MANAGING BIOLOGICAL RISK

with an emphasis on risks associated with biotechnology

Opinions expressed in this report are those of the contractor, not necessarily those of Emergency Preparedness Canada or the Government of Canada

This report was published to foster discussion and encourage initiatives to reduce biological risks and improve emergency response measures.

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SECTION 1

1.0 INTRODUCTION

The purpose of this report is to identify and describe those biological risks of which Emergency Preparedness Canada (EPC) should be aware. Of specific interest are those associated with the research into and application of biotechnology.

A broad definition of biotechnology *is the use of organisms (and their products) for industrial, agricultural, or medical purposes*.[1] In the context of this report, the legislated definition of "biotechnology" is contained in the Canadian Environmental Protection Act[2]:

> …biotechnology means the application of science and engineering in the direct or indirect use of living organisms or parts or products of living organisms in their natural or modified forms.

Biotechnology is, therefore, both a science and an art, since it involves such practices as raising crops for consumption (e.g., wheat), crafting products for use (e.g., beer), and obtaining materials for use (e.g., penicillin). The tools of biotechnology include such traditional practices as cross-breeding and selective breeding as well as rapidly evolving techniques such as recombinant DNA and cell fusion.

In the last 25 years there have been rapid advances in the science of genetics. Geneticists now understand the structure of genetic material and the mechanisms of genetic transmission from generation to generation well enough to allow them to manipulate organisms in ways that were previously not possible. Genes that produce specific chemicals can now be moved from place to place within a genome, from cell to cell, and even from one organism to another. The resulting technology is genetic engineering - only one facet of biotechnology.

In its broad interpretation, biotechnology offers the promise of many benefits, including:

- cheap ways to produce large quantities of hormones, drugs, and chemicals;

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[1] United Nations Industrial Development Organization, 1990. An International Approach to Biotechnology Safety, Vienna.

[2] R.S.C. 1985, Chapter 16.

- improvements over time in the qualities of crops (production, disease resistance, pesticide resistance, nutritional value);

- detoxification of pollutants; and

- prevention of genetic diseases.

Hence, as a rapidly evolving branch of science, biotechnology poses both incredible opportunities and potential and unforeseen risks to human health and the environment. There is, moreover, continuing scientific controversy over the nature and extent of the risks presented by research into and application of biotechnology, particularly with respect to genetically engineered organisms.

Also included is an overview of Canadian legislation and international protocols which govern the employment of measures to address these risks. In addition, this report identifies and describes Canada's emergency response mechanisms which would be expected to come into play following a biological accident or deliberate terrorist activity.[3] The deficiencies in these response mechanisms are then identified and recommendations are offered toward their resolution.[4]

1.1 Report Structure

This report consists of seven sections, including the Introduction - Section 1. The discussion of biological risks is facilitated by a review of the legislative framework that addresses the response to these risks. Therefore, the Canadian legislation and guidelines which exist to control biotechnology are identified in Section 2. In addition, the international legislation and protocols that affect Canada or of which Canada is a part are also noted.

In Section 3, the various types of biological risk of which EPC should be aware are identified and described.

In Section 4, the emerging field of biotechnology is overviewed and its potential risks

[3] For the purposes of this report, it may be assumed that a biological accident constitutes a hypothetical event such as a spill of anthrax germs in a public setting.

[4] Please note that the opinions expressed in this report are those of the contractor and not necessarily those of Emergency Preparedness Canada.

identified.

In Section 5, deficiencies in Canada's biological risk response capabilities are identified. These deficiencies hinder the emergency response capabilities of the Canadian organizations that would be charged with responding to a biological accident. Hence, identification and descriptions of such deficiencies are necessary first steps toward assuring effective emergency response measures to biological risks.

Section 6 contains the report's main conclusions and Section 7 contains recommendations directed at mitigating biological risk. These recommendations are directed at resolving the deficiencies cited in Section 5.

Information for this report is derived from a literature search and from interviews with experts in the field of microbiology and biotechnology. A listing of documents sourced and individuals interviewed is provided in Annexes II and III respectively.

1.2 Perspectives on Biological Risk

There are two broad categories of biological risk that can be identified: the risk to the environment and public health and the risk to those who work with the biological sciences, including biotechnology. The former refers to the deleterious effects that may be experienced upon accidental or intentional release of harmful organisms into the environment. With respect to the latter, the advent of biotechnology has led to concerns over the potential exposure of biotechnology employees to biological agents in the workplace. While voluntary regulations have been in place for some time (since the mid 1970s) for the control of exposure to biological agents (microorganisms, animal and plant cells) in the research laboratory, only recently have such guidelines been developed that are applicable to commercial scale uses of biological agents. Beyond the normal scope of provincial occupational health and safety legislation and the federal Hazardous Products Act[5], there is little *legally enforceable* legislation to directly regulate the use of biotechnology in the workplace. Debate continues on the adequacy of protection for Canadian workers involved in the handling, manufacturing, or using of biotechnology products and biological agents.

Judgments of the inherent risks of a pathogen are made on the basis of such factors as the severity of the disease it causes, the routes of infection, and its virulence and infectivity. In addition, the time from which an organism is introduced into an

[5] R.S.C. 1985, Chap.H-3.

environment to the time it has caused significant damage or poses a serious threat, is also an important variable in risk assessment. For example, while the introduction of Dutch elm disease has had disastrous consequences, it took many years for these consequences to be manifested. By the time the risk was generally recognized, it was too late to stop its progress. Thus, as with many microbial invasions, an emergency response in this example would have been effective only if the risk had been quickly identified and aggressively countered during its incipient stages.

Judgment of biological risk severity should take into account the existence of effective therapies; possibilities for immunization; the presence of vectors; quantity of agent and whether it is indigenous to Canada; possible effects on other species, including plants; or possible economic effects.[6] It should be noted that the risks associated with biotechnology are only one facet of biological risk. Indeed, as is demonstrated in this report, many of the biological risks with which society may increasingly be forced to contend are those of natural origin. The present evolution of many bacterial pathogens toward antibiotic resistance is an example.

As previously noted, with respect to risks posed by biotechnology to the environment and public health, there is a general lack of agreement among scientists on what these risks are and what should be done to address them. On one hand, arguments are raised that with uncertainty as to what constitutes biotechnological risk, the science should advance under only the strictest of conditions. For example, the Pure Food Campaign, an organization based in Washington that opposes biotechnology in foods, claims that the long-term effects of biotech products in foods is uncertain and should simply not be used. Bovine somatotropin (BST), the agriculture industry's first commercial product, is a case in point. BST is a genetically engineered hormone that allows cows to produce 10-25 percent more milk. Alternatively, the proponents of biotechnology speak not only to the lack of evidence suggesting biotechnology has ever harmed health or the environment, but also to the fact that many organisms, especially livestock, have been intentionally and safely modified over the millennia through selective and cross-breeding techniques.

The following statement to the U.S. Congress succinctly expresses the prevailing view of the risks associated with genetic engineering:

> The testimony presented to the Subcommittees (on Investigations and Oversight) indicated that predicting the specific type, magnitude, or probability of

[6] Medical Research Council of Canada and the Laboratory Centre for Disease Control, Health Canada, Laboratory Biosafety Guidelines, 1990, p.11.

> environmental effects associated with the deliberate release of genetically engineered organisms will be extremely difficult, if not impossible, at the present time. This is principally the case because no historical and scientific data base exists concerning the behavioral characteristics of genetically engineered organisms in the environment and no standard ecological methodology for predicting the outcome of an exotic introduction currently exists. In addition, as experiences with naturally occurring organisms have demonstrated, it is possible to make only an imprecise estimate, at best, of the effect that an organism may have on the environment. Nevertheless, the testimony indicated that it would be possible to devise procedures to produce generalized estimates of the probability of environmental damage by, and survival and growth of, a genetically engineered organism, although specific risk assessment may not be achievable.[7]

Despite these uncertainties, over the past 15 years the initial fears about the possible risks associated with biotechnology have generally diminished. More specifically, it appears that there is a prevailing view among experts in the field of biotechnology, including those in the federal government, that there are no special risks beyond those inherent in the materials being used. Notwithstanding this perspective, there is also a concern among many that there may be risks if the application of biotechnology resulted in the expression of a gene that made a harmful product. This might occur, for example, if, by design or accident, manipulations to DNA disrupted a control that kept a harmful gene from being expressed. In Section 4 the scientific arguments over the extent of the risks associated with biotechnology are examined.

Before looking more closely at biological hazards, particularly those associated with biotechnology, it is important to understand the nature and extent of the legislation directed at reducing these hazards. An overview of this legislation follows.

SECTION 2

2.0 LEGISLATION

This subsection highlights only legislation that either supports Canada's emergency response capability following a biological accident or reduces the chances of such an accident occurring in the first place. For further details on legislation, refer an Industry Canada publication entitled *Biotech - A User's Guide*.

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[7] *Staff Report: Environmental Implications of Genetic Engineering*, Subcommittee on Investigations and Oversight, House Committee on Science and Technology, Ninety-eighth Congress, second session 9 (1984).

It should be noted that, in addition to the federal legislation, there exists a variety of provincial, territorial and municipal legislation that, directly or indirectly, has a bearing on the response that may be expected following a biological accident. A full review of this legislation is beyond the scope of this report. However, with the exception of Alberta (and soon B.C.), *biotechnology* is not explicitly defined in provincial legislation. Faced with a crisis, a municipality or province, where the need for an immediate response will almost always lie, will have to construe biotechnology within legislation covering such matters as hazardous waste, liquid industrial waste and biological products.

The absence of provincial legislation may delay accident response and it will certainly complicate risk assessment and planning. Developments in these two fields will go forward:

- in the primary regulatory area, through the actions of the provincial officials required by legislation to look after such things as the risks posed by biotechnology to water quality, waste management, or industrial development; and

- in the secondary regulatory area, through the responses of boards, municipal councils, tribunals, or courts to specific issues relating to biotechnology.

Even assuming the highest quality of work on the part of these provincial and local institutions, it is possible that their responses in legislation (if not practice) to biological accidents will be complex, inconsistent, crisis-oriented and narrowly focussed. Uncoordinated legislation and regulation will, therefore, be a barrier to broader national or provincial initiatives designed to ensure prompt response to risks associated with biotechnology.

With the advent of recombinant DNA (rDNA) technology and societal concerns over the potential hazards of working with rDNA techniques and genetically altered organisms[8], the Medical Research Council of Canada (MRCC) published the first edition of "*Guidelines for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells*" in 1977. There have since been three revisions to the Guidelines. The most recent (1990) was produced as a joint effort between Health Canada and the MRCC, and is heretofore referred to as MRC/HC Guidelines.[9] This document is the *Medical Research Council of Canada Laboratory Biosafety Guidelines* (1990) and it

[8] The hybrid DNA resulting from joining pieces of DNA from different sources.

[9] Health Canada now administers the MRCC Laboratory Biosafety Guidelines.

constitutes a total revision of original documents regarding the levels of containment required for work with potentially infectious agents. These revisions were made to ensure that Canada's guidelines paralleled those generally accepted internationally.

The MRC/HC Guidelines were intended to apply to all research carried out or supported by the federal government. However, while there is no formal legislative or regulatory enforcement, all the labs, institutions and companies contacted in production of this report claim to have adopted the MRC/HC Guidelines.

Central to the MRC/HC Guidelines is the classification of organisms into one of four risk groups. The higher the risk group, the more stringent the laboratory containment procedures applied. Because of their wide applicability, both in Canada and abroad, and their large influence in governing laboratory operations, the risk groups deserve presentation. The following are the criteria for classification of infective pathogens by risk group.

Risk Group 1 *(low individual and community risk)*
A microorganism that is unlikely to cause disease in healthy workers or animals.

Risk Group 2 *(moderate individual risk, limited community risk)*
A pathogen that can cause human or animal disease but, under normal circumstances, is unlikely to be a serious hazard to laboratory workers, the community, livestock, or the environment. Laboratory exposures rarely cause infection leading to serious disease; effective treatment and preventive measures are available and the risk of spread is limited.

Risk Group 3 *(high individual risk, low community risk)*
A pathogen that usually causes serious human or animal disease, or which can result in serious economic consequences but does not ordinarily spread by casual contact from one individual to another, or that can be treated by antimicrobial or antiparasitic agents.

Risk Group 4 *(high individual risk, high community risk)*
A pathogen that usually produces very serious human or animal disease, often untreatable, and may be readily transmitted from one individual to another, or from animal to human or vice-versa, directly or indirectly, or by casual contact.

The Guidelines list a number of specific bacteria, viruses, fungi, and parasites which have been assigned to each of the various risk groups.

The MRC/HC Guidelines primarily address handling of infectious agents in clinical, diagnostic and research laboratories. They do not, however, address the handling of

microorganisms in large-scale industrial processes. Indeed, risk assessment of large-scale applications of biotechnology is at a very early stage of its development. It has, however, been determined by at least one group that the risk assessment methods used in other technologies, particularly in the chemical industry, could be adapted for biotechnology.[10] Nonetheless, there has been little experience in applying these methods to large-scale biotechnological processes, such that a risk assessment could not be rigorously applied. In other words, no one knows what long-term impacts to look for. For this reason, Health Canada's Office of Biosafety, Laboratory Centre for Disease Control has recently developed a supplement to the 1990 Laboratory Biosafety Guidelines entitled, *Guidelines for the Large Scale Production of Microorganisms* (in draft stage of development and not available for general release).

2.1 Workplace Legislation

The *Canadian Labour Code* and its *Occupational Health and Safety Regulations* require that each employer provide safe working conditions and that employees be informed about all hazards faced in the course of carrying out duties. The employee is also given the right to withdraw from the workplace if faced with an unsafe condition. These regulations, which apply to those organizations whose principal activity falls under federal jurisdiction, cover approximately 10 percent of Canadian workers and 10 percent of employers, including the federal government. The regulations provide that, depending on the size of the business, each business site have a joint employee/management safety and health committee or an employee safety and health representative. Should an issue arise that the Committee cannot resolve, then a regulator from Labour Canada may be appointed.

It should be noted that the provinces also have occupational health and safety regimes similar to the federal model, covering a substantial portion of Canada's workers. With particular reference to the biotechnology industry, a recent survey found that, as required by the Occupational Health and Safety Act of each province excluding Alberta, Joint Health and Safety Committees were present and functioning in all biotechnology facilities contacted.[11] Moreover, most biotechnology companies have a biosafety committee which provides advice on biotechnology issues to the joint safety

[10] Based on interviews with WHO Health Officers, Regional Office for Europe, Copenhagen, Denmark, 6 September 1985, as cited in *An International Approach to Biotechnology Safety*, 1990.

[11] Cantox Inc., Consultants in Toxicology, Health and Environmental Sciences and Goodfellow Consultants, *Assessment of the Potential Risks Associated with the Use of Biological Agents (Natural or Modified) in the Workplace*, prepared for Occupational Safety and Health Branch, Labour Canada, November 30, 1993.

and health committee. However, while the latter is mandatory, the former is voluntary only and has, therefore, no legislated requirement.

Under the federal *Hazardous Products Act* are the *Controlled Products Regulations* (CPR) which are administered by provincial agencies. According to Section 64 of the CPR, an organism and its toxins are to be classified as a Controlled Product in WHMIS (*Workplace Hazardous Materials Information System* - WHMIS, 1988) Class D, Division 3 (Biohazardous Infectious Materials) if they have been shown to cause disease or are reasonably believed to cause disease in persons or animals. Organisms are classified according to pathogenicity, availability of effective treatment, modes of transmission, the host range of the organism and the availability of effective preventative measures. The four risk groups identified in the WHMIS legislation are similar to those described by the World Health Organization (WHO, 1983) and are almost identical to those identified in the MRC/HC (1990) guidelines. WHMIS also requires that all hazardous substances, including microorganisms, be labelled in a specified manner and that there be a Material Safety Data Sheet (MSDS) available to accompany each hazardous substance. An MSDS describes the hazard potential of the organism and any appropriate protective measures must be made available by the employer or the supplier of the organisms to any employees who may potentially be exposed. In addition, other measures prescribed in the WHMIS legislation (e.g., product labelling and worker education) must be followed if the organism is considered a "Controlled Product" under the CPR. Please see Annex I for an example of an MSDS.

2.2 Importation and Export of Infectious Substances

Permits are required for the importation of all infectious substances into Canada regardless of whether they infect humans, animals or plants. The importation of infectious agents is regulated by the *Animal Diseases and Protection Act* and Regulations (1987) administered by Agriculture and Agri-Foods Canada. There has, however, been confusion among importers as to why this department would be responsible for the importation of human pathogens. As a consequence, legislation known as the *Import of Human Pathogens Regulations* has been passed under the *Health and Welfare Act*. These Regulations ensure that Health Canada is charged with managing the import of human pathogens.

It is also necessary to obtain permission from Health Canada's Laboratory Centre for Disease Control (LCDC) to transfer pathogens of Risk Groups 3 or 4 imported under permits within Canada from one scientist or laboratory to another. Import permits for many pathogens brought into Canada restrict their distribution and may stipulate special

conditions for their use. In addition, requests for single-entry and long-standing permits to import infectious substances affecting humans should be directed to the LCDC. The LCDC is a national public health institute that monitors, investigates and manages risks to health. It has approximately a $30 million budget with 250 person years, some 10 of which are in the provinces. While it has no legislated mandate to assure compliance to legislation, it provides assistance to provinces on an as-required basis. The Centre is one of five directorates in the Health Protection Branch of Health Canada. The Branch's mandate is to protect the Canadian public from health risks posed by microbial, food-borne, drug-related or environmental hazards.

With respect to the export of human and animal pathogens, an Export Control List found under the *Export and Import Permits Act* contains those pathogens that could constitute a security threat in the wrong hands. The Act is administered by Foreign Affairs and International Trade. Under the Act, an export permit is required for the export of substances on the Export Control List to a majority of the world's countries; only 23 countries (the Australia Group) are exempt from this Act. The objective of the Act is to reduce the chances that high-risk countries may have access to pathogens which could, as a consequence, constitute a security threat to Canada.

2.3 Transportation of Infectious Substances

Effective July 1, 1985, Transport Canada became responsible for regulations concerning the transportation of dangerous goods. Any person handling, offering for transport or transporting dangerous goods must comply with the *Transportation of Dangerous Goods Act* (1992) (TDGA) and *Regulations* (TDGR). More specifically, Sections 7.15-7.19 of the Regulations (including Schedule XII) require that, for any quantity of infectious substance, a summary emergency response plan be filed with the Director General of the Transport of Dangerous Goods Directorate. Some 500 substances, including a host of infectious substances (e.g., hepatitis B, HIV, tuberculosis) are included in Schedule XII.

It should be noted, however, that the risk group system, as found in the MRC/HC Guidelines, will soon be incorporated into the TDGR through Amendment Schedule #16. Under this schedule, emergency response plans are only required for those substances in Risk Group 4. As such, many of the substances that would have required an emergency response plan under Schedule XII will no longer have such a requirement under the amendment. Under Schedule XII, a Dangerous Occurrence Report was required to be filed with the Canadian Transport Emergency Centre (CANUTEC) operated by Transport Canada if, upon an accident involving an infectious substance, the party responsible for the accident determined that the

occurrence was dangerous and that it constituted a hazard to safety or the environment.[12] This reporting regime has been criticized as too arbitrary and subjective. As a result, it will be replaced by Schedule 16, whereby a Dangerous Occurrence Report must be filed as a result of *any* accident involving an infectious substance under transit. As further protection, it should be noted that for any shipping document for a dangerous good (which includes infectious substances), CANUTEC's emergency number must be displayed as well as a 24-hour emergency phone number for the shipper. Hence in the event of any accident, the party responsible is required to contact the shipper, CANUTEC and the local police.

Transport Canada liaises with Health Canada and Agriculture and Agri-foods Canada to determine what substances are infectious and into which of the four risk groups they should fall within the TDGR. Moreover, for the first time, Class 9 in the TDGA includes "genetically modified organisms" and, as of October 1994, these will be regulated under the TDGR. Although genetically engineered, these substances are not infectious, but warrant regulation due to the uncertainty surrounding their possible risks to health or the environment.

2.4 Other Relevant Canadian Legislation

The *Canadian Environmental Protection Act* (CEPA) will soon (estimated to be early 1995) embody Substance Notification Regulations for Biotechnology Products. Under CEPA, substances must be assessed for toxicity prior to being introduced into Canadian commerce and placed on the Domestic Substances List. The Regulations will control the manufacture and import of biotechnological products new to Canada. That is, products not already on the Domestic Substances List will be subject to review; the Regulations are intended as a catchall for those substances which may not be adequately assessed for potential impacts on human health and the environment by other legislation. The details of CEPA's scope in this regard are presently under review.

Research into and application of transgenic plants and biologically engineered fertilizers comes under the auspices of Agriculture and Agri-Foods Canada through the *Seeds Act* and the *Fertilizers Act* respectively. The former provides authority to regulate the testing, inspection and sale of seeds. The latter regulates the sale and distribution of fertilizers and supplements through pre-sale registration and post-sale inspection. The *Plant Quarantine Act* provides authority to protect Canadian agriculture and forestry

[12] CANUTEC is operated by Transport Canada to assist emergency response personnel in handling dangerous goods emergencies.

from pests injurious to plants. In addition, the *Feeds Act* provides authority for regulating the manufacture, sale and importation of livestock feed and feed ingredients, including those produced by biotechnology.

The *Pest Control Products Act*, also administered by Agriculture and Agri-Foods Canada, governs the use of biologically engineered organisms designed to control pests.[13] Increasingly, such organisms are being looked to as a means of replacing chemical based pesticides Clearly, therefore, those who develop biological and chemical pesticides face the same difficulties - ensuring species specificity, slowing the development of pest resistance, preventing harm to non-target organisms, clearing regulatory hurdles, and providing profits for manufacturers.

2.5 International Context

Ecological effects and the geographic ranges of organisms transcend political boundaries; it is, therefore, considered essential to promote and achieve international coordination of risk assessment and regulation of biotechnology involving the cross-border movement of biological agents. Moreover, as Canada is party to various international agreements relating to the development, handling and application of biotechnology products, it is important to understand what these agreements achieve in terms of risk reduction.

Given the international scope of biotechnology, the United Nations and its affiliated organizations have made a major commitment to become parties to the development and uses of biotechnology. A desire for the developing countries to share in the benefits of biotechnology led the United Nations Industrial Development Organization (UNIDO) to create an international centre to promote the development and peaceful application of biotechnology, especially for developing countries. The centre, known as the International Centre for Genetic Engineering and Biotechnology (ICGEB), is supported by 41 countries, including Canada, and operates at Trieste, Italy, and New Delhi, India, under the auspices of UNIDO.

With regard to the international movement of dangerous goods, Canada respects - and domestic legislation closely parallels - several international protocols. The TDGA is, for example, consistent with the United Nations Recommendations on the Transport of Dangerous Goods; the International Civil Aviation Organization (ICAO); Technical

[13] The Pest Control Products Act defines a pest as "any injurious, noxious or troublesome insect, fungus, bacterial organism, virus, weed, rodent or other plant or animal pest, and includes any injurious, noxious or troublesome organic function of a plant or animal."

Instructions for the Transport of Dangerous Goods; and the International Marine Organization (IMO) International Maritime Dangerous Goods Code.

Concern over possible safety and environmental risks raised by biotechnology prompted the World Health Organization (WHO) and the United Nations Environment Program (UNEP) to identify and study the various safety issues involved. In response to its concern about these issues, the WHO published the biosafety manual, Laboratory Biosafety Manual in 1983.

The Organization for Economic Cooperation and Development (OECD) has been extensively involved with the development of guidelines related to the use of biotechnology, both in the workplace and for potential releases into the environment. In the OECD's 1986 report, *Recombinant DNA Safety Considerations*, the classification of rDNA organisms was proposed to be the same as that for non-recombinant organisms (i.e., based on the ability of the microorganism to cause disease). The central concept of the OECD (1986) guidelines was the application of different degrees of physical confinement for organisms of differing hazard potential. Similar to the guidelines of many of its member countries, including Canada, the OECD prescribes a four-tiered system for the physical containment of organisms.
In 1990, several proposed revisions and updates to the OECD (1986) guidelines were presented and discussed at a meeting of an OECD working group. As a result of these meetings, the OECD issued *Safety Considerations for Biotechnology - 199*2, in early 1992. This document contains guidelines for "Good Industrial Large Scale Practice & Good Development Practices" for small-scale field research.

In addition, the OECD is currently working on the "Scientific Issues and Principles Pertaining to the Environmental Safety of the Scale-up of Field Trials of Micro-organisms."

A common characteristic across most international guidelines is the absence of specified monitoring of the workplace to verify that exposures to biological agents are minimized or prevented, as required, for the specific hazard classification of the organisms being handled. In addition, a review of international guidelines indicates that, in no instance, recommended or permissible levels of exposure to biological agents are specified. It may be the intention of the guidelines to maintain flexibility in this area, recognizing that employers will utilize different strategies to minimize exposure.[14]

[14] See Cantox/Goodfellow study (Annex II, Reference #4) for further details on international guidelines dealing with biosafety.

2.6 Summary List of Legislation Addressing Biological Risk[15]

For summary purposes, the following is a list of the federal and international legislation and protocols that directs the management of biotechnology and its products:

· Canada Labour Code (*Labour Canada*)
Occupational Safety and Health Regulations

· Health and Welfare Act (*Health Canada*)
-Import of Human Pathogens Regulations

· Food and Drugs Act (*Health Canada*)

· Hazardous Products Act (*Labour Canada/Health Canada*)
-Controlled Products Regulations
·Workplace Hazardous Materials Information System (WHMIS)

· Transportation of Dangerous Goods Act and Regulations (*Transport Canada*)

· Canadian Environmental Protection Act (*Environment Canada*/*Health Canada*)
- New Substances Notification Regulations for Biotechnology Products (pending)

· Seeds Act/Pest Control Products Act/Feeds Act/Plant Quarantine Act/Fertilizers Act/Animal Disease Protection Act (*Agriculture and Agri-Food Canada*)

· Export and Import Permits Act (*Foreign Affairs and International Trade*)

· International Protocols
-United Nations Recommendations on the Transport of Dangerous Goods
-The International Civil Aviation Organization (ICAO) Technical Instructions for the Transport of Dangerous Goods
- International Maritime Dangerous Goods Code
-Organization for Economic Cooperation and Development (OECD) Safety Considerations for Biotechnology (1992)

[15] For further details please refer to: *Biotech: A User's Guide*, Industry Canada, 1991.

2.7 Response Mechanisms to Biological Risk

The intent of this subsection is to outline, in the context of the above legislative overview, the expected responses to a biological accident relating to the release of a harmful microorganism. (With respect to the response to deliberately induced biological risk, please refer to Section 3.2.) Having identified the federal legislation that addresses biological risk, it is also important to identify the main actors in an emergency response to a biological accident and their responsibilities.

Most municipalities or regions have emergency response plans which provide guidance on who should be involved and what their role should be in responding to a biological accident. While these plans vary from place to place, they all have the objective of mobilizing a response to any type of emergency in the most efficient manner possible. The response processes which may be expected following a biological accident, therefore, are largely subsumed within these plans. As a means of illustrating the type of emergency response regimes typical of the provinces, Appendix I describes the role of Emergency Planning Ontario.

The first expected response to a biological accident is a call to local civil authorities such as the police or fire department. In the interest of public safety, these people have the authority to control the scene. Once a determination has been made that a biological hazard exists, the next response would be for the authorities to contact the regional Medical Officer of Health (MOH). Each major city or region has an MOH who is usually employed by the Board of Health. It is the MOH's duty to advise the authorities on the appropriate course of action. If there are casualties following a biological accident, the MOH would liaise with the Infection Control Officer at the hospital likely to receive these casualties. It would be the responsibility of the MOH to forward all pertinent information on the nature of the casualties and the biological agents to the Infection Control Officer. Typically, the province and local governments share the costs for the MOH and his office.

Once the MOH is informed of the accident, several things can be expected to happen. If further direction on responding to the accident is required, the MOH may, if he/she feels it necessary, seek advice from the Provincial Medical Officer of Health (PMOH) or the provincial body in charge of emergency planning (e.g., Emergency Planning Ontario). If more information is required regarding the handling of a biologically hazardous substance, the MOH or the PMOH may call Health Canada's Laboratory Centre for Disease Control (LCDC). Should the LCDC be contacted, a 24-hour answering service is provided by an on-call LCDC medical doctor, who has a resource index containing the names of several dozen pathogens. Beside each pathogen is the name(s) and phone number of an LCDC expert(s) on this pathogen. These individuals

would then be contacted to provide advice on the appropriate response to the pathogen in question.

Affiliated with the LCDC is the Risk Management/Strategic Planning Unit. The Unit's purpose is to develop risk management strategies and to provide the LCDC with relevant surveillance and risk assessment data. The Unit's strategic planning activities ensure that LCDC programs address current priority public health issues and concerns. In addition, the LCDC has some 10 field epidemiologists, most of whom are situated outside of Ottawa. These people may also be contacted to go to the scene or to provide advice to the authorities in charge of handling the biological emergency response.

As noted in Section 2.3, should a biological accident occur in the course of shipment of an infectious agent - and possibly beyond the purview of any specific emergency response plan - the steps which the responsible party (i.e., typically the person transporting the agent) must follow are clear. CANUTEC, the police and the shipper *must* be informed according to the TDGA. It will then remain for CANUTEC and the police to determine whether to liaise with the MOH and LCDC for further information and direction on the handling of the biological agent in question.

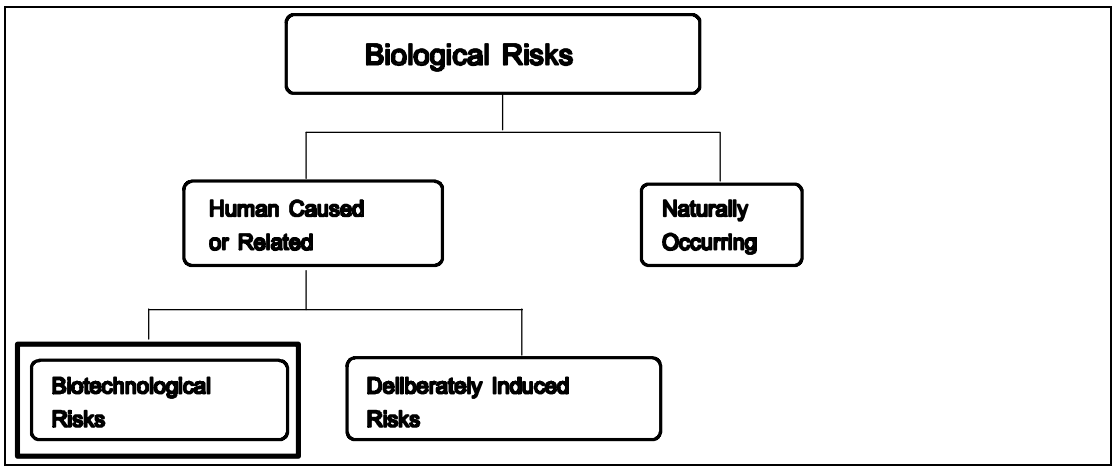
It is apparent, therefore, that, with respect to most biological accidents, much of the response would be in accordance with the applicable emergency response plan and, as such, would be mobilized at the local level. To the extent it would be involved, the federal government would participate in an advisory capacity (e.g., LCDC) and through the federal legislative framework overviewed in the previous section. It should be emphasized, however, that, with few exceptions, the federal legislation cited above is directed at proactively minimizing the likelihood of a biological accident occurring - not in how to address *poste hoc* a biological accident. Hence, the hands-on response to a biological accident would be local in nature and would abide, for the most part, by the relevant local emergency plan as implemented by local authorities and aided by the MOH.

(Please refer to Appendix II for a schematic depiction of the response to a major biological accident/incident.)

SECTION 3

3.0 BIOLOGICAL RISKS

As the following diagram illustrates, there are several categories of biological risk with which EPC must be familiar. While this report deals predominantly with the area of biotechnological risk, the other areas of biological risk are also noteworthy as they too may lead to emergencies to which EPC may become involved through its monitoring, reporting and facilitating functions.



3.1 Naturally occurring risks

Naturally occurring biological risks include: the emergence of antibiotic resistant bacterial infections, such as appears to be occurring with antibiotic resistant strains of pneumonia and tuberculosis[16]; major flu epidemics, such as the one in 1918-19; appearance of haemorrhagic fevers; and the spread of HIV. Clearly, human activity has a heavy influence on the emergence of these risks, and this should be recognized when referring to "naturally occurring" biological risks.

In assessing the damages associated with naturally occurring risks, a leading microbiologist recently told the annual meeting of the American Association for the Advancement of Science that a powerful worldwide resurgence of antibiotic resistant microbial diseases in the 1990s is a real possibility and would pose "nothing short of a medical disaster."[17] The main cause of this emerging problem is considered to be two fold: first, many bacteria are acquiring resistance to antibiotics and, second, a growing part of the population is becoming immunodefective. This immunodefiency is a result of such factors as AIDS, growing numbers of homeless, malnutrition, and chronic diseases associated with an aging population, such as emphysema, diabetes, kidney disease and heart disease.

Naturally emerging pathogens are also being attributed to deforestation. As noted recently in *The Globe and Mail*:

> As the world's virgin forests are despoiled…killer viruses are emerging. They include Lassa fever, Marburg, Machupo, Chikungunya and Monkeypox. The fastest and most lethal is Ebola, which turned up in Zaire in 1976. At the time, the virus killed 88 percent of the victims (compared with 50 percent for bubonic plague) - the highest mortality.[18]

From an emergency response perspective, the threat of naturally occurring pathogens is largely correlated with the speed in which the threat is identified and responded to by health authorities. There are concerns that this identification and response capability

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[16] Tuberculosis (TB) is considered to be the most troubling example of antibiotic resistance. Three million people a year die from TB, most of them living in impoverished areas or in developing countries, although a growing number of people in North America and Europe contract the disease, especially AIDS patients. Strains of the disease are evolving at a rapid pace toward the point at which many could become immune from existing antibiotics.

[17] Tomasz, Alexander, quoted in *the Globe and Mail*, February 21, 1994, p.1.

[18] Preston,Richard,quoted in the Globe & Mail, February 28, 1994, p.22.

may not be as effective as it could be and with, therefore, a commensurate increased threat to health.

3.1.1 Animal Diseases

Also in the category of naturally occurring biological risks are a variety of virulent animal diseases. While Canadian livestock are currently free of these diseases, it should be noted that, should they arise, certain of them can be transmitted to humans. An infectious disease of this kind is usually called a zoonosis. The spreading of a zoonosis is based on an infected animal population conveying the disease to humans via direct contact, vector or water/foodstuffs (e.g., *Salmonella* contaminated meat). Usually the disease is not thereafter spread from person to person. The most serious of these diseases, all of which are viral in origin except contagious bovine pleuropneumonia, appear on List A of the Reportable Diseases List.[19] The List is as follows, with those diseases transmissible to humans marked with an asterisk.

Foot and mouth disease
* Vesicular stomatitis
Swine vesicular disease
Rinderpest
Peste des petits ruminants
Contagious bovine pleuropneumonia
Lumpy skin disease
* Rift Valley fever
Bluetongue
Sheep pox and goat pox
African horse sickness
African swine fever
Hog cholera
Fowl plague
* Newcastle disease

The only one of these diseases which poses a serious human health risk is Rift Valley fever, a disease in which a mosquito is the vector from animal to human. However, while prevalent in parts of Africa, the disease has never appeared in Canada and is not

[19] List A consists of diseases that have the potential for very serious and rapid spread, irrespective of national borders; which are of serious socio-economic or public health consequence; and are of major importance in the international trade of livestock and livestock products. Other diseases of significance, but not on the List include rabies and *Giardia lamblia* - both widespread in Canada.

considered to pose a risk to Canadians.

Not on the above list, but worth noting is anthrax. This disease, which flourished in the Middle Ages, but is now relatively rare, is so deadly that the anthrax germ is stockpiled by several armies as a biological weapon. If ingested by eating bad meat, the anthrax bacillus multiplies in the human digestive tract causing grotesque bloating that can be fatal in 36 hours. Vaccinating animals prevents anthrax.

The Animal Diseases Research Institute, located in Nepean, Ontario, is the only laboratory in Canada that is authorized, through the *Health of Animals Act*, to work with the animal pathogens cited in the above list.[20] Among the procedures followed in the Institute's laboratories, and consistent with the MRC/HC Guidelines, is the use of biological safety cabinets,[21] High Efficiency Particulate Air (HEPA) filtering, showering out procedures, and waste incineration or boiling processes.

3.1.2 Fungi and Molds

In addition to bacterial and viral pathogens, naturally occurring biological risks also include those posed by toxins arising from certain molds and fungi. These toxins have appeared on various crops such as wheat, corn and peanuts. The following are the three main toxins which the Canadian Grain Commission watches, although none is considered to pose a material threat to Canadians.

· DEOXYNIVALENOL - also known as Vomitoxin, affects wheat, particularly in Eastern Canada. The toxin is directly correlated with the number of tombstone kernels found on wheat. The Canadian Grain Commission has grading standards based on the number of tombstone kernels and that ensure contaminated wheat is not used in the preparation of human foodstuffs. It should also be noted that contaminated wheat would not, in any case, be palatable to humans.

· AFLATOXIN - is produced by a fungus known as *Aspergillus flavus*. The fungus affects such crops as corn and peanuts, but because it requires warm and wet conditions, it has not affected Canadian crops. A potent carcinogen, it could only pose a threat to Canadians by the import of contaminated products into Canada. As a result of strict monitoring procedures from exporting countries, such a threat has never

[20] It should be noted that the laboratory will be moving to Winnipeg in 1997.

[21] Laboratory hoods are a frequently used apparatus which is designed such that air over hazardous substances is continuously withdrawn through a pressure differential process and filtered.

arisen.

· OCHRATOXIN A - can develop in stored grain. Unlike other toxins, it can pass to humans who ingest the meat of animals that have consumed contaminated grain. Because of rigorous storage standards and Canada's generally dry and cool storage conditions, it is not considered a serious threat to Canadians.

3.1.3 Parasitic Infections

Another relevant biological risk is parasitic infection outbreaks in humans. A comprehensive discussion of the nature of the many possible parasitic infections affecting humans is beyond the scope of this report. It is evident that certain parasites, such as *Giardia*, are spreading and pose a threat to human and animal health via contaminated drinking water. However, in general, parasites are not seen to be "a serious hazard to healthy laboratory workers, the community, livestock, or the environment".[22]

3.2 Deliberately Induced Risks

Essential to a discussion of biological risk is comment on the possibility of deliberate use of harmful biological agents through warfare or terrorism. Biological warfare/terrorism is generally considered to involve the use of naturally occurring infectious organisms, or the toxins produced by such organisms, for the purposes of directly attacking civilians or military personnel, or by indirectly undermining a target population by attacking crops and livestock.[23] Biological agents include viruses, fungi, bacteria, rickettsiae and biological toxins. Biotechnology could also be used to produce variants of known living biological agents for the purposes of biological warfare/terrorism.

While the risks of such biological warfare/terrorism in Canada (and the world) is minimal at present, the manifestation of these risks could be horrendous. Fortunately, there are international agreements that prohibit the use, development, manufacturing and storage of biological weapons (BW). Specifically, Canada is a signatory to the Geneva Protocol (1925) which banned the use of biological weapons. In addition,

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[22] Medical Council of Canada/Health Canada Laboratory Biosafety Guidelines, p.20.

[23] Department of National Defence, *Review of the Chemical and Biological Defence Program, May 1991-March 1992*, Government of Canada, p. 5.

along with about 100 other countries, Canada is a party to the Biological and Toxin Weapons Convention of 1972. The Convention prohibits their production, stockpiling, acquisition and use. Lacking in the Convention, however, is a verification regime which would ensure that the prohibitions against biological weapons are being observed. At the Third Review Conference of the Biological and Toxin Weapons Convention in Geneva in 1991, Canada and other countries urged the Conference to set up an *ad hoc* group of experts to make a detailed investigation of verification methods and processes. This process is now underway.

A drawback to the Conventions is their lack of agreement on control procedures, which arose because of the logistical difficulties in verifying preparations for the use of BW, even on a relatively large scale. Without verification procedures, there is uncertainty as to how - and whether - the conventions are observed by signatories and whether BW agents in commercial or otherwise non-threatening applications might be used for aggressive purposes.

Uncertainty over the efficacy of the Conventions has led to claims that some countries have access to or are indeed using BW in covert form; that is, BW may be used in localized and low-scale applications such that the knowledge of this use is not widely spread. Generally, however, it has proven impossible to verify or refute accusations of this kind. Nonetheless, as noted elsewhere in this report, the microbiological, biomedical and genetic sciences have undergone rapid development in recent years, both by commercial and government enterprises. This work creates new possibilities for the use of BW (as well as improving the means of protecting against them) and in clandestinely transferring BW technology toward the development of biological weapons.The central message, therefore, is that, despite the Conventions, there are few controls over the development of biological weapons; meanwhile, the science to further develop these weapons continues to advance.

From EPC's perspective, it should be noted that Canada has mechanisms to respond quickly to a biological warfare/terrorist threat. The Department of National Defence (DND) has in place a nuclear-biological-chemical (NBC) response team which would be capable of rapid response to such a threat. Many of the instructors at DND's NBC Defence School at CFB Borden are on this team. In addition, an interdepartmental scientific advisory group established by the Solicitor General, known as the Strategic Threat Assessment Group (STAG), exists to provide advice to counter an NBC terrorist threat. The STAG is chaired by Health Canada which would be responsible as the lead department in the event of an incident - deliberate or otherwise - that poses a biological threat to civilians.

SECTION 4

4.0 THE RISKS OF BIOTECHNOLOGY

As previously noted, over the past 25 years new techniques have been developed that greatly increase the ability of scientists to manipulate the inherited characteristics of plants, animals and microorganisms. These techniques are generally referred to as genetic engineering and fall within the field of biotechnology. The best known of these techniques deal with rDNA. This technology allows scientists to transfer genes between unrelated organisms and species. As such, specific identifiable traits of one species are given to another; genes from a specific bacteria can, for example, be moved into plants for insect resistance. Myriad real and potential applications of rDNA techniques have spawned the recent surge in biotechnology.

Biotechnology traces its beginnings back thousands of years to the selection and breeding of superior crops and animals, and the production of wines and cheeses. In the 1970s, emerging applications of biotechnology made available new manufacturing processes and products. Pharmaceuticals and diagnostic medicine were early users of modern day biotechnology techniques. In the 1990s, however, biotechnology is moving throughout the economy into such sectors as agriculture, food and beverage, forestry, aquaculture, mining, energy and chemicals.

Globally, the biotechnology industry is expecting sales to grow from $6 billion in 1989 to in excess of $100 billion by 2000.[24] In addition to commercial success and benefits to human health, biotechnology offers opportunities for protecting the environment. Examples include bioremediation of contaminated sites, including oil spills; the conversion of waste materials to energy; the manufacture of chemicals without producing hazardous waste; and the treatment of agricultural crops to reduce the need for chemical fertilizers and pesticides.

Along with its promise have been concerns about biotechnology's possible risks to humans, animals and the environment. There has been concern, for instance, that genetically engineered organisms could be harmful if established in an environment where they could proliferate and become pests or agents of disease. There are also ethical questions as to how far biotechnology should go in areas such as human genetic engineering. There has, moreover, been criticism that there is a general lack of cohesive and comprehensive - and legislated - standards to govern both the research and

[24] *Canadian Biotech '89: On the Threshold, a survey of business and financial issues*, Ernst & Young, Winter House Scientific, Industry, Science and Technology Canada, National Research Council Canada, 1989.

application of biotechnology and the handling of accidents or unexpected operational results. The fear of possible risks arising from organisms altered by this technology led Canada, the United States and Great Britain, among other countries, to develop the stringent biosafety requirements and guidelines of the mid 1970s. However, experience rapidly showed that the initial fears were not justified. By the early 1980s, many of the containment requirements had been removed.

A look at the actual number of incidents reported to Transport Canada's Canadian Transport Emergency Centre (CANUTEC) relating to biological hazards as compared to chemical hazards provides some perspective on the relative frequency of biological accidents and incidents.

YEAR	TOTAL CALLS	BIOLOGICAL HAZARDS
1988	702	5
1989	966	7
1990	953	9
1991	1105	6
1992	1044	5

The biological accidents/incidents reported typically involved the spilling or leakage of small amounts of infectious substance or biomedical waste while being transported. Hence, to date, biological hazards of all types represent an extremely small proportion of calls. In addition, according to Transport Canada, in none of the calls relating to biological hazards was human health jeopardized.

An often-expressed concern is that there may soon be so many biotechnological processes that employ pathogenic microorganisms that associated containment techniques - both in and out of the laboratory - could be inadequate to nullify, or at least minimize, possible risks. The chief concern is that the existence of regulations and guidelines concerning containment - and their degree of enforcement - may be vague not only to the public but, much more importantly, to those working in the field of biotechnology.

It should be noted that a consensus seems to have emerged among experts in biotechnology that genetic engineering *techniques* present no special risks in themselves and, therefore, ought to be governed by standard good laboratory practices. Specifically, as noted in Section I, the practices are based on the following: · a recognition that infectious organisms can be classified according to the risk they present to individuals in the laboratory and to the community at large;
· risk can be classified in various levels from low to high. The guidelines and practices are geared to these increasing levels of risk;
· containment of the organisms is the principal means of addressing the risks, with recommended containment levels corresponding with each risk category; and
·sound microbiological practices must be inculcated in the scientists, technicians and other support staff.

In sum, the following perspective suggests that when conducted according to generally accepted practices, biotechnology offers no greater risk than other realms of science:

> The current monitoring mechanism of voluntary self-regulation in the form of guidelines appears to be adequate for dealing with the risks presented to laboratory workers by microorganisms, whether genetically engineered or not. The guidelines for good laboratory practices in the microbiological laboratory have been developed over and are based upon several decades of experience. Even the newer guidelines that are focused solely on recombinant DNA are the result of over 10 years of experience with that technique in the laboratory. During this time, there have been no reports of illnesses or injuries attributed to the recombinant DNA technique. Most experts believe that laboratory work with recombinant DNA presents no risks beyond those already inherent in the biological materials and systems being used. [25]

4.1 The Scientific Debate

The following brief review of the scientific controversy surrounding biotechnological risks is intended to provide an idea of the complexities of assessing these risks. More specifically, some understanding of the science behind the thinking on risk assessment pertaining to biotechnology is important to appreciate why there is a continuing lack of consensus in the scientific community over the nature and extent of this risk. (For a more detailed review of the scientific details supporting various arguments relating to

[25] Based on interviews with WHO Health Officers, Regional Office for Europe, Copenhagen, Denmark, 6 September 1985, as cited in *An International Approach to Biotechnology Safety*, 1990, p. 17.

biological risk, see the articles referenced in Annex II.)

In the 1980s, arguments arose over the limits, if any, that should be imposed on recombinant DNA technology.[26] Compromises were reached that allowed continued use of the technology with various safeguards. Debate continues over how biotechnology should be managed in future.

The identification of environmental impacts and risks associated with biotechnology is complicated by lack of knowledge about how new life forms or products will interact with existing species. There have been few releases of genetically engineered organisms to date, so there has been little data collected concerning potential environmental effects. Microbiologists from the University of Waterloo, for instance, have noted that "…when dealing with the potential risks to ecological systems (from genetically engineered organisms), the existing database is meagre and the predictive ability of the ecological sciences is almost nil."[27] Without a predictive capability, it is difficult to make informed decisions about how to use biotechnology. As a result, there has been wide-ranging speculation on the results that are likely to follow from increasing uses of biotechnology.

Speculation on the ultimate effects of biotechnology on human health and the environment tends to differ depending on the roles of the individuals involved: alarm raised by concerned lay people and disenchanted scientists; caution urged by many observers (both scientists and non-scientists); and calm assurance issued by biotechnology practitioners and futurists.

It is known (from the science of ecology) that, in a new environment, an introduced organism (whether the result of a natural mutation or other change in genetic structure, or of migration, or of biotechnology) may die, become dormant, or reproduce. If it reproduces, the resulting population may be small, of moderate size, or large. A population equilibrium may or may not be reached (if it is not, the population will eventually die off). Independent of the size of the population, the organism may affect other organisms in the environment in various ways.

The risks posed by the introduction of new organisms through biotechnology arise

[26] DNA is deoxyribonucleic acid, the very large molecule which makes up genetic material. DNA can be broken up and recombined by a variety of techniques, hence the term recombinant DNA technology (rDNA). In rDNA, the recombination is often of single genes from one organism with the entire set of genes from another, so that the gene is transferred from one to the other.

[27] Mausberg, Burkhard. "Patenting Life", *Earthkeeper*, (October/November 1993), p.14.

because potential impacts remain unforeseen when a decision on use of the organism is made. These unforeseen impacts could be felt if there is natural selection of certain traits in the introduced organism after it is released, or the ecosystem into which the organism is released was not fully characterized and understood prior to release. In either case, the organism may survive in the environment and perform unintended, and perhaps undesirable, functions.

There are many examples from past human activities in the environment of what can happen following the introduction of organisms to new environments.[28] Some people argue that the potential effects from the introduction of genetically engineered organisms are likely to be similar to the effects of harmful non-indigenous species (NISs). In the last 100 years, 15 percent of all NISs introduced into the United States caused severe harm, and it is expected that 25 percent of recent NIS introductions will cause severe harm.[29]

The results of NIS introductions are changes in how species interact through competition, predation and herbivory, pathogenicity, and decomposition. The specific ecological changes may include:

- displacement or replacement of native species;
- toxicity (including allergic reactions) to unintended target species, either directly or as a result of products of metabolism;
- physical damage (e.g., burrowing, decomposition of wood);
- expansion of species ranges;
- invasion of new habitats (through long-range transport);
- conversion from non-confrontational to problem-causing life habits (e.g., commensal organisms may become virulent);
- selection for resistance in target organisms; and

[28] For example, Pimental, D., M.S. Hunter, J.A. LaGro, R.A. Efroymson, J.C. Landers, F.T. Mervis, C.A. McCarthy, and A.E. Boyd, 1989. Benefits and risks of genetic engineering in agriculture. *BioScience* 39,9:606-614.

[29] Office of Technology Assessment, *Harmful non-indigenous species in the United States*. Report Brief. U.S. Congress, (Washington, D.C.), 1993.

· transmission of traits to other organisms post release.

The effects of these ecological changes may be felt by society in loss of productivity, loss of capability to maintain natural systems, and requirements for wider use of pesticides and other control measures. As well, there may be unintended negative economic impacts from the use of biotechnology products, even when they are used in ways for which they were designed (e.g., reduced farm income resulting from higher production of a crop so that supply exceeds demand, driving down prices) and social impacts (e.g., the movement of rural inhabitants to cities as larger farms become the only way to maintain production of certain crops). The effects could be severe in some circumstances (e.g., the elimination of whole industries, as may occur if genetically engineered production of coffee and cocoa extracts becomes widespread).

The probability that any of these types of ecological changes - or other effects - will occur following the introduction of any one new product of biotechnology is the focus of ongoing controversy. Whether introduced biotechnology products can survive in the environment outside the laboratory is a crucial issue in this debate.

One perspective holds that most ecological niches are *already* occupied because organisms evolve to fill all of an ecosystem's niches.[30] If so, introduced products of biotechnology will not be able to survive in the face of competition with native species. However, it is clear that organisms are continually being introduced to new ecosystems in which they sometimes thrive. Thus, it has been argued that in all likelihood, few ecological niches are completely filled, and ecosystems are unlikely to resist invasion by foreign organisms, including genetically engineered organisms. On this basis, genetically engineered organisms may be able to survive for extended periods after release, potentially with significant effects.

It has been suggested that natural species and genetically engineered organisms would not normally compete in the same ecological niche. Once a genetically engineered organism intended for a task such as bioremediation has completed its intended task (i.e., its nutrient supply is exhausted), it should be unable to survive in already-filled niches where the natural organisms are adapted to exist. For instance, after a genetically engineered organism specifically designed to metabolize oil into harmless

[30] A niche is a set of environmental conditions that a species can exploit to survive and reproduce. Niches are the inventions of ecologists, not real boxes into which species fit. They are essentially "ways of life". They do not become filled to the exclusion of other organisms. As well, new species may have behaviours and physical attributes that allow their survival in a new environment, and may create new niches by their presence.

byproducts has consumed the oil, it should die off. However, like all natural species, a population of genetically engineered organisms is subject to natural mutations, recombination, and selection pressures. The introduced organism could, therefore, continue to exist in the environment if it develops the capability to use new sources of food, and it would not be driven to extinction unless it had a significant disadvantage to its competitors. To reduce or eliminate the prospects for a genetically engineered organism to survive beyond completion of the task for which it is intended, genetic weaknesses may be engineered into the organism to cause its demise after its work is done.

There are also many times when the establishment of persistent populations of genetically engineered organisms will be the goal of a biotechnology introduction. For example, organisms intended for the biological control of particular pests may be designed to persist at low population levels in the absence of a pest outbreak. Such organisms must be capable of surviving for the long term in niches previously unfilled or in which they may effectively compete with natural species. As a result of their survivability, such biotechnology products may have a higher probability of causing unwanted environmental effects.

Another crucial issue is whether biotechnology products will survive *unchanged* in the environment after release. A process of reversion may cause genetically engineered organisms to lose any recombinant DNA they contain and, in essence, revert to the original organisms from which they were developed. Reversion could occur if the genes in the recombinant DNA are of no use to the organisms, and be encouraged if there is negative selection pressure on these genes. However, unless the genes specifically render the organisms less capable of surviving in the natural environment, there is no reason for reversion to occur. As well, the organisms may have advantages over their natural competitors if they can accomplish as much as their parent organisms *plus* what they have been engineered to do. Then, the genetically engineered organisms can thrive, perhaps with unwanted effects.

That genetically engineered organisms may survive past their intended period of usefulness is not the only circumstance in which unwanted effects may arise. Bacteria can exchange genetic material with other bacteria quite easily. When transfer from genetically engineered organisms to other organisms occurs, genes may persist in the natural environment even after the genetically engineered organisms have died. Since some changes in single genes can convert benign organisms into serious pathogens, the potential effects of movements of genes from one organism to another can be very important. Note, however, that such an occurrence is considered very unlikely; pathogenesis is usually a multifactorial state, so it is very unlikely that a benign organism can be switched into one that is harmful.

Conclusion

It is evident that introducing new combinations of DNA through biotechnology is equivalent to producing new variations in genetic material through the natural processes of mutation and recombination. As such, the risks with each do not differ markedly, except that biotechnology offers a means to produce these variations both in a particular and tailored fashion and at a rate which far exceeds that found in nature.

The problems that will arise from the use of biotechnology will likely be similar to those faced in more traditional agricultural breeding programs. Ecological effects will vary from one incident to the next, and may range from no effect to acute toxicity in humans or other organisms to changes in growth rates for crop species. Although some feel that prediction of the course of events following a planned release of a biotechnology product is possible, there is a growing consensus that because of the complexity of ecological relationships, unforeseen events will always happen with some frequency. By extension, risks associated with biotechnology cannot be entirely eliminated.

The lack of agreement concerning these risks is not surprising considering, among other examples,

- the increasing experience in the manipulation of the environment exhibiting the prospect for great success (e.g., the elimination of small pox) as well as failure (introduction of harmful species, such as rabbits to Australia and African "killer bees" to North America);

- the increasing understanding of the complexities and interlinkages in and among ecosystems; and

- the recent rapid advances in biotechnology including the emerging capabilities for genetic control.

In general, the accuracy of predictions of ecological, economic and social effects of releasing a genetically engineered organism depends on the specific organism, the type of genetic information introduced, the particular environment into which it is released, and the availability of detailed ecological information. Even so, the complexity of ecology is such that prediction is likely to remain problematic.

Not all natural populations of organisms are harmless to agriculture and other human

activities _ there are many species of weeds, parasites, unwelcome herbivores, and unwanted predators. As well, natural genetic change is constant and new species arise from time to time. Sometimes problem species arise from natural migrations or introductions (either intentional or unintentional). In any case, because humankind has the option to prevent or minimize problems associated with some human activities (like biotechnology), the appropriate management of these effects should be of primary concern in developing policies and procedures for dealing with the effects of unwanted organisms.

4.2 Commercial Applications of Biotechnology

Questions over the nature and extent of risks presented by large-scale operations involving genetically engineered organisms (i.e., large fermenters with contained organisms) appear to be less settled than in the case of laboratory scale operations. This state is attributed to biotechnology companies without much experience with large-scale uses of genetically engineered organisms, although this situation is quickly changing. [31] It is generally considered that the use of culture volumes of 10 litres or more constitutes large-scale handling and/or use of biotechnology in the workplace. This perspective is not, however, without criticism. It has been argued, for instance, that the use of volume as a criterion in classifying the handling of biological agents is inappropriate. Since a small volume of a culture can be grown into a large volume - often quite quickly and easily - for biological agents, volume is simply not the relevant and useful measure of risk as it is for chemicals.

Notwithstanding the aforementioned *MRC/HW Guidelines for the Large Scale Production of Microorganisms*, some argue that large-scale operations may be more risky than laboratory-scale operations. The larger amount of material involved may increase the probability of worker exposure, especially in the case of a spill. In addition, notwithstanding the previously mentioned workplace regulations such as WHMIS, factory workers may be less well-informed of the hazards of particular organisms and less well trained in safety procedures than laboratory personnel. Moreover, it is clear that large-scale fermentation operations produce large quantities of biowastes, including water, reagents and microorganisms. While existing practices are generally deemed sufficient to address risks associated with large-scale operations, the continuing rigour with which these practices are applied cannot be taken for granted.

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[31] United Nations Industrial Development Organization, *An International Approach to Biotechnology Safety*, Vienna, 1990, p. 18.

> Successful early releases (of commercial biotechnology products) may create the public perception that rDNA organisms are risk-free. The probability of a problem occurring will increase, however, if public confidence leads to relaxation of the protocols. Commercialization, large-scale releases, and multiple releases in diverse habitats will also increase the probability of problems.[32]

4.3 Lack of Moral Clarity

As noted earlier, there are few legally binding standards that give direction to biotechnology research and product application. Indeed, an often heard criticism is that the technology is leaping ahead of man's ability to control it. As such, moral and ethical concerns with genetic engineering revolve around the human domination and control of life at the microbiological level.

Underlying any response to an accident or incident relating to biotechnology research or application will likely be a need to contend with questions on the moral and ethical legitimacy of the work that led to the accident/incident. An individual's commitment to fundamental beliefs has a significant effect on attitudes to biotechnology. Beliefs about God, nature, and science and technology are significantly related to whether an individual believes it is morally acceptable for humans to alter the genetic code of life. A recent poll by Decima Research confirmed that those who subscribe to nature or God as the ordering standard for life, and believe that human disruption of these standards may result in catastrophe, are more likely to believe it is immoral for humans to alter the genetic structure of life. Individuals who hold less to these standards, and more to science and technology as standards for knowing and ordering life, are more likely to find it morally acceptable for humans to alter life.[33]

Other ethical issues that transcend concerns over whether changes that result from use of technology will be harmful or not include the rights of people to know what they are eating or using (some religious beliefs ban the consumption or touching of certain animal materials), whether people should play as gods (creating new forms of life), and whether interference with the genetic make-up of non-human organisms is justifiable.

The moral position on the acceptability of humans altering the gene structure of

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[32] Pimental, D. etal., "Benefits and Risks of Genetic Engineering in Agriculture", Bioscience, Vol. 39 No. 9, October 1989, p. 608.

[33] In September, 1993,the Canadian Institute of Biotechnology commissioned Decima Research to provide a baseline study of public attitudes to biotechnology.

organisms has a significant and direct effect on whether an individual believes biotechnology will be beneficial or dangerous to society. It may be concluded, therefore, that the public perception of risk relating to biotechnology cannot be ignored in framing policies aimed at addressing this risk.

4.4 Other Studies

In 1990, Labour Canada commissioned a company named Cantox Inc. with the assistance of Goodfellow Consultants Inc.to evaluate the potential risks associated with the use of biological agents in the workplace. [34] The study reviews available guidelines, both domestic and international, pertaining to the control of biological agents in the workplace, and reports on a survey to determine the current work practices and procedures, and the types of biological agents used in Canada's biotechnology industry. Because of the relevance of Cantox's study to this report, the findings of the study are worth summarizing.

The results of a survey involving questionnaires mailed to 100 research, commercial and educational facilities, with 40 responses, and of subsequent site visits indicated that
· the MRCC Laboratory Biosafety Guidelines are normally followed throughout the biotechnology industry;

· joint Health and Safety Committees are present and active in most biotechnology companies;

· Biosafety Committees and/or Biosafety Officers were not consistently present at biotechnology facilities;

· Biosafety Committees tended to be present in larger companies or in those involved with organisms in MRCC Risk Group 2 or higher;

· written health and safety programs are not consistently developed at facilities; facilities involved in research and development have less stringent occupational health and safety requirement than other biotechnology sectors; and

· workplace monitoring and medical surveillance of employees are undertaken at those

[34] Cantox Inc., Consultants in Toxicology, Health and Environmental Sciences and Goodfellow Consultants, Assessment of the Potential Risks Associated with the Use of Biological Agents (Natural or Modified) in the Workplace,prepared for Occupational Safety and Health Branch, Labour Canada, November 30, 1993.

facilities handling higher risk organisms, but such procedures are not routinely conducted at other facilities.

The Cantox/Goodfellow study concluded:

> … the current guidelines appear to be adequate for the protection of workers from exposure to biological agents handled in the workplace, but there appears to be a need for more information, perhaps a "User's Guide", that explains current guidelines and regulations to the uninitiated. Also, in general, the biotechnology industry adheres to the appropriate guidelines and has implemented appropriate Joint Health and Safety Committees or Biosafety Committees to monitor potential biological hazards in the workplace. During the site visits, training at certain facilities was found to be exhaustive while at others training and the documentation of worker training were found to be weak. This was especially so for organizations employing university graduates and experienced researchers who were assumed to be trained as a result of their education.[35]

SECTION 5

5.0 DEFICIENCIES IN BIOLOGICAL RISK REDUCTION

It is apparent that there are a number of fronts on which a biological risk could develop into an emergency situation. Although, as noted, various legislation and safeguards exist to reduce and respond to these risks, they are not without deficiencies. These deficiencies could compromise the effective mobilization of a response to an emergency.

A summary of the main deficiencies in the operational procedures surrounding biological research and application are as follows:

- MRC/HC Laboratory Biosafety Guidelines (and its supplement, Large Scale Production of Microorganisms[pending]) are only enforceable relative to the importation of microorganisms into Canada. Hence, those involved in the research and application of biotechnology may choose to apply the Guidelines at

[35] Cantox Inc., Consultants in Toxicology, Health and Environmental Sciences and Goodfellow Consultants, *Assessment of the Potential Risks Associated with the Use of Biological Agents (Natural or Modified) in the Workplace* ,prepared for Occupational Safety and Health Branch, Labour Canada, November 30, 1993., p.ii.

their own discretion.

- Under the Importation of Human Pathogens Regulations, an importer must declare the nature and details of his research. Other than this, there is no legislated requirement that a researcher or his institution declare to any authority the nature of biological research undertaken. As a consequence, there is no legislated restriction on the nature of this research. Such a lack of control means that a laboratory may be engaged in research for which it is not equipped in terms of personnel expertise/training and/or containment capability. Moreover, unlike some countries, such as the United Kingdom, there is no ongoing mandatory inspection of laboratory containment capabilities for those working with Risk Level 3 or 4 microorganisms.

- In conducting basic research into the study of pathogen virulence and the building of antibiotic immunity into pathogens there is no legislated obligation to disable such organisms in the conduct of this research — the outcome of their escape into the environment could be extremely serious.

- The MRC/HC Guidelines deal with containment procedures, but do not address the need for formal credentials for those working in biotechnology. As a consequence, biological risk may be enhanced because neither guidelines nor legislation exists to ensure that only those who are formally trained in microbiology handle and oversee the handling of pathogens.

- Regulations stipulating a requirement for the life cycle management of biologically hazardous substances are absent. (The life cycle regime covering the management of toxic chemicals could form a useful model.)

- Depending on the nature of a biological emergency, many of those spoken to indicated that there is a general lack of knowledge of what the response to an emergency would be, including who the relevant responding agencies would be. Such a gap could detract from Canada's emergency response capability.

- International protocols on the movement of biological agents are far less rigorous that those applied to the production and cross-border movement of weapons-grade toxic chemicals. It has been argued, however, that the former represents a greater threat than the latter, since only a small culture of pertinent organism is required to be grown into one that could be used for warfare/terrorism.

- In an emergency response to a biological accident, there may be valuable time lost in determining precisely what organisms are involved. This deficiency is

attributable to both possible jurisdictional/legislative overlap and confusion, and a lack of experience in responding to biological accidents.

- Definitional ambiguities in legislation that diminish the efficacy of legislation directed at reducing biological risk. Specifically, it has been suggested that the source of this ambiguity is the attempt to apply in legislation the risk reduction models for chemical risk to biological risk. In some instances, the latter does not fit into these models.[36]

- Control of the contained use of biological organisms (e.g., research and industrial applications where there are no intentional releases of the organisms into the environment) is not considered separately from the control of chemical exposure; that is, there is no distinction made between occupational exposures to chemical or biological agents.

- The MRC/HC Guidelines indicate that workplace sampling and medical surveillance of employees should be conducted, particularly when handling higher risk organisms. However, the details as to how and when this sampling and surveillance should be done is left to the discretion of the employer. There are, therefore, no assurances or controls to verify that these precautions are followed.

SECTION 6

6.0 CONCLUSIONS

• Considerable uncertainty remains among experts as to the degree of risk associated with research into and application of biotechnology. It is, however, apparent that the perceived risk of the science 15 years ago is considerably diminished today.

• Stringent laboratory biosafety guidelines are widely adopted, but are legally enforceable only in respect to importation of human pathogens.

• Numerous pieces of legislation, in addition to non legally binding guidelines, govern the research into biotechnology and its applications. However, questions of harmonization and enforcement are evident and have been raised by critics.

[36] For example, the use of product *volume* as one criterion to control the movement or use of bioengineered organisms, as is done for chemicals, may not be valid or reliable; rapid growth of even small cultures can quickly obviate the notion of volume as a control measure.

• Application of the MRC/HC Guidelines along with normal laboratory practices is generally considered sufficient to nullify risks associated with the conduct of research into biotechnology.

• The potential risk of environmental effects from biotechnology is widely seen to be of a "low probability, but high consequence" nature. In other words, although the chances of something going wrong are remote, if something does go wrong, the ecological consequences, albeit unknown, may be disastrous (although they could also be harmless).

• The threat to human health from exotic plant and animal diseases in Canada is remote.

• Unlike chemical accidents (e.g., the Mississauga railway accident) there has never been a serious emergency resulting from biological (or biotechnological) research/application in Canada. As a result, with the exception of the biological warfare/terrorism threat, Canada's response mechanisms have never been tested. There are consequent uncertainties as to the actors and the mechanics of the processes should such a response be required. There appears to be a general sense of complacency with regard to biological risk on the grounds that legislation/guidelines are seen as both sufficient and respected. There is, however, a lack of clear and comprehensive insight from any one person or agency into how an emergency response would be mobilized, who would be in charge, and what legislation would apply and under precisely what circumstances.

• The risks associated with biotechnology tend not to be of the type to which an emergency response would be feasible. This is because the risks tend to manifest themselves insidiously over time, rather than suddenly (e.g., through a major spill). If a biologically engineered organism is developed and escapes into the environment, it would normally only gradually multiply to the point at which it has a deleterious effect on the ecosystem in which it lives. Instead, the greatest biological risk to which an emergency response is required is likely to come from either naturally emerging pathogens harmful to humans, which could conceivably strike certain segments of the population or geographic regions; or organisms intentionally introduced through terrorism/biological warfare.

• Traditional concerns about biotechnology have centred on the containment of organisms used in research and the proper handling of the products of this research. However, with the advent of biotechnology's commercial applications, the concern has shifted to identifying the often uncertain results of intentionally introducing the biotechnological products into the environment.

• With respect to other countries, a review of the guidelines and regulations available regarding the safety of biotechnology in the workplace reveals several common features. In particular, in most nations, there are very few regulations entrenched in law that govern occupational health risks specifically posed by biotechnology in the workplace. As in Canada, most of the current regulations are in the form of voluntary guidelines.

SECTION 7

7.0 RECOMMENDATIONS

The following are general recommendations that, if implemented, would address the deficiencies cited in Section 5.

1.0 In the event of a fire or explosion at a biological research facility, emergency response personnel, (i.e., firefighters, paramedics) may have to contend with potentially hazardous laboratory contents about which they may know little or nothing. As a result, it is recommended that, as a precaution, off-site Material Safety Data Sheets be kept on each biotechnology laboratory and its contents, in a place external to the lab, but readily available to firefighters. Such a location could, for instance, be at a Commissioner's desk or in an Administrative Office.

2.0 It is recommended that consideration be given to examining the MRC/HC Laboratory Biosafety Guidelines with a view to converting some or all of these Guidelines into legislation.

3.0 Should it be decided to promote the conversion of the MRC/HC Laboratory Biosafety Guidelines into legislation, it is recommended that consultation with the biotechnology industry be undertaken.

4.0 It is recommended that a regime to monitor and report regularly on the operations of laboratories conducting research into biotechnology be considered.

5.0 Due to the lack of serious biological accidents to date, there is little experience in mobilizing an appropriate emergency response to such accidents. As such, it is recommended that tests of local emergency response plans be encouraged by the conducting of mock-up scenarios depicting a hypothetical biological accident.

6.0 It is recommended that formal microbiological training of those working in

biotechnology and on the maintenance of records documenting the completion of this training be promoted.

7.0 It is recommended that the possibility of using a life-cycle approach to the management of biotechnology products be explored. A formal and regimented documentation from the initial obtaining/growth of microorganisms through their use and ultimate disposal would go far toward enhancing the controls needed to minimize risk associated with biotechnology.

8.0 It is recommended that the harmonization of federal and provincial legislation governing biotechnology be encouraged wherever possible. Such harmonization would help ensure less confusion in the management of biotechnology and a more rapid and clear response in the event of an emergency.

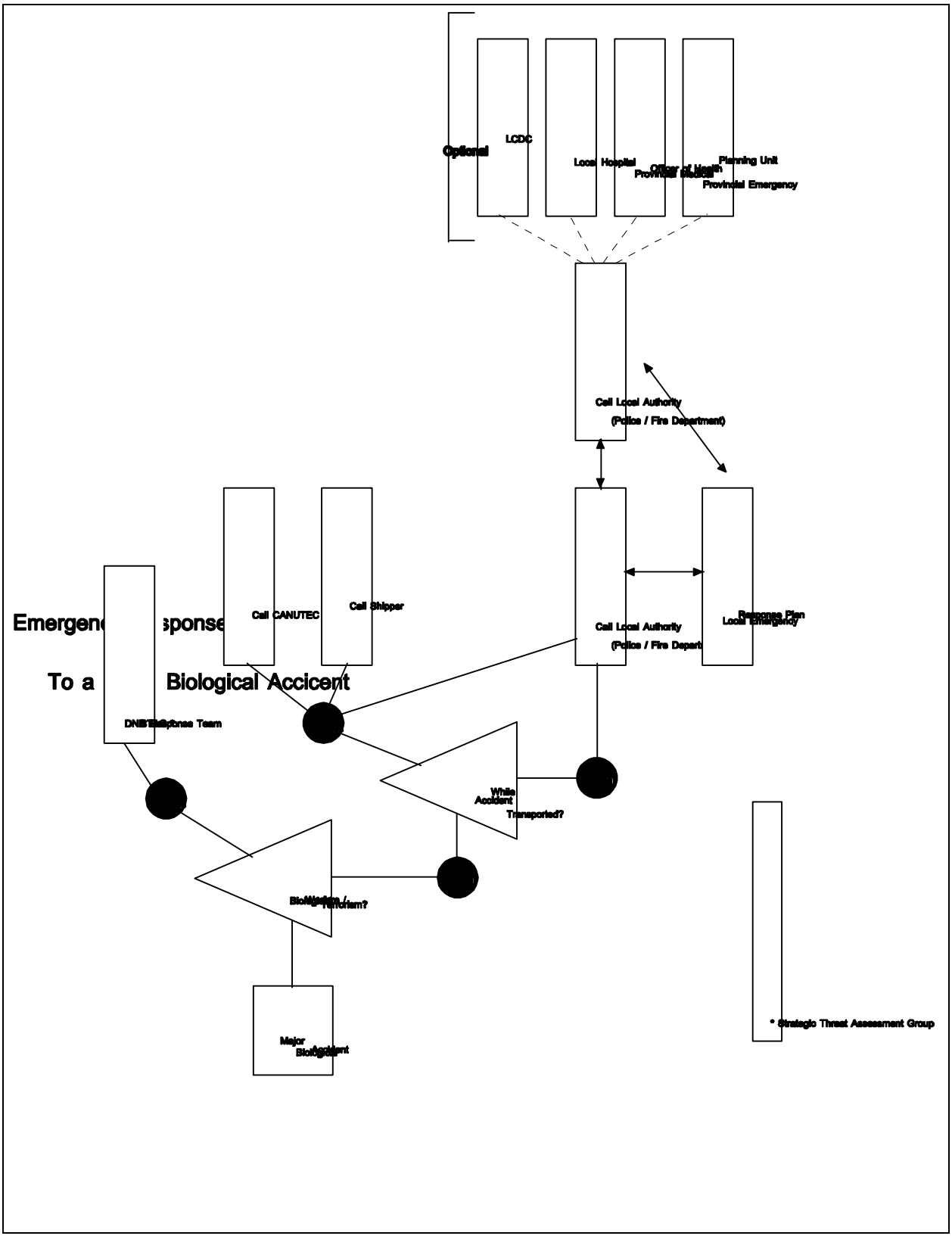
9.0 It is recommended that the biotechnology industry be consulted to resolve areas of ambiguity in the MRC/HC Guidelines and other legislation.

APPENDIX I - Emergency Planning Ontario

Emergency Planning Ontario is responsible for monitoring, coordinating and assisting in the formulation and implementation of emergency plans throughout Ontario. Activities within the branch are grouped under the two broad general headings of emergency preparedness and emergency response. Emergency preparedness includes the activities of planning, training, public education and exercises. Emergency response includes the provision of liaison and advice, and procedures for arranging, coordinating and directing personnel, services, equipment or material resources to the site of a major emergency.

The branch assists municipalities and First Nations with the development of emergency plans and other preparedness activities; manages the Provincial Nuclear Emergency Plan and the Provincial Emergency Plan; coordinates planning for emergencies assigned as the special responsibility of the Solicitor General; coordinates interministry/agency emergency planning; monitors the emergency plans of other provinces and the federal government; conducts emergency preparedness courses for municipalities, First Nations and provincial officials; processes applications for attendance at courses conducted at the Canadian Emergency Preparedness College, Arnprior; organizes and conducts workshops and seminars; supports the development and conduct of exercises; publishes the periodical *Emergency Planning News*; and conducts public education programs to enhance emergency preparedness. The branch also processes applications and claims for funds made to the federal government for emergency preparedness under the Joint Emergency Preparedness Program (JEPP). The Branch assists with emergency response as required.

APPENDIX II


Optional
LCDC
Local Hospital
Provincial Emergency
Call Local Authority
(Police / Fire Department)
Call CANUTEC
Call Shipper
Call Local Authority
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While
Accident
Transported?
Major
* Strategic Threat Assessment Group

ANNEX I - Sample of Material Safety Data Sheet

LABORATORY CENTRE FOR DISEASE CONTROL

MATERIAL SAFETY DATA SHEET - INFECTIOUS SUBSTANCES

SECTION I - INFECTIOUS AGENT

NAME: Hepatitis B virus

SYNONYM OR CROSS REFERENCE: Serum hepatitis, Type B hepatitis, Homologous serum jaundice, Australia antigen hepatitis, HB

CHARACTERISTICS: double-stranded DNA, 42nm diameter, enveloped, Hepadna virus, lipoprotein coat contains the HBsAg

SECTION II - HEALTH HAZARD

PATHOGENICITY: Onset is insidious with anorexia, vague abdominal discomfort, nausea and vomiting, sometimes arthralcias and rash, often progressing to jaundice; fever may be absent or mild; severity ranges from inapparent cases to fatal acute hepatic necrosis; low short term case fatality rate in hospitalized patients; long term case fatality rate is 2-3% due to cancer or cirrhosis of the liver

EPIDEMIOLOGY: Worldwide; endemic with little seasonal variation; commonly in young adults in North America and in infancy or childhood in Africa and Asia; antigen carrier rate in North America is under 1% for the general population and 10-15% in Asia; common in high risk groups - drug abusers, persons in the health care field exposed to blood or serous fluids, sexually promiscuous individuals

HOST RANGE: Man (chimpanzees are susceptible)

INFECTIOUS DOSE: Not known

MODE OF TRANSMISSION: Percutaneous or permucosal exposure to infectious body fluids (blood, serum-derived fluids, saliva, semen, vaginal fluids); commonly spread by contaminated needles, syringes and other IV equipment; contamination of wounds or lacerations; exposure of mucous membranes; sexual contact

INCUBATION PERIOD: Usually 45-180 days; average 60-90 days; HBsAg appears in 2 wks or rarely, 6-9 months, depending on dose, mode of transmission and host factors

COMMUNICABILITY: Blood can be infective weeks before onset of symptoms; remains infective through clinical and chronic carrier states; infectivity of chronically infected individuals varies from highly infectious to sparingly infectious

SECTION III - DISSEMINATION

RESERVOIR: Humans

ZOONOSIS: none

VECTORS: none

SECTION IV - VIABILITY

DRUG SUSCEPTIBILITY: No specific antivirals

SUSCEPTIBILITY TO DISINFECTANTS: Susceptible to many disinfectants; 1% sodium hypochlorite, 70% ethanol, 2% glutaraldehyde, formaldehyde

PHYSICAL INACTIVATION: Stable at 37C for 60 min but not at temperatures above 60C; stable at pH 2.4 for up to 6 hours (infectivity is lost); HBsAg not destroyed by W of blood products

SURVIVAL OUTSIDE HOST: Survives in dried blood for long periods (weeks)

SECTION V - MEDICAL

SURVEILLANCE: Testing of blood samples for the presence of HBsAg

FIRST AID/TREATMENT: No specific treatment

IMMUNIZATION: Inactivated vaccine is available and recommended for those of increased risk such as laboratory workers and other health care workers exposed to blood

PROPHYLAXIS: Hepatitis B immunoglobulin (HBIG)

SECTION VI - LABORATORY HAZARDS

LABORATORY-ACQUIRED INFECTIONS: The most frequently occurring laboratory-associated infection; incidence in some categories of lab workers is 7 times greater than that of the general population; 234 reported cases up to 1974 with one death (3921 total infections surveyed); 26 reported cases in UK labs form 1980-1987

SOURCES/SPECIMENS: Blood and blood products, urine, semen, csf, and saliva

PRIMARY HAZARDS: Parenteral inoculation; droplet exposure of mucous membranes; contact exposure of broken skin

SPECIAL HAZARDS: Needlestick with infected blood

SECTION VII - RECOMMENDED PRECAUTIONS

CONTAINMENT REQUIREMENTS: Biosafety level 2 practices and containment for activities utilizing infectious body fluids and tissues; Biosafety level 3 primary containment and personnel precautions for activities with high potential for droplet or aerosol production and high production quantities or concentrations; Animal Biosafety level 2 for work with nonhuman primates

PROTECTIVE CLOTHING: Laboratory coat; gloves when skin contact is unavoidable and when working with animals; wrap-around gown and gloves for work in biosafety cabinet

OTHER PRECAUTIONS: General needle safety precautions important - do not bend, break or recap needles; dispose directly into puncture-proof container

SECTION VIII - HANDLING INFORMATION

SPILLS: Allow aerosols to settle; wearing protective clothing, gently cover spill with absorbent paper towel and apply 1% sodium hypochlorite, starting at perimeter and working way to centre; allow sufficient contact time (30 min) before clean up

DISPOSAL: Decontaminate before disposal; steam sterilization, chemical disinfection, incineration

STORAGE: In sealed containers that are appropriately labelled

SECTION IX - MISCELLANEOUS INFORMATION

Date prepared: Jan. 1993

Prepared by: Office of Biosafety
LCDC

Although the information, opinions and recommendations contained in this Material Safety Data Sheet are compiled from sources believed to be reliable, we accept no responsibility for the accuracy, sufficiency, or reliability or for any loss or injury resulting from the use of the information. Newly discovered hazards are frequent and this information may not be completely up to date.

ANNEX II - Documents Referenced

Cantox Inc. and Goodfellow Consultants Inc., *Assessment of the Potential Risks Associated with the use of Biological Agents (Natural or Modified) in the Workplace*, prepared for Occupational Safety and Health Branch, Labour Canada, November, 1993.

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ANNEX III - Individuals/Organizations Contacted

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MIACC - Major Industrial Accidents Coordinating Council

Brian Mansfield - Chief of the National Emergencies Centre, Environment Canada

Dr. Joe Losos - Field Epidemiology Program and LCDC Program, Health Canada

Maryellen Kennedy - Laboratory Centre for Disease Control Office of Biosafety, Health Canada

Agriculture Canada Emergency Planning

Verner Seligy - Environmental and Occupational Toxicology, Health Canada

Bill Sterritt - Animal Disease Research Institute, Agriculture and Agri-food Canada

Grant Reader - Critical Science and Technology Directorate, Science Strategy Branch, Industry and Science Canada

Nancy Porter-Cathcart /Dr. John Reed - Legislation, Regulation and Permits, Transport Canada

Ken Rozee - Halifax Victoria General Hospital

Howard Savoie - Environmental Law Centre, Edmonton

Phyllis Windle - Office of Technology Assessment, Washington, USA

Dr. Andy Storer - Biological Research Centre, Montreal

Bruce MacDonald/Larry Van Loon/Adele Stewart - Canadian Security Intelligence Service

Roger Perreault - Industrial Biotechnology Association of Canada

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