFB). Many NFB films are available at your local library. NFB films are also available from the NFB library in Toronto, located at 150 John Street, Toronto, M5V 3C3, (416) 973-9110. There are also other NFB outlets across Canada from which the films could be rented/borrowed. To find out where the nearest outlet is, call the following 1-800 numbers: in Ontario, 1-800-267-7710; in Quebec, 1-800-363-0328; in Atlantic Canada, 1-800-561-7104; and in Western and Northern Canada, 1-800-661-9867.

Discussions in Bioethics

This video program consists of eight short dramas designed to stimulate discussion of values and ethics in relation to modern medical technology.

Making Perfect Babies

This is about the new reproductive and genetic technologies.

Perspectives in Science

This series of one-hour interactive videos is designed to foster lively discussion and learning on science and technology issues.

The Technological Stork

This is an informative documentary on the topical medical, social, and personal issue of *in vitro* fertilization.

CHAPTER 9

Glossary

Antibiotic A specific chemical substance that is used to fight infections, usually bacterial infections. Antibiotics can by produced naturally using micro-organisms, or synthetically.

Antibody Protein produced in animals in response to the presence of an alien protein.

Bacterium Any of a large group of single-celled, microscopic organisms with a very simple cell structure. Some manufacture their own food, some live as parasites on other organisms, and some live on decaying matter.

Biochemical The product of a chemical reaction in a living organism.

Biodegrade To break down by the action of living organisms.

Biodiversity The diversity or variety that exists within a natural environment, in terms of both the types of species present and the amount of variety which exists within each species. Biodiversity depends upon genetic diversity (see below).

Biotechnology The application of science and engineering on living organisms or their parts or products to make or modify a product.

Cell The smallest structural unit of living organisms that is able to grow and reproduce independently.

Chromosomes Thread-like components in the cell that contain DNA and proteins. Genes are carried on the chromosomes.

Culture A cultivated growth of cells or whole living organisms under laboratory conditions.

Deoxyribonucleic acid (DNA) The molecule that carries the genetic information for most living systems which through many steps can help to determine the structure, function and development of an organism. DNA can replicate itself and is passed from generation to generation.

DNA sequence The order of the subunits in a DNA molecule. This order determines what function if any, a segment of DNA will have.

Double helix A term often used to describe the structure of double-stranded DNA, a structure which consists of two spiralling strands of DNA wound around one another.

Ecosystem A term used to denote a natural area with respect to all that it contains (e.g. geological features, plants, animals) and all the processes which occur within it (e.g. climate, nutrient transport, water movement, reproduction).

Genes The basic units of heredity; the segments of DNA/chromosome which are functional (versus the segments which appear to have no function). Some genes direct the making of proteins, while others serve to regulate the activity of other genes.

Genetic diversity The variety that is present within a given species with respect to the genetic make-up of the individual organisms. The more genetic differences that exist from organism to organism, the greater the genetic diversity of the species.

Gene transfer The use of genetic or physical manipulation to introduce foreign genes into cells in order to achieve desired characteristics in offspring.

Genetic engineering A technology used to alter the genetic makeup of living cells in order to make them capable of producing new substances or performing new functions. This is done by deliberately inserting, removing or altering individual genes.

Genome The genetic information contained in one complete set of chromosomes.

Growth hormone A hormone that helps to regulate growth in animals.

Heredity The transfer of genetic information from parent cells to offspring.

Hormone A chemical that acts as a messenger within the body, relaying instructions to stop or start certain bodily activities. Hormones are synthesized in one type of cell and then released to direct the function of other cell types.

Hybrid The offspring of genetically dissimilar parents, such as a new variety of plant or animal that results from the cross-breeding of two different existing varieties, or a cell formed by fusing two unlike cells as in the production of monoclonal antibodies.

Insulin A hormone that stimulates cell growth via glucose uptake by cells. Insulin deficiency leads to diabetes.

In vitro fertilization Fertilization which occurs in an artificial system as opposed to within a living organism.

Mutagen A substance that induces mutations (see below).

Metagenesis The act of causing a mutation in the genetic material of an organism; physical or chemical means may be used to

cause mutations for the purpose of changing the capabilities of an organism.

Mutation A change in the genetic material of a cell; specifically, a change in the DNA sequence which can in turn, alter the original function(s) of the DNA.

Patent A limited property right granted to inventors by government allowing the creator of a new invention the right to exclude all others from making, using, or selling the invention unless specifically approved by the inventor, for a specified time period. In return the inventor gives the government a disclosure about the invention.

Pathogen A disease-causing organism.

Plasmid A small circular form of DNA that carries certain genes and is capable of replicating independently of chromosomal ("regular") DNA. Plasmids, as well as some viruses, can be used to carry new DNA into a cell.

Proteins A large class of molecules of which there are many types. Proteins carry out a number of different functions essential for cell growth and reproduction.

Recombination The process of creating recombinant DNA (see below).

Recombinant DNA (rDNA) The DNA formed by combining segments of DNA from different types of organisms.

Replication (of DNA) New synthesis of DNA by copying from pre-existing DNA. The new, or replicated DNA, is an exact copy of the original DNA.

Species A level in the classification system for living creatures. A group of closely related, structurally similar individuals that are capable of successfully interbreeding.

Toxin A substance in some cases produced by disease-causing micro-organisms, that is poisonous to other living organisms.

Transgenic Used to describe an organism engineered to contain DNA from different species; made via recombination.

Vaccine A preparation from a disease-causing bacterium or virus, or parts of such organisms, that is used to confer immunity against the disease that the organism causes. Vaccine preparations can be natural, synthetic, or derived by recombinant DNA technology.

Vector The agent (ie. plasmid or virus) used to carry new DNA into a cell.

Virus A submicroscopic organism that contains genetic information but cannot reproduce itself. To replicate, it must invade ("infect") another cell and use parts of that cell's reproductive machinery.

13. Biotechnology Council of Ontario. Enabling Biotechnology. A Strategic Plan for Ontario, (Toronto: Biotechnology Council of Ontario, 1994), p. 27.

14. See, generally, A. Kimbrell. The Human Body Shop: The Engineering and Marketing of Life, (San Francisco: Harper, 1993), chap. 11.

15. David Suzuki and Peter Knudtson, *Genethics*, (Toronto: Stoddart Publishing), 1990 (Revised Edition), pp. 179-181.

16. Royal Commission on New Reproductive Technologies. Proceed With Care, Volume 2, (Ottawa: Canada Communications Group - Publishing, 1993), pp. 942-945. See recommendations 269, 270 and 271 in particular.

17. Values were obtained from government field trial information for the years 1988-1994, compiled by the Plant Biotechnology Office of Agriculture Canada, Food Production and Inspection Branch, Nepean, Ontario.

18. R. Goldburg, J. Rissler, H. Shand, and C. Hassebrook. Biotechnology's Bitter Harvest: Herbicide-Tolerant Crops and the Threat to Sustainable Agriculture, (Washington, D.C.: Biotechnology Working Group, 1990), p. 43.

19. National Biotechnology Advisory Committee. National Biotechnology Business Strategy: Capturing Competitive Advantage for Canada, (Ottawa: NBAC, 1991), p. 35.

20. Personal communications, Brewster Kneen, author of The Rape of Canola, From Land to Mouth and other publications on food systems.

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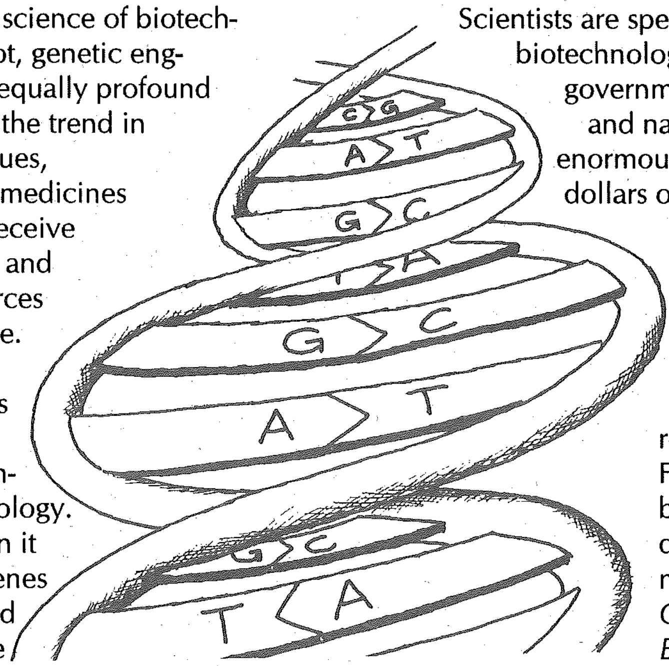
Why a Citizen's Guide on Biotechnology?

Biotechnology is here and it's affecting every area of our lives. In this century, we have seen three major revolutions that have touched nearly every aspect of our lives: the chemical industry, the nuclear industry, and an explosion in the field of information and computers. The new science of biotechnology and its offshoot, genetic engineering, promise an equally profound effect on our lives. If the trend in biotechnology continues, the foods we eat, the medicines and health care we receive and the way we view and use our natural resources will never be the same.



The Citizen's Guide is a thought-provoking exploration of the concerns about biotechnology. In illuminating fashion it untangles proteins, genes and chromosomes and explains why they are important and how industry is using biotechnology to create products. Emerging applications are explored, as well as the ethical, environmental and social concerns arising from this technology.

Scientists are speeding ahead with biotechnology, and our governments, both provincially and nationally, are spending enormous amounts of our tax dollars on this industry. But while they race forward, many fundamental issues have not been discussed or debated by Canadians, and remain unresolved. Find out how you can become involved in the debate about biotechnology with *The Citizen's Guide to Biotechnology*.

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