Cancer and the environment: Ten topics in environmental cancer epidemiology in Canada

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Executive Summary

This Chronic Diseases in Canada supplement is a compilation of literature reviews by scientific experts. It was initiated as follow-up to the Green Plan, the federal government's environmental agenda in the 1990s. In recognizing that Canadians are concerned about the environment and its relationship to their health, this document attempts to address some of these concerns in relation to cancer by reviewing and summarizing the epidemiological literature for ten environmental exposures, and highlighting future research needs. The topics include three types of radiation exposure (ultraviolet, radon and electromagnetic (powerfrequency electromagnetic fields)), three classes of chemical exposure (organochlorines, disinfection byproducts, and pesticides), two types of air pollution (environmental tobacco smoke and outdoor air pollution), and two industrial sources (pulp and paper milling, and metal mining and processing).

This publication is intended to provide a base of information for researchers interested in environmental cancer epidemiology and to assist with the formulation of research priorities. The ten topics reviewed here were selected because concern about them has been expressed or because they involve known animal carcinogens. Complete elimination of exposures to carcinogens in the environment, synthetic or natural, is not technically feasible if cancer can potentially occur at any level of exposure (i.e., the linear non-threshold theory). Consequently, it is important to have an operational concept of safety which is more practical than that of zero risk. Such an approach uses the concept of acceptable or essentially negligible risk to determine the exposure levels at which carcinogens are regulated.¹ Acceptable risk has been defined as one that is "so small, whose consequences are so slight, or whose associated benefits (perceived or real) are so great that persons or groups in society are willing to take or be subjected to that risk". The level of risk where remedial action is recommended will vary according to the "agent or process being regulated, the economic and social costs and benefits and technology factors".¹⁻³

In accordance with the system used by the International Agency for Research on Cancer (IARC) to assess the strength of the evidence for human carcinogenicity,⁴ the ten exposures reviewed here can be grouped into three broad categories, with some exposures occupying more than one and the first category—human carcinogens should be subdivided. Tables 1-4 refer to these categories. For many of the exposures discussed here, ongoing etiological research awaits methods development, particularly in exposure assessment.

I Human carcinogens

a) Exposures for which estimated attributable numbers of cancers are cause for concern

The epidemiological evidence is adequate to conclude that ultraviolet radiation, environmental tobacco smoke and radon are human carcinogens, and to estimate the number of cancer cases and deaths attributable to them at typical exposure levels (Table 1).

Ultraviolet radiation

Approximately 69,000 Canadians are diagnosed with non-melanoma skin cancer each year, making it the most common form of cancer, and about 350 are diagnosed with lip cancer.⁵ Approximately 94% percent of all new cases of skin cancer are basal or squamous cell, with malignant melanoma accounting for the remaining 6 percent. Exposure to solar ultraviolet radiation is likely responsible for over 90 percent of skin cancer in Canada and for more than half of lip cancer.^{6,7} Malignant melanoma is the most serious of the skin cancers and accounts for approximately 4,600 cases and 900 deaths in Canada each year.⁵ Death from non-melanoma skin cancer and lip cancer is rare. It is estimated that approximately 450 UVR-related cancer deaths yearly (one half the total UVRrelated deaths) are preventable by reducing sun exposure.

Environmental tobacco smoke

Tobacco smoke is the major component of indoor air pollution. Recent research suggests that each year about 250 nonsmoking Canadians die of lung cancer caused by prolonged exposure to other people's tobacco smoke.8 A recent metaanalysis (i.e., systematic summary of studies) estimated the risk of lung cancer among non-smoking women as 24 percent higher for those living with a smoker than for those not, and 39 percent higher for those exposed to ETS in the workplace. Because of the large number of Canadians who have never smoked but have been exposed to second-hand smoke regularly over a number of years as a child, as a spouse and/or in the workplace, the risk associated with exposure has significant public health implications.

Radon

Radiation from radon gas is carcinogenic to humans.⁹ Most of the evidence for carcinogenicity has been obtained from studies of miners exposed to high concentrations; however, radon exposure at levels to which many Canadians are routinely exposed have also been found to increase the risk of lung cancer. Radon has been estimated to be responsible for over fifteen hundred cases of lung cancer a year in Canada (about 8% of lung cancer cases).¹⁰ A number of techniques are available to homeowners to reduce radon concentrations in their homes.

b) Exposure levels that result in small increases in risk

For three exposures—selected organochlorine insecticides, outdoor air pollution and some nickel species—the accumulated evidence suggests that typical Canadian

exposure levels result in small increases in risk (Table 2). To estimate the number of cases of cancer that can be attributed to an exposure, it is necessary to know the prevalence of the exposure and the magnitude of the risk. There is only limited evidence regarding the prevalence of exposure to these agents in the Canadian population. As well, much evidence of their carcinogenicity comes from occupational studies, where exposures are much higher than those experienced by the general Canadian population. The nature of the exposureresponse relationships at low exposure levels is unclear, making it inappropriate to attempt to quantify the cancer burden in the Canadian population which can be attributed to their exposures. In addition, it has been difficult to control for potential confounding factors.

Organochlorine insecticides

The limited epidemiological evidence regarding a number of organochlorine insecticides and several cancers generally supports the toxicological evidence of an association with cancer. Because of these concerns and others, and with the exception of lindane, which is permitted for the treatment of head lice as a pharmaceutical, organochlorine insecticides are no longer marketed in Canada.

Air pollution

The most commonly measured outdoor air pollutants in Canada include particulates, ground-level ozone, carbon monoxide, sulphur dioxide and oxides of nitrogen. These substances are the principal ingredients of precursors of smog and acid rain.² Some particulates are small enough to be inhaled and deposited in the lungs. Some studies suggest that long-term, regular exposure to particulate matter is associated with increased risk of lung cancer.11 In Western industrialized countries that have pollution regulations, air pollution poses only a small risk for developing cancer. Further research is a priority to better control residual confounding from cigarette smoking (active and passive), and more accurately assign air pollution exposures.

Nickel mining and processing

IARC has concluded that there is sufficient evidence in humans for the carcinogenicity

of nickel sulphate and the combinations of nickel sulphides and oxides encountered in the nickel refining industry. Furthermore, there is sufficient evidence in experimental animals to conclude that metallic nickel is possibly carcinogenic to humans.¹² Some early studies of nickel workers in the early half of the 20th century revealed higherthan-expected rates of various cancers of the respiratory tract. Since then, exposure levels to workers have been reduced to the point where there is little or no detectable risk in most sectors of the nickel industry. The general population risk from the extremely small concentrations of nickel compounds detectable in ambient air is negligible.

II Exposures for which the epidemiological evidence of carcinogenesis in humans is limited

According to the IARC classification, limited evidence of carcinogenicity in humans means that a positive association has been observed between exposure and cancer for which a causal interpretation is credible, but chance, bias or confounding cannot be ruled out with reasonable confidence.⁴ Limited evidence exists for three of the ten exposures reviewed here (Table 3).

Dioxins

Polychlorinated dibenzo-para-dioxins (PCDDs)—a class of organochlorines are formed as inadvertent by-products during the production of chlorophenols and chlorophenoxy herbicides and have been detected as contaminants of these products. Dioxins may also be produced in thermal processes such as incineration and metal-processing, and the bleaching of paper pulp with free chlorine. Dioxins have been related sufficiently to specific cancers such as soft-tissue sarcoma, non-Hodgkin's lymphoma and Hodgkin's disease, to warrant further research. This judgement is based on consistency of findings across studies, the magnitude of the risk estimates and absence of major sources of bias. Toxicological studies have demonstrated the carcinogenicity of 2,3,7,8tetrachlorodibenzo-para-dioxin, but other dioxins are not classifiable as to their carcinogenicity.13

Phenoxy herbicides

Pesticides encompass many classes of chemicals that share the ability to kill or otherwise control pests. Many are rated as possible or probable human carcinogens. Epidemiological studies suggest that phenoxy herbicides may be associated with non-Hodgkin's lymphoma and soft-tissue sarcomas; however, this finding is not supported by the toxicological evidence. IARC has concluded that there is limited evidence that phenoxy acid herbicides as a group are carcinogenic in humans, with inadequate evidence of carcinogenicity in animals.¹⁴ This position was based on the class of chemicals which included the more highly contaminated 2,4,5-T and "may not apply to individual chemicals within the group". The United States Environmental Protection Agency (US EPA) considers 2,4-D is not classifiable as to human carcinogenicity.¹⁵ However, both the US EPA and the Canadian Pest Management Regulatory Agency have recently concluded that the domestic use of one of the most commonly used phenoxy herbicides, 2,4-D, does not entail an unacceptable risk of harm to human health.

TABLE 1 Estimated numbers of cancer cases and deaths annually attributable to environmental carcinogens to which Canadians are commonly exposed

Exposure	Most likely cancer sites	Estimated attributable annually ^a		Comment
		Cases	Deaths	
Ultraviolet radiation	Skin and lip	70,000 ^b	450	Solar UVR is the major environmental risk factor for skin and lip cancers. Phenotype and exposure factors, such as age, intensity and duration, affect risk.
Environmental tobacco smoke	Lung	280 ^c	252	Environmental tobacco smoke is considered a causal agent in lung cancer. The estimated numbers are for non-smoking Canadians exposed to environmental tobacco smoke.
Radon	Lung	1,589	1,430°	Radon is a cause of lung cancer.

^a Except where indicated, estimates are taken from the individual topic chapters.

^b Estimated at approximately 90% of estimated skin and lip cancers.⁵

Estimated on the basis of 90% case fatality rate.⁵

TABLE 2

Exposure levels that result in very small increases in cancer risk in the Canadian population

Exposure	Most likely cancer sites	Comment
Organochlorine insecticides	Sarcoma, lymphoma, leukemia	Many of the organochlorine insecticides used in Canada in the past are now considered to be known or suspected animal carcinogens. The limited epidemiological evidence regarding a number of organochlorine insecticides generally supports the toxicological evidence of an association with cancer.
Air pollution	Lung	Slightly increased risks of lung cancer are associated with exposure to highly polluted air. In general, air pollution in Canada is not severe enough to pose a significant cancer threat.
Nickel mining and processing	Respiratory	Risks are related primarily to high levels of exposure to certain nickel compounds encountered in the work environment in the past. The general population risk from the extremely small concentrations detectable in ambient air is negligible.

Electromagnetic fields

Electric and magnetic fields, both of which are forms of non-ionizing radiation, are ubiquitous in Canada. Sources include electrical equipment, power lines and household appliances. IARC rates extremely low-frequency magnetic fields as possibly carcinogenic to humans and extremely lowfrequency electric fields as not classifiable as to their carcinogenicity to humans. There is limited evidence in humans for the carcinogenicity of extremely low-frequency magnetic fields in relation to childhood leukemia.¹⁶

III Exposures for which the epidemiological evidence is inadequate for assessing carcinogenicity in humans

In IARC's classification, inadequate epidemiological evidence means that the available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence or absence of a causal association between exposure and cancer, or no data on cancer in humans are available (Table 4).⁴

Disinfection by-products

To prevent water-borne diseases, most municipal Canadian water supplies are disinfected with chlorine. During water disinfection, chlorine reacts with organic material in the water, producing a number of by-products, including trihalomethanes (THMs). Several studies of cancer incidence in human populations have reported associations between long-term exposure to high levels of disinfection by-products and increased risk of bladder and possibly colon cancer. However, toxicological studies do not support the magnitude of risk observed in the epidemiological studies. A recent summation of the toxicological and epidemiological evidence can be accessed via the Web site of the WHO International Programme on Chemical Safety (IPCS).17 IARC rates chlorinated drinking water as not classifiable as to its carcinogenicity to humans because the evidence for carcinogenicity in both humans and experimental animals is considered inadequate.18

TABLE 3

Exposures for which the epidemiological evidence of human carcinogenicity is limited

Exposure	Most likely cancer sites	Comment
Dioxins	Soft-tissue sarcoma, non-Hodgkin's lymphoma, Hodgkin's disease	For specific groups of organochlorines, the epidemiological evidence of an association with specific cancers is sufficient to warrant concern, such as dioxins and soft-tissue sarcoma, non-Hodgkin's lymphoma and Hodgkin's disease. Toxicological studies have demonstrated that 2,3,7,8- Tetrachlorodibenzo- <i>para</i> -dioxin (TCDD) is carcinogenic.
Electromagnetic fields	Leukemia	Some studies of high exposures suggest an association with leukemia; however, others show no such association. There is inadequate evidence that residential exposures to electric or magnetic fields are associated with increased cancer risks for adults. In particular, evidence is inconclusive as to whether living close to a source of EMF (e.g., power lines) increases one's risk of developing cancer.
Phenoxy herbicides	Non-Hodgkin's lymphoma and soft-tissue sarcoma	Epidemiological studies suggest associations with phenoxy herbicides; however, this finding is not supported by the toxicological evidence obtained using animal studies.

TABLE 4 Exposures for which the epidemiological evidence is inadequate for assessing human carcinogenicity

Exposure	Most likely cancer sites	Comment
Disinfection by-products	Bladder	The sum of evidence, especially from studies with the most detailed exposure assessments, supports a modest increase in risk of bladder cancer after many years of exposure. However, toxicological data do not support the magnitude of risk observed in epidemiological studies.
Pulp and paper milling	Various	Several compounds found in bleached pulp mill effluent are mutagenic and have been identified as mammalian carcinogens in laboratory studies. Studies of both workers and communities nearby pulp and paper mills have failed to produce conclusive results.
Gold and copper mining and processing	Lung and stomach	Some associations between lung and stomach cancer and gold and copper mining were found primarily in early studies of workers before the introduction of methods to reduce dust exposure. Conclusions linking cancer to exposures in gold and copper mining and processing are not possible.

The pulp and paper industry

Although several chlorinated organic compounds found in bleached pulp mill effluent are mutagenic and proven carcinogens in mammals, epidemiological studies of pulp and paper mill workers and nearby communities have failed to produce conclusive results. IARC rates exposures from pulp and paper manufacture as not classifiable as to their carcinogenicity to humans.¹⁹

Gold and copper mining

Conclusions linking cancer to exposures generated by gold and copper mining and processing are not yet possible.

General considerations

No single epidemiological study should be expected to provide the definitive answer regarding the carcinogenic potential of an environmental exposure. Thus, despite the often large number of studies reviewed, the need for further research is a recurring theme for most of the topics examined here. However, the types of research required differ across exposures. For ultraviolet radiation and environmental tobacco smoke, risk-reduction research as well as etiological research into other cancer sites is called for. For the three exposures that result in small increases in risk at typical exposure levels for Canadians (organochlorine insecticides, air pollution and nickel mining and processing), ongoing monitoring of exposure levels is important. For those exposures where the potential to cause cancer in humans is still in question, etiological research is a priority. For many of these exposures, further etiological research awaits methods-development research, particularly in relation to exposure assessment.

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Preface

The Public Health Agency of Canada's Canada's Centre for Chronic Disease Prevention and Control produces and communicates cancer surveillance findings and their implications for cancer control policies and programs. In 1998, a review committee recommended that the Centre (then housed within Health Canada) compile and disseminate results of cancerrelated work funded under the Government of Canada Green Plan program. Initiated in December 1991, the Green Plan program was the federal government's environmental agenda in the 1990s. In addition, the Federal-Provincial-Territorial Advisory Committee on Environmental and Occupational Health recommended improving the identification and assessment of factors in the environment that influence health.

Researchers with expertise in specific subject areas were asked to provide material for a supplement that would review the epidemiological literature on the risk of cancer, if any, associated with some Canadian exposures. The text was received, reviewed for scientific accuracy and edited over the next few years. Each section retained its own style and can stand alone as an essay on its topic. Introductory and summary sections were written to present important concepts and to tie the document together, and a glossary was added. However, the views expressed remain those of the authors rather than the Public Health Agency of Canada. This supplement to Chronic Diseases in Canada is the result of the process.

This is a technical document most suited to the information needs of the many parties interested in environmental health and members of the cancer control community, especially health professionals, policy makers and researchers. In particular, students and teachers in the health sciences may find this a useful introduction to the area of environmental cancer epidemiology.

Finally, a work of this magnitude and complexity takes a long time to produce.

Introduction

This supplement assesses the epidemiological evidence relating ten environmental exposures to cancer causation. Environmental exposures are defined broadly as those that are not a lifestyle choice (such as diet and smoking), are ubiquitous (e.g., ultraviolet radiation and air pollution) and/or involve involuntary exposure (e.g., occupational exposures, industrial pollution and environmental tobacco smoke). Although biological agents (e.g., bacteria, protozoa, viruses, fungi, algae, dust mites, and allergens, such as pollen) are a class of environmental exposures/hazards, they are not dealt with here.

The material in this supplement is organized into four main sections: radiation, chemicals, air pollution and industry. The radiation section includes chapters on radon, ultraviolet radiation and electromagnetic fields. The chemicals section includes organochlorines, disinfection byproducts and pesticides. The air section includes environmental tobacco smoke and air pollution. The industry section includes chapters on pulp and paper mills and gold, nickel and copper mining and processing. Occupational exposures are included for three reasons: First, the pulp and paper and metal mining industries are prominent in Canada. Second, occupational epidemiology is closely related to environmental epidemiology in that the exposure and disease experiences of workers can be extrapolated to give an estimate of the degree of risk associated with non-occupational exposures to the same substances. Third, occupational studies are particularly valuable in instances where too few community studies are available to provide an estimate of the degree of risk to the general population. For example, most of the information on the hazards of radiation from exposure to radon gas derives from occupational studies.

The exposures discussed arise from both the "natural" and "built" (i.e., constructed or human-made) environments.³ Ultraviolet radiation and radon are examples of the former, whereas by-products of the disinfection of water, electromagnetic fields, pesticides, air pollution and environmental tobacco smoke arise primarily from the built environment. However, it is acknowledged that exposures are often the interaction of factors in both environments.

Also, several of the topics are not mutually exclusive. For example, the disinfection of water as well as the pulp and paper industry both produce organochlorines, and several pesticides are organochlorines. As well, workers in metal mining are not infrequently exposed to radiation from radon decay products and environmental tobacco smoke is a component of air pollution.

Estimating cancer risk from the environment in Canada

Incidence, contaminant sources and exposure variation

Excluding non-melanoma skin cancer, approximately 160,000 Canadians are diagnosed with cancer each year and half that many die from it.¹ Cancers of the lung, breast, prostate, colon and rectum account for over half of all cancers diagnosed in Canada. Lung cancer is the most common cancer cause of death in either sex, accounting for over a quarter of cancer deaths. The most common cancer among women is breast cancer, accounting for 30 percent of new cases, while the most common cancer among men is prostate cancer, accounting for one quarter of new cases. Although cancer is primarily a disease of older Canadians (with 69 percent of new cancer cases and 82 percent of deaths occurring among those who are at least 60 years old), it attacks all ages, including infants.²

Public opinion polling conducted at the outset of this publication showed that a major concern of Canadians in relation to their health in general—and to cancer in particular—is environmental pollution. Although most Canadians believe that air is the primary route by which environmental contaminants reach us, Canadians are exposed to environmental contaminants primarily through food. Food accounts for 80 to 95 percent of our total daily intake of persistent organic pollutants, air for between 10 and 15 percent and, for most persistent substances, soil and drinking water contribute less than five percent.³

The nature and degree of exposures to environmental hazards vary significantly from region to region across Canada and by many factors such as age, sex, occupation and eating habits. Also, the potential of a specific exposure to cause harm depends on a variety of factors, including exposure levels (duration and concentration), inherent toxicity, the route by which individuals take in the contaminant (e.g., ingestion versus inhalation) and the susceptibility of different groups. The very young, the elderly, people with weakened immune systems and native populations are particularly susceptible.³ Children can be more vulnerable to environmental contaminants because of their rapid growth and metabolic immaturity, as well as their greater food, air and fluid intake relative to body weight.⁴ Native populations are particularly susceptible because of the tendency of many organic pollutants to concentrate in colder northern climates and contaminate fish and other wildlife on which these populations depend for sustenance.

Risk investigations

Estimates of the degree of risk associated with exposure to environmental contaminants depend upon various types of investigation. Since environmental exposures are low for both radiological and chemical hazards, risk levels are rarely detectable from direct observational studies of human populations.⁵ For effects such as cancer, it is often difficult to estimate exposure or demonstrate cause and effect in the general population because cancer takes a long time to develop and multiple factors may be involved in its onset. Sources of variability in epidemiological studies include physiological parameters (such as body weight, respiratory rate and cardiac output, which can vary among individuals), routes of exposure, uncertainties in exposure estimates, errors in disease diagnosis and the effects of confounding factors.

Toxicology experiments, typically performed in laboratories on non-human models, are used widely to identify possible human health hazards (especially for chemicals) and to determine, for specific substances, the levels of exposure that present little or no risk to humans. Highly sensitive tests are available to examine a variety of deleterious effects, including tests of acute and chronic toxicity in animals, metabolism of chemicals, reproductive and developmental effects, and long-term carcinogenic effects.⁵

Biological markers are useful in the study of chemical hazards. These are biochemical changes that indicate that an exposure has occurred, but that are not necessarily linked to a clinically harmful effect. These markers may be studied to evaluate exposure, health effects or susceptibility, to assess intra- and inter-subject variability, to clarify mechanisms, or to identify dose-response relationships. Their ultimate usefulness is the extent to which they can predict disease occurrence.⁵

Structure/activity relationship studies use the chemical structure of a compound to predict toxic or carcinogenic effects. Predictions are often based on the known behaviour of similar compounds, considering specific properties and attributes. However, while such classification rules are useful, they are not perfect predictors of health effects.⁵

Extrapolations are used to relate the results of tests involving high doses of substances in different species to relatively low doses of substances in humans. Similar models for quantitative risk assessment are used for both radiation and chemicals.5 For genotoxic carcinogens, such as ionizing radiation and certain types of chemicals that cause cancer by damaging DNA, it is assumed that there is a probability of harm at any level of exposure (in other words, it is assumed that there is no threshold for effects). Although dose-response curves may be non-linear at high doses, it is generally assumed that the dose-response curve for ionizing radiation and genotoxic chemicals is linear at low doses. Risks at low doses are therefore predicted from effects observed at high doses using what is known as the linear, non-threshold hypothesis (LNTH). This assumption has been widely used in cancer risk assessment in the absence of convincing evidence to the contrary. For other substances, including chemicals that cause cancer but do not damage DNA (non-genotoxic carcinogens), it is assumed that there is a threshold dose below which adverse effects are unlikely to occur.

Although epidemiology and toxicology are useful for estimating risk, both have limitations that can result in considerable uncertainty. For example, when human risks are estimated using animal toxicology, some uncertainty is introduced from the

extrapolation of effects seen at the high doses used in laboratory studies to potential effects at the lower exposure levels experienced by humans in everyday life.3 Results from studies of people exposed to particular contaminants in the workplace may not apply to people exposed in other settings because the health effects observed at high levels of exposure may not occur at lower levels. Thus, when performing risk assessments, a range of possible risks is considered, as indicated by a careful analysis of all sources of uncertainty in the data, and conclusions are generally based on appropriately conservative interpretations. Such uncertainties are believed to be smaller for ionizing radiation than for genotoxic chemical hazards.

Information sources

It should be noted that the data cited in this supplement, including the toxicology data, were obtained from the published literature only. It is acknowledged that extensive additional databases for the chemicals cited exist within regulatory agencies, including Health Canada, and that their data may not support the conclusions in this supplement. However, current legislation restricts access to these databases as they contain proprietary data supplied by manufacturers.

Three sources that were relied upon heavily as background material for this introduction are recommended for further reading. The first is Health and Environment: Partners for Life,³ a Health Canada publication that describes our current understanding of the relationship between human health and the Canadian environment. It focuses on contaminants that are of particular concern to the health of Canadians, notes the progress made in reducing levels of environmental contamination and describes the impact that either the human-made or built environments can have on our health. The report also provides practical suggestions for things that individuals can do to protect and enhance their own health, and notes some emerging issues and future challenges 5. related to health and the environment.

A second major resource is Assessment and Management of Cancer Risks from *Radiological and Chemical Hazards*,⁵ produced jointly by Health Canada and the Atomic Energy Control Board of Canada (now the Canadian Nuclear Safety Commission). This publication describes the risk assessment and management processes used to protect the public from radiation, chemicals and microbiological hazards.

Thirdly, *It's Your Health*,⁶ a component of Health Canada's Web site, provides periodic updates on topics relating to the health of Canadians, including the relationship between some environmental exposures and cancer. Readers interested in the topics discussed here may wish to look at the sections for dioxins and furans, electric and magnetic fields, occupational exposure to radiation and PCBs.

The following chapter discusses general principles and some of the methodological challenges in environmental cancer epidemiology.

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Basic Concepts in Epidemiology

Several of the exposure-specific chapters that follow deal with methodological issues unique to the exposure being examined. This chapter briefly sets out general principles and strategies in environmental cancer epidemiology and uses specific exposures to illustrate concepts. These concepts provide context for the critiques of the evidence that are contained in the exposure reviews and may be helpful for readers not familiar with epidemiological methods. Detail on methods can be found in publications devoted to environmental epidemiology, medicine and statistics.¹⁻⁹

Types of evidence from epidemiological studies

For both ethical and practical reasons, studies to investigate the effects of environmental exposures on human populations must be observational rather than experimental. Unlike the experiment, where only the agent of interest is manipulated and all other extraneous factors are held constant, the observational study must contend with the difficulty of identifying, measuring and controlling (either by design or analysis) the many factors, other than the one of interest, that could influence outcome. In addition, measuring both the exposure and the disease outcome can be problematic. The ability of an epidemiological study to provide accurate risk estimates depends heavily on the strength of its design and the types of information it uses.

A strong study design uses accurate measurements that result in little misclassification, controls extraneous factors that could confound the results and permits causal inference. General criteria for concluding that a relationship is causal rather than only an association include a strong association, consistency, specificity, a relationship in time, a biological gradient (doseresponse effect), biological plausibility and coherence of the evidence.9 Generally speaking, the stronger the association, the less likely it is to have occurred as a result of chance or to be the result of confounding by another factor. An association that has been repeatedly observed by different persons in different places, under different circumstances and over time is considered to be consistent and unlikely the result of some constant error or fallacy that permeates every enquiry. Specificity is a more difficult concept. Suffice it to say that an association that is limited to specific individuals and to particular sites and types of diseases is a strong argument in favour of causation. Demonstration that the suspected causal factor preceded the effect (and is consistent with the known latency of the disease) is further evidence for a causal association, as is a biological gradient or dose-response effect (i.e., the greater the exposure, the higher the risk of disease). Biological plausibility lends further strength to the argument for causation, but often cannot be demonstrated; what is biologically plausible depends upon the biological knowledge of the day. And finally, coherence means that the causeand-effect interpretation of an association should not seriously conflict with the generally known facts of the natural history and biology of the disease. In his discussion of this criterion. Hill gives the example that the association of lung cancer with cigarette smoking is coherent with the temporal rise in the two variables and with the sex difference in both smoking rates and mortality from lung cancer.9

In terms of the strength of a design, a continuum extends from descriptive analyses (useful for formulating hypotheses) to the "natural experiment" (in which an exposure has occurred to a defined group of people who can be compared to a similar group of individuals not exposed). In between, lie study designs that yield evidence of varying degrees of strength. These approaches are described below.

Ecological (or *cross-sectional*) *studies* relate cancer mortality or incidence *rates* (usually age- and sex-adjusted) with characteristics of regions. The units of analysis in these studies are populations or groups,

rather than individuals. Thus, the ecological design provides no information on the relationship between exposure and disease at the individual level. The measure of association is the correlation coefficient. Values for the correlation coefficient range from -1 through 0 to +1, representing, respectively, a perfect negative correlation, no relationship and a perfect positive relationship. Example of ecological studies could be the rates of bladder cancer of various communities by water supply (chlorinated municipal water as opposed to well water), or skin cancer rates of communities with different average numbers of hours of sunlight per day.

Although this study design can be a useful preliminary step in investigating an association between disease and a suspected causal factor, the evidence it provides for a cause-effect relationship is relatively weak for at least three reasons. First, a relationship that applies with respect to groups of people does not necessarily apply at the individual level. This is referred to as the ecological fallacy. For example, it is conceivable that people who developed bladder cancer used well water rather than chlorinated municipal water even though they lived in communities with a chlorinated water supply. Second, to impute a cause-and-effect relationship, the suspected "cause" must precede the effect. If both "cause" and "effect" are measured at the same time, there is no assurance that the cause has preceded the effect. This is a particular problem in cancer epidemiology where a long latency between exposure and the development of cancer is the norm. Third, there is little opportunity in this type of study design to control for other factors, besides the study factor, that could affect outcome. For example, if the population of the sunnier communities tended to be more prone to skin cancer (e.g., have fair skin), than those of the less sunny communities, an apparent relationship between average daily sunshine exposure and skin cancer could be overestimated.

In *case-control studies*, individuals with the disease of interest are compared with individuals without the disease on factors being investigated as potential causes. The measure of association in this context is

the odds ratio (OR). When the control group is representative of the general population with respect to the suspected causal factor, the odds ratio provides a good estimate of the degree of risk of the disease for persons with the attribute relative to those without it. For example, an odds ratio of two means that the risk of disease for persons with the attribute is approximately twice the risk for those without it. The case-control design is stronger than the ecological design for the three reasons mentioned above: the unit of analysis is the individual, a time interval between exposure and disease onset can be approximated, and information on a variety of other factors can be collected. It may be weaker than other designs discussed below in that measurement of the potential exposure factors can be limited. The case-control study is of particular value for diseases, such as cancer, that are relatively rare.

A cohort is a group of persons who share a common experience within a defined time period. In cohort studies, the disease status of individuals known to be exposed to a particular factor is determined at a later date and compared to the disease status of individuals known not to have been exposed. The measure of association in the cohort study is the relative risk (RR). This is the risk of disease in the exposed group, expressed as a rate, divided by the risk in the unexposed group. The cohort study is often much more costly than the casecontrol study when the disease is rare because a very large number of people must be included in order to accumulate a sufficiently large number of participants with the outcome of interest. Also, depending upon the time between the exposure and the disease, selective losses to follow-up can be a major weakness.

A *nested case-control study* is a case-control study conducted within a cohort. For example, workers in a factory (the cohort) who have developed cancer can be compared with those who have not, in terms of their specific jobs and/or exposure to the agent of interest. This study design can benefit from the advantages of both the case-control and cohort approaches in that similar information is collected for both the case-control study is especially useful where

biological specimens have been procured in a cohort study, particularly if they can provide data on biological markers of exposure, susceptibility or disease natural history.

The *natural experiment* is one that arises from the activities of humanity. It is a variant of the cohort design, and one in which a group of individuals exposed to an event that would not normally occur without the actions of humankind—a nuclear accident, for example—are then followed for disease occurrence relative to individuals not exposed. For example, much of the information we know about the effects of radiation exposure has been derived from follow-up studies of individuals exposed to radiation fallout from the atomic bombings of Hiroshima and Nagasaki.

It is not uncommon for the different types of studies of an exposure-disease relationship to yield different results. A cause-effect relationship is increasingly likely if various study designs, executed in different populations, suggest the same relationship (even though the strength of the relationship may differ) and if the association increases with the magnitude of the exposure (i.e., a doseresponse relationship is observed).

The results of multiple epidemiogical studies are often aggregated using two techniques: a *meta-analysis* and *a pooled analysis*. A meta-analysis produces a weighted average of risk estimates from previously published studies. Studies are often weighted on the basis of the variability of the risk estimates or to reflect in some other fashion the quality of the studies. A pooled analysis combines the original data on individual exposures and outcomes from multiple studies. It is methodologically generally preferred to a meta-analysis.

Measuring outcome

Cancer epidemiology studies can use either incidence or mortality as a measure of outcome. Mortality information is often more readily available because mortality data are part of the vital statistics that most countries collect. Cancer mortality data approximate incidence data for cancers that are highly fatal. Mortality data are less useful in epidemiological studies for cancers where mortality is low since factors, other than those that cause cancer may contribute to death from cancer and, thus, obscure the etiology. Also, use of cancer mortality information usually limits the amount of other information that can be collected, such as occupational and residential histories, and behaviours such as smoking.

One way of obtaining more comprehensive exposure information is through studies using incident cancer cases and personal interviews. This greater detail and precision renders incidence studies better able to detect relationships than mortality studies. Canada is fortunate to have the Canadian Cancer Registry as part of a national cancer registration system to which all provinces and territories contribute information.¹⁰

Measuring exposure

In order to estimate risk, it is important to assess the amount of exposure to the person, group or area being monitored. Exposure assessment can be either direct or indirect. An example of direct exposure measurement is the use of radiation monitors worn by workers. Indirect exposure assessment includes predicting exposure from levels monitored in various media (air, water, food, soil) and reconstructing historical exposure patterns (e.g., by using job classifications and exposures known to be associated with specific jobs).

Examples of exposure indices in order of increasing accuracy are as follows: 1) a binary categorical assessment (when, in fact, there are a range of individual exposures); 2) a matrix of categories associated with a person's exposure, along with a length of exposure; 3) subject-specific exposure measurements; 4) the effective biological dose received by an individual; and 5) extending the previous index to incorporate information on the genetic susceptibility of the individual to the dose received. Cumulative exposure is a commonly used index, calculated by multiplying exposure intensity by duration of exposure.

Assessment of exposure to any environmental contaminant is difficult because the general population is often not aware of specific exposures and may have difficulty remembering proxy indicators of exposure, such as residential history, drinking water sources and dietary intakes from 10 to 40 or more years ago. Environmental measurements may not be available for the earlier periods. Thus for many studies there has been an element of misclassification. To the extent that this misclassification is nondifferential (e.g., random error), elevated risks probably represent an underestimation of the true risk. Where misclassification is systematic (e.g., the tendency of persons with the disease to report exposures of concern more often than those without the disease), overestimation of risk is likely to occur. This is referred to as *exposure bias*.

Controlling extraneous factors

Controlling extraneous factors that can distort the risk estimate is one of the biggest challenges in epidemiology and various design and analysis strategies have been developed for this purpose. One design approach is to restrict participant inclusion so that the study groups are as homogeneous as possible and sources of variability are reduced. One example is the inclusion of people of one sex and/or within a limited age range. A second approach is matching, whereby controls are selected for inclusion in the study if they match individual cases on certain attributes (e.g., age group and sex). A third approach is to collect as much descriptive information about the study participants as possible so that the study groups can be compared to determine how similar they are on factors other than those of interest. A factor that differs between the comparison groups and is associated with the outcome of interest is a potential confounder which can distort the relationship being studied. Analytic strategies for controlling potentially confounding factors involve mathematical models to adjust the risk estimate for the distorting effects of the confounders. Direct and indirect ageadjustment of rates, logistic regression, multiple linear regression and the Cox proportional hazards model are some of these techniques.

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Glossary

The chapters in which each item is discussed are given in brackets, using the legend: AP (Air Pollution), DB (Disinfection By-Products), EF (Electromagnetic Fields), ET (Environmental Tobacco Smoke), MM (Metal Mining), OC (Organochlorines), PE (Pesticides), PP (Pulp and Paper), R (Radon), UR (Ultraviolet Radiation). Where no chapters are indicated, the term is considered generic to environmental cancer epidemiology.

Although chemical compounds can have several names, only one is given here for each. Very complex names are not included. Where possible, the CAS (Chemical Abstract Service) registration number is provided in brackets at the end of each entry. This number can be used to search for information on a compound.

The Canadian spelling ("ph") is used in the glossary whenever there is an option of "ph' or "f" even though the "f" variant may appear in the text at the discretion of the author and particularly when referring to a product name.

 μ g/L: Micrograms per liter. For aqueous (water) samples 1 μ g/L is equal to one part per billion (*ppb*).

1,1-dichloro-2,2-bis(p-chlorophenyl) ethylene (DDE): $(C_{14}H_8Cl_4)$. The stable breakdown product of DDT that is a persistent widespread environmental contaminant, is readily stored in fatty tissues, and has been identified in human tissues such as blood and milk. (72-55-9) (*OC*, *PE*)

1,1,1-trichloro-2,2-bis(4-chlorophenyl) ethane/dichlorodiphenyltrichloroethane (DDT): $(C_{14}H_9Cl_5)$. An organochlorine implemented largely during WWII as an insecticide to control body lice and insect vectors of malaria and typhus, and subsequently used for agricultural purposes. Its registration for use in Canada was discontinued in 1985. Although DDT is no longer manufactured in North America, trace amounts still enter our environment as a result of leakage from waste sites and long-range transport in the atmosphere. (50-29-3) (*OC*, *PE*)

1,2-dibromo-3-chloropropane (DBCP): $(C_3H_5Br_2Cl)$. An organohalide fungicide/ fumigant and nematicide. Any that leaches into surface water evaporates within a few

days. In air, it takes several months to break down, and it may remain in soil for several years. Exposure is mainly from consuming contaminated water or food. (96-12-8) (*PE*)

1,3-dichloropropane: $(C_3H_6Cl_2)$. A contaminant of soil fumigants containing 1,3-dichloropropene. It is rarely found in water and is of low toxicity. (142-28-9) (*PE*)

1,3-dichloropropene: $(C_3H_4Cl_2)$. Used in Canada as a soil fumigant to control fungi and nematodes. A colourless liquid at room temperature, it is soluble in water and evaporates quickly from it and from soil into air, where it is broken down by sunlight. It may leach into and travel in ground water. Trade name is Telone II. (542-75-6) (*PE*)

1,3,7-trichlorodioxins: By-product contaminants of some pesticides. (*PE*)

2,3,7,8 congener: (C₈H₅Cl₃O₃). 2,3,7,8-TCDD. The most toxic congener of TCDD. (93-76-5) (*PE*)

2,3,7,8-TCDD: See 2,3,7,8, congener.

2,3,7,8-tetrachlorodibenzo-p-dioxin: First discovered as a by-product of chlorinated phenol production in the 1950s, TCDD was industrially produced as the by-product of manufacture of 2,4,5-trichlorophenol. It is the most potent carcinogen known to some animals, and is known to bind to some human receptors. (1746-01-6) (*PE, OC, PP*)

2,4-D acid: Acid form of 2,4-D. (PE)

2,4-D: See 2,4-dichlorophenoxyacetic acid.

2,4-dichlorophenoxyacetic acid (2,4-D): $(C_{s}H_{6}Cl_{2}O_{3})$. One of the chlorophenoxyacetic acid herbicides. Its crystals are prismatic, white to pale yellow in colour, and have a phenolic-like odour. A chlorinated phenoxy compound that functions as a systemic herbicide and is used to control many types of annual and perennial broadleaf weeds in fruit, vegetable, turf, and ornamental plantings. It serves a secondary purpose as a plant growth regulator and is applied to crops to induce rooting and blossom set, to control ripening of bananas and citrus fruits, and to prolong fruit life on the tree. As with 2,4,5-T, 2,4-D chemically stimulates

plant growth hormones, causing uncontrolled cell proliferation. It contains chlorine, thus posing a risk for dioxin formation, as seen with its use as one of the ingredients of Agent Orange. There are many forms or derivatives (esters, amines, salts) of 2,4-D and these vary in solubility and volatility. (94-75-7) (*OC*, *PE*)

2,4,5-T: See 2,4,5-trichlorophenoxyacetic acid.

2,4,5-trichlorophenol (TCP): $(C_6H_3Cl_3O)$. An organochlorine precursor of 2,4,5-T that is structurally similar to phenoxy herbicides and is used as an antiseptic and fungicide/ fumigant. A yellow solid, also known as Omal, 2,4,6-T, and Phenochlor, it is broken down in 1 to 9 days by sunlight and by bacteria in soil. (95-95-4) (*PE*)

2,4,5-trichlorophenoxyacetic acid (2,4,5-T): $(C_8H_5Cl_3O_3)$. A chlorophenoxyacetic acid herbicide that was used in Canada in the past as a defoliant to control undesirable brush and woody plants. The crystals can be formulated as soluble or emulsifiable concentrates and are white and pale brown in colour. It should be stated which salt or ester is present: i.e., 2,4,5-T-trolamine; 2,4,5-T-triethylammonium. (93-76-5) (*OC, PE*)

3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX): A very potent mutagen and genotoxic compound in laboratory animals; it has also been shown to be carcinogenic in rats. MX appears to account for about one third of the mutagenicity of chlorinated drinking water, as determined in *in vitro* tests.

4-aminobiphenyl: *See* Para-aminobiphenyl (PAB).

4-chloro-2-methylphenoxy acetic acid (MCPA): $(C_9H_9ClO_3)$. A systemic phenoxy herbicide used to control annual and perennial weeds (including thistle, dock, buttercup and horsetail) in cereals, grasslands, trees and turf. The herbicide works by concentrating in the actively growing regions of a plant where it interferes with protein synthesis, cell division and ultimately the growth of the plant. It should be stated which acid, salt or ester is present. (94-74-6) (*PE*)

A priori: Based on an hypothesis or theory rather than on experiment or experience. Heuristic.

Acetic acid: (CH₃COOH). A colourless pungent liquid that is the chief acid of vinegar; may be a component of vapours emitted from wood pulp. (*PP*)

Acryl group: $(C_3H_3O_2)$. An unsaturated group that is part of compounds such as acrolein, acrylonitrile, acrylic acid.

Additivity: A mathematical model based on the assumption that the combined effects of several factors is the sum of the effects that would be produced by each of the factors in the absence of others.

Adduct: A complex that forms when a chemical binds to a biological molecule, such as DNA or a protein.

Adenocarcinomas: Tumours in which the cancerous cells are arranged in the form of glands. Cancers of the lung, stomach, pancreas, prostate gland, and ovary are most often adenocarcinomas.

Adjusted odds ratio: An odds ratio that represents the association between two factors after the effects of other confounding effects have been mathematically removed.

Adjustment: A summarizing procedure for a statistical measure in which the effects of differences in composition of the population being compared are minimized. (*PE*)

Aerated stabilization basin: A water basin with an on-going flow of air bubbles, used to treat waste water. (*PP*)

Aerosol: A gaseous suspension of fine solid or liquid particles, such as paint, a detergent, or insecticide, packaged under pressure with a gaseous propellant for release as a spray of fine particles.

Aerosolize: Disperse as an aerosol. Radon daughters, which are solid particles, disperse into the atmosphere as an aerosol.

Age-adjusted rates: A mathematical procedure designed to minimize the effects of

differences in age composition when comparing rates for different populations. In direct adjustment, the observed age-specific rates in the two populations are applied to a third "standard" population with a known age structure to calculate the expected number of deaths in each of the comparison populations. Indirect adjustment is the mirror image of direct adjustment and is used when the rates in the populations to be compared are either unstable or unknown. In this situation, the expected numbers of deaths in the study populations are calculated by applying the standard population age-specific rates to the study populations.

Agent Orange: A code name for the orange band that was used to mark the drums in which a herbicide, developed for the military, was stored. Primarily for use on broadleaf foliage, such as the dense jungle found in Southeast Asia, Agent Orange was a 50-50 mix of 2,4-D and 2,4,5-T. The earliest health concerns about Agent Orange were about the product's contamination with TCDD. (*OC*)

Ah: See Aryl hydrocarbons.

Ah receptor: A receptor that binds a wide variety of aromatic compounds, including polycyclic hydrocarbons, among which are dioxins (e.g., TCDD), dibenzofurans, and biphenyls (PCBs). Detectable in many tissues and organs, the Ah receptor is responsible for mediating the carcinogenic effects of these agents. (*OC*)

Alachlor: 2-chloro-2',6'-diethyl-*N*-methoxymethylacetanilide ($C_{14}H_{20}$ ClNO₂). An aniline herbicide used to control annual grasses and certain broadleaf weeds in crops such as field corn and soybeans. It is a selective systemic herbicide, absorbed by germinating shoots and by roots. (15972-60-8) (*PE*)

Aldehydes: Organic chemical compounds belonging to a class of highly reactive substances obtained mainly by the oxidation of primary alcohols. Aldehydes are characterized by the group – CHO and are used industrially in the manufacture of resins, dyes and other organic compounds. (*PP, PE*) **Aldicarb:** 2-methyl-2-(methylthio)propionaldehyde*0*-methylcarbamoyloxime ($C_7H_{14}N_2O_2S$). A broad spectrum, systemic oxime carbamate insecticide and nematicide that is the most toxic of the carbamate insecticides. (116-06-3) (*PE*)

Aldrin: $(C_{12}H_8Cl_6)$. A cylcodiene insecticide. Aldrin is the name for material containing 95% pure compound. The pure compound has the common name HHDN. Aldrin degrades to dieldrin quickly in the body and the environment. Once used around the world to control soil insects and mosquitoes, in the 1970s its use was restricted to licensed pest control operators for the removal of underground termites. Today it is no longer manufactured or used in Canada. (309-00-2) (*PE*)

Aliphatic: Saturated or unsaturated hydrocarbon compounds of the open chain formation. (*PE*)

Alkaline oxide: See Hypochlorite.

Alkyl bromide: An alkyl halide with one or more bromine atoms in its structure. (*PE*)

Alkyl halide: A chemical compound made up of an alkyl group (C_nH_{2n+1}) and a halide atom. Halides are compounds containing a halogen atom (chlorine, bromine, fluorine and iodine). (*PE*)

Alkylation: A chemical reaction in which a hydrogen atom in an organic compound is replaced by an alkyl group (C_nH_{2n+1}) . (*PE*)

Alpha particle: A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). The most energetic alpha particle will generally fail to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. (*R*, *MM*)

Ambient: A term used to describe the surrounding environment.

Ames reversion assay: A quantitative measurement of the mutagenicity of a chemical substance by the Ames test. The greater the number of bacterial colonies that grow in the presence of the chemical, the more mutagenic the chemical. (*PE*)

Ames test: A test for mutagenicity of chemical compounds that uses a special strain of the bacterium, *Salmonella typhimurium*. The bacteria are incubated in the presence of the suspected mutagen. Growth of bacterial colonies indicates mutagenicity of the chemical. (*PE*)

Amides: Compounds with the formula RCONH₂. (*PE*)

Amines: A class of organic compounds having a nitrogen atom attached to a carbon framework by single bonds. (*PE*)

Aminotriazole: See Amitrole.

Amitrole: 1-*H*-1,2,4-triazol-3-ylamine ($C_2H_4N_4$). A triazole herbicide that is applied as a liquid. Trade names include Amerol, Amino Triazole, Amitrol, Amizine, Amizol, Azolan, Azole, Cytrol, Diurol, and Weedazol. (61-82-5) (*PE*)

Ampere: A unit for measuring the rate of flow of an electric current, defined in terms of the force which a current produces. Approximately one ampere of current is required to produce 100 watts of electric power. (*EF*)

Amphibole: Any of a group of rock-forming silicate minerals, including hornblende and asbestos. (*MM*)

Androgen receptor: A member of the subfamily of steroid hormone receptors. The gene for this receptor is localized on the human X chromosome. Androgens enter the cells by passive diffusion and bind to the androgen-binding domain of the receptor, initiating the production of androgen-specific proteins.

Angiosperms: Flowering plants and trees that form seeds inside a protective chamber called the ovary; includes hardwood trees, such as oak and maple. (*PP*)

Anilides: When aniline is heated with an organic acid, amides called anilides are produced. Commercially they are used as herbicides, such as alachlor, propachlor, pentanochlor and propanil. (*PE*)

Aniline: (Phenylamine C_6H_7N). A benzene ring with an amine (NH_2) group attached to one of the carbons in the ring. A degradation product of anilides. Pure aniline is a highly poisonous, oily, colourless substance with a pleasant odor. (62-53-3) (*PE*)

Anion: A negatively charged ion. (*AP*)

Ankerite: $Ca(Mg,Fe^{+2},Mn)(CO_3)_2$. A mineral belonging to the carbonate group, related to dolomite. (*MM*)

Antibody: A globulin (protein insoluble in water) in the blood or other body fluids which can be incited by the presence of an antigen.

Antibody producing cells: After encountering stimulating antigenic signals, B lymphocytes develop into plasma cells which produce antigenic-specific antibody molecules.

Antigen: A foreign substance that stimulates an immune response.

Antigenic transplanted UV related tumours: UV-induced tumours in the skin of rats or mice are antigenic and are rapidly rejected when transplanted into normal, genetically similar animals. If the tumours are transplanted into animals previously exposed to subcarcinogenic doses of UV-B, they are not rejected and instead grow progressively in the recipients. While the mechanism of suppression of tumour rejection is unknown, such a response might be a critical determinant of cancer risk in human skin. (*UR*)

Aramite®: Sulphurous acid, 2-chloroethyl 2-(4-(1,1 dimethylethyl)phenoxy)-1-methyl ester ($C_{15}H_{23}ClO_4S$). A colourless liquid organochlorine insecticide. (140-57-8) (*PE*)

Arithmetic mean: Sum of all values in a set of measurements, divided by the number of values in the set.

Aromatic amines: Amines in which one of the organic groups is an aromatic ring. (*PE*)

Aromatic compounds: A term applied to a large family of compounds structurally similar to benzene; i.e., a closed ring. (*OC*, *PE*, *PP*)

Aromatic hydrocarbons: Aromatic compounds made up of only carbon and hydrogen atoms. (*OC, PE*)

Aromatic ring: See Aromatic compounds.

Arsenic: (As). A highly poisonous chemical element having three allotropic forms, yellow, black, and grey, of which the brittle, crystalline grey is the most common. Arsenic is widely distributed in nature uncombined or in association with ores of antimony and silver. Extracted from arsenopyrite, arsenic and its compounds are used in insecticides, weed killers and various alloys. (*R*, *PE*, *MM*)

Arsenopyrite: (FeAsS). A primary source of arsenic. Arsenopyrite can be found in veins of lead or silver. (*MM*)

Aryl: A group derived from an aromatic hydrocarbon by removal of a hydrogen atom from the molecule. (*PE*)

Aryl hydrocarbons: (Ah). Aromatic hydrocarbons with a hydrocarbon group attached to the ring structure. (*OC*)

Ascertainment bias: Systematic failure to represent equally all classes of cases or persons supposed to be represented in a sample.

Atrazine: 6-chloro-N²-ethyl-N⁴-isopropyl-1,3,5-triazine-2,4-diamine ($C_{14}H_{20}$ ClNO₂). A chloro triazine herbicide used to control broadleaf and grassy weeds in corn. It acts as a strong inhibitor of photosynthesis and is soluble in water. It is used as a nonselective, granular soil sterilant and can remain in the soil for two years. It has a high potential for ground water contamination. (1912-24-9) (*PE*)

Autosomal: Referring to the non-sex chromosomes.

Autosomal dominant pattern (of inheritance): The pattern of inheritance in which a trait or disease will be expressed in an organism when only one member of a gene pair (rather than both) on a non-sex chromosome contains the DNA code that carries that trait or disease. In a recessive pattern, both genes of the pair must be affected for the trait/disease to be expressed.

Auxin growth regulators: Chemical compounds that act as synthetic auxins or plant hormones, altering the plant's metabolism and hence growth characteristics (e.g., chlorophenoxy herbicides). (*PE*)

Axon: The part of a neuron that carries nerve impulses away from the nerve cell body to other nerve cells or effector organs.

Axonic poisons: Poisons that damage axons. (*PE*)

Azinphos-methyl: $(C_{10}H_{12}N_3O_3PS)$. A white crystalline solid that is one of the most toxic of the organophosphate insecticides. It has low persistence in soil, the half life being 21 to 68 days under anaerobic conditions. It is unlikely to contaminate ground water and degrades in UV light. Use is being phased out in Canada. (86-50-0) (*PE*)

Backcasting: A method of estimating what might have happened in the past that relies on existing trends and statistics. (*AP*)

Basal cell carcinoma: The most common malignant skin tumour in Caucasians, basal cell carcinoma begins to occur in significant numbers in the fourth decade of life and increases with age. The lesions occur in fair-skinned persons and on areas of skin that receive a significant amount of intermittent or continuous sun exposure. Treatment with inorganic arsenical drugs and exposure to ionizing radiation (X- rays, radium) may also contribute fewer than five % of these cases. These cancers rarely metastasize but may be highly invasive locally. (*UR*)

Bayesian inferences: This method for inference involves working "backward" from effect to cause by estimating the conditional probability of a cause given that certain events have occurred. (*AP*)

Benomyl: Methyl-1-(butylcarbamoyl) benzimidazol-2-yl carbamate $(C_{14}H_{18}N_4O_3)$. A protective and eradicant benzimidazole fungicide and nematicide effective against a wide range of fungi, such as apple scab and black spot that affect fruits, nuts, vegetables, turf, and field crops. All uses have been discontinued. (17804-35-2) (*PE*)

Benzene: (C_6H_6) . A thin, colourless, highly flammable liquid that is a coal-tar derivative used in the manufacture of numerous chemical products, including insecticides, detergents and motor fuels; commonly called benzol. (*PP*)

Benzene ring: Six carbon atoms forming a ring to which are attached six hydrogen atoms. (*PP*)

Benzimidazole: A compound having a benzene ring fused to an imidazole ring. It is a weak base and remarkably stable. It resists acids and bases and is not easily oxidized. (51-17-2) (*PE*)

Benzimidazoles: A group of compounds having benzimidazole in their structure, including benomyl, carbendazim, thiabendazole, thiophanate and thiophanate-methyl. They are used as fungicides/fumigants. (*PE*)

Benzoic acid: Benzenecarboxylic acid, a fungistatic compound widely used as a food preservative. (65-85-0) (*PE*)

Benzoics: Aryl aliphatic acids that are used as herbicides (e.g., Dicamba). They are applied to soil to prevent germination, or as a post-emergent herbicide. (*PE*)

Benzo[a] pyrene: A type of polycyclic aromatic hydrocarbon, or PAH, that is probably carcinogenic to human beings. (*ET*)

Beta rays/particles: A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Large amounts of beta radiation may cause skin burns, and beta emitters are harmful if they enter the body. Beta particles may be stopped by thin sheets of metal or plastic. (R)

Bioconcentrate (bioaccumulate): A chemical present at infinitesimal concentrations in air or water may be increasingly concentrated as it moves up the food chain, until humans eating meat or fish ingest relatively high concentrations. Such chemicals enter the bodies of plants and animals, are not easily expelled, and accumulate over time.

Biodegradable: Can be chemically degraded using natural effectors such as soil bacteria, weather, plants or animals. Bacteria are considered "a biodegradable detergent" because they break down substances in the soil for resorption and uptake in the natural environment.

Biomarkers: A biological indicator (e.g., a genetic locus or a biochemical) useful for measuring the effects of a particular hazardous exposure (e.g., cotinine). Once an exposure has occurred, a continuum of biological events can be detected. These events may serve as indicators of exposure, of susceptibility, or of effect. For example, metabolites of exogenous substances may be detected in the body and indicate exposure. An important metabolite of heptachlor is heptachlor epoxide, which is an oxidation product formed from heptachlor by many plant and animal species.

Biota: Animal and plant life characterizing a given region.

Biotite: Black or dark-coloured mica (a mineral that divides into thin, partly transparent layers, withstands heat, and is used for insulation). (*MM*)

Biphenyl: An aromatic hydrocarbon, also known as diphenyl, that is composed of two benzene rings. It is used alone or with diphenyl ether, as a heat-transfer fluid. Pure biphenyl is a colourless crystalline solid with a pleasant odour; it is insoluble in water but soluble in ordinary organic solvents. (*OC*)

Bisdithiocarbamate: A class of fungicide used on potatoes, fruits and vegetables (e.g., Mancozeb). (*PE*)

Blind assessment: The person doing the assessment does not know whether the subject is a case or control.

Boron compounds: Compounds containing boron (B), a non-metallic chemical element. (*PP*)

Brachiopod crustaceans: Small invertebrate, predominantly aquatic animals, having segmented bodies covered with an exoskeleton and two coiled arms called brachia on either side of the mouth, used to draw in food-bearing water; includes lobsters, shrimps, crabs, barnacles, wood lice. (*PP*)

Bromide: A compound of bromine with a positive radical. (*DB*)

Bromine: (Br). In its diatomic form, Br_2 , bromine is a deep reddish brown liquid at room temperature, but if exposed to air, will emit a pungent brown coloured vapour. Like chlorine, bromine is a halogen. It is found naturally in seawater and saline springs, though at small concentrations. Bromine is used as a fire retardant and pesticide and to make brominated organic compounds. (*DB*)

Bromodichloromethane: (CHBrCl₂). Methane (a colourless, odourless, flammable gas) that has one bromine and two chlorine atoms in place of the hydrogen atoms. Bromodichloromethane is a product of the reaction between chlorine and naturally-occurring organic matter in water. (*DB, PP*)

Bromoform: (CHBr₃). A volatile organic compound found in chlorinated water supplies as a consequence of the reaction between chlorine during water treatment and natural organic substances in the presence of bromide ion. One of the four compounds constituting trihalomethanes. (*DB*)

Bromoxynil: 3,5-dibromo-4hydroxybenzonitrile ($C_7H_3Br_2NO$). A nitrile herbicide. Trade names: Brominal, Buctril. It is used on grain, vegetables and grass for post emergent control of broadleaf weeds (1689-84-5). It should be stated which salt or ester is present: Bromoxynil-potassium (2961-68-4) or bromoxynil-octanoate (1689-99-2). (*PE*)

Bronchiolitis obliterans: Dense, irreversible scarring of the terminal and respiratory bronchioles of the lung. This scarring may partially or totally close off the airway. (*PP*)

Butylate: S-ethyl-di-isobutylthiocarbamate ($C_{11}H_{23}NOS$). A thiocarbamate herbicide used on corn. The half-life under crop growing conditions is 1.5-3 weeks. All uses have been discontinued in Canada. Trade name: Sutan (2008-41-5) (*PE*)

Calcinate: To heat (a substance) to a high temperature but below the melting or fusing point, causing loss of moisture, reduction, or oxidation and the decomposition of carbonates and other compounds. (*PP*)

Calcining: Heating an inorganic substance to a high temperature, but not high enough to melt or fuse it, in order to bring about evaporation of certain matter in it or cause chemical changes such as oxidation. Limestone is calcined to produce lime. (*MM*)

Calcite: (CaCO₃). A mineral composed of calcium carbonate. It occurs as limestone, chalk, marble etc. (*MM*)

Calcium carbonate: $(CaCO_3)$. An inorganic chemical found in nature as calcite (limestone, chalk, marble, etc.) and aragonite (a crystalline carbonate of lime) and in plant ashes, bones etc. (*PP*)

N-(1,1,2,2-

Captafol/captofol:

tetrachloroethylthio) cyclohex-4-ene-1, 2-dicarboximide ($C_{10}H_9Cl_4NO_2S$). A broadspectrum dicarboximide fungicide, also called Captafol and Difolatan, that is effective for the control of almost all fungal diseases of plants, except powdery mildews, and is widely used to control foliage and fruit disease. Captafol is also used in the lumber and timber industry. (2425-06-1) (*PE*)

Captan: *N*-(trichloromethylthio)cyclohex-4-ene-1,2-dicarboximide ($C_9H_8Cl_3NO_2S$). A dicarboximide fungicide powder used to control diseases on many fruit, ornamental, and vegetable crops. It is used in agricultural production as well as by the home gardener. It is also applied to packing and shipping boxes for fruits and vegetables. (133-06-2) (*PE*)

Carbamates: Derivatives of carbamic acid that inhibit cholinesterase (ChE) and are used as insecticides. Many are designated as N-Methyl carbamates; others have an amide functional group with substituents other than a methyl group. (*PE*)

Carbamic acid: (H_2 NCOOH). A compound that exists only in the form of salts or esters (carbamates), amides (carbamides), and other derivatives. (*PE*)

Carbaryl: 1-naphthyl methylcarbamate $(C_{12}H_{11}NO_2)$. Also known as Sevin. A wide-spectrum, general use carbamate pesticide that controls insects on citrus, fruit, cotton, forests, lawns, nuts, ornamentals, shade trees, and other crops, as well as on poultry, livestock and pets. It is also used as a molluscicide and an acaricide. (63-25-2) (*PE*)

Carbathiin: See Carboxin.

Carbofuran: 2,3-dihydro-2,2-dimethyl benzofuran-7-ylmethylcarbamate $(C_{12}H_{15}NO_3)$. A carbamate insecticide of lesser toxicity than aldicarb. (1536-66-2) (*PE*)

Carbon tetrachloride or tetrachloromethane: (CCl_4) . A colourless oily, incombustible liquid; formerly used as a cleaning agent, but no longer recommended because of its toxicity to the liver and kidney. *(PP)*

Carboximide: A class of fungicides that includes Carboxin and Folpet. (133-07-3) (*PE*)

Carboxin: 5,6-dihydro-2-methyl-1,4-oxathiine-3-carboxanilide ($C_{12}H_{13}NO_2S$). A systemic anilide fungicide used as a seed treatment for control of smut, rot, and blight on barley, oats, rice, cotton, vegetables, corn and wheat. One of the leading fungicides in Canada, carboxin is also used to control fairy rings on turf grass. (5234-68-4) (*PE*)

Carcinogen: An agent capable of initiating development of malignant tumours. May

be a chemical, a form of electromagnetic radiation, or an inert solid body.

Case: A person in the population or study group identified as having the particular disease or condition under investigation. Various sources may be used to identify cases (e.g., physicians' diagnoses, cancer registries and notifications, and abstracts of clinical records).

Case-control study: A study that starts with the identification of persons with the disease or other outcome of interest, and compares them to a suitable control group (comparison or a reference group) of persons without the disease.

Cation: A positively charged ion. (AP)

CDKN2A: A germline mutation at human chromosome 9p21 present in 10–15% of individuals developing two or more independent melanomas. The mutation is also present in many families with two or more affected first degree relatives. At the present time, these germline mutations are thought to be transmitted from one generation to another in an autosomal dominant pattern, with variable penetrance, and individuals with them appear to be at high risk for the disease. (*UR*)

Cell cycle: An ordered set of events, culminating in cell growth and division into two daughter cells. These events include protein synthesis, DNA replication, DNA repair and mitosis (cell division).

Cell signaling cascade: A chain of events, initiated by an environmental agent, that leads to aberrant cell proliferation and carcinogenesis.

Cellulose: $(C_6H_{10}O_5)_n$. The main constituent of the cell walls of plants. (*PP*)

Chalcopyrite: (CuFeS₂). The most common mineral containing copper, found in porphyry copper deposits, skarns, contact metamorphism, hydro-thermal vents and other places. Consists of a sulphide of copper and iron. (*MM*)

Chinese hamster: An animal whose cells (ovary, lung, bone marrow etc.) are isolated

and cultured for use in tests to determine the outcome of hazardous exposures (e.g., pollutants, herbicides). (*PE*)

Chip chute: A piece of machinery that feeds logs into a heavy, vertically rotating disk where they are shredded into small chips. (*PP*)

Chloracne: A skin disease that is one of the most sensitive indicators of exposure to dioxins and related chemicals. Clinically it is a persistent acne on the cheeks and behind the ears. (*OC, PP, PE*)

Chloramination: Treating drinking water by applying chlorine before or after applying ammonia. (*DB*)

Chloramines: (CH₃C₆H₄SO₂NClNa – 3H₂O). Compounds formed by the reaction of hypochlorous acid (or aqueous chlorine) with ammonia for the purpose of water disinfection. Mono-, di-, and trichloramines may be formed depending on the ratio of chlorine to ammonia, the pH, and the temperature of the water. (*DB*)

Chlordane: $(C_{10}H_6Cl_8)$. An organochlorine (cyclodiene) insecticide that can cause potentially fatal neurotoxic symptoms, such as muscle spasms and seizures. It is no longer registered as an active ingredient in Canada. (57-74-9) (*PE*)

Chlordecone: $(C_{10}Cl_{10})$. A cyclodiene insecticide used on tobacco, ornamental shrubs, bananas and citrus trees and in ant and roach traps. It breaks down slowly in the environment and does not readily dissolve in water. (143-50-0) (*PE*)

Chlorinated cyclodienes: A group of organochlorines (including dieldrin, mirex, chlordecone – kepone) that are stable in soils and under solar UV radiation and hence are persistent insecticides. Their toxicity increases with the environmental temperature. (*OC*, *PE*)

Chlorinated ketones: Ketones in which the hydrogen atom(s) is/are replaced by an equal number of chlorine atoms. Ketones are a group of compounds having a carbonyl group (CO) linked to hydrocarbon groups. (*DB*)

Chlorinated organic compounds/chemicals/ hydrocarbons/synthetics: Compounds having one or more chlorine atoms in place of a hydrogen atom. (*PP, OC, PE*)

Chlorination: The process of adding chlorine to water, for the purpose of disinfection. (*DB*)

Chlorine: (Cl). Normally existing in its gaseous diatomic form, Cl_2 , chlorine is produced for industry principally by electrolysis of sodium chloride (salt), and is used as a disinfectant and bleaching agent, as well as to disinfect water. Chlorine gas can combine with nearly all other elements, and especially with water, causing it to be highly irritating to the lungs and other mucous membranes at high levels when inhaled. However, under normal conditions of use, the inhalation of mists or vapours from dilute chlorine solutions is not expected to be significant or to result in any health effects in the general population. (PP, DB)

Chlorine dioxide: (ClO_2) . A gas generated through the reaction of sodium chlorite and chlorine or by acidification of strong sodium chlorite solution. ClO_2 is a highly effective, environmentally-friendly microbiocide that eliminates planktonic and sessile bacteria, disinfects surfaces, and destroys biofilms. *(PP, DB)*

Chlorite: A salt of chlorous acid. (MM)

Chloroacetanilide: A benzene ring where one hydrogen atom is replaced by the – NHCOCH₃ group and also having one or more hydrogen atoms replaced by chlorine atoms. (*PE*)

Chlorodibromomethane: *See* Dibromochloromethane.

Chloroform/chloroformtrichloromethane: (CHCl₃). A volatile organic compound found in water as a consequence of the reaction between chlorine and naturally-occurring substances. One of the four compounds constituting trihalomethanes. (*DB, PP*)

Chloronitrile: A nitrile having one or more chlorine atoms in its structure. (*PE*)

Chlorophenols: Organic chemicals in which one or more hydrogen atoms of phenol are replaced by one or more atoms of chlorine. Chlorophenols are formed as a result of the chlorination of humic matter or of natural carbonoxylic acids during the treatment of water. They are well-known chlorination by-products, since they can confer objectionable taste and odour. Chlorophenols are also a class of pesticides with widespread use. There are 19 chlorophenol congeners, many of which are used in Canada in pesticide products or wood preservatives. (*PP, PE, DB*)

Chlorophenoxyacetic acid herbicides: Chlorophenoxyacetic acid is synthesized from phenol (a benzene ring with a hydroxyl group on the ring) and acetic acid. The chlorinated derivatives include 2,4-D and 2,4,5-T which would have two and three chlorine atoms on the ring respectively. (*OC, PE*)

Chloropicrin: Trichloronitromethane (CCl_3NO_2) . A clear, colourless, oily liquid with a strong, sharp, highly irritating odour used primarily for preplant soil fumigation to control soil borne fungi, diseases and nematodes. It also is used to treat wood poles and timbers for internal decay by fungi and insects. (76-06-2) (*PE*)

Chlorothalonil: Tetrachloroisophthalonitrile ($C_8Cl_3N_2$). An aromatic fungicide sprayed on vegetables, trees, small fruits, turf, ornamentals, and other agricultural crops. It also controls fruit rot in cranberry bogs and snow moulds and is used in paints. (1897-45-6) (*PE*)

Chlorotriazine: $(C_3Cl_3N_3)$. Colourless crystals that react violently with water. Decomposes when heated or burned to produce toxic fumes including hydrogen chloride and nitrogen oxides. (*PE*)

Chlorovanillins and chlorosyringols: Aromatic or low molecular weight compounds that are by-products of the degradation of lignin using alkaline or chlorine treatment. (*PP*)

Chloroxanthins: Xanthine (2,6-dihydroxypurine) is found in tea and in animal tissues. Chloroxanthines (having one or more chlorine atoms as substituents) are toxic by-products of some pesticides. Purine is an aromatic heterocyclic compound. (*PE*)

Chlorpyriphos: *O*,*O*-diethyl *O*-3,5,6-trichloro-2-pyridylphosphorothioate ($C_9H_{11}Cl_3NO_3PS$). An organothiophosphate that acts by interfering with the activities of cholinesterase, an enzyme essential for the proper working of the nervous systems of both humans and insects. Chlorpyrifos is a contact dust, foam or liquid spray used against flying and non-flying insects such as hornets, wasps, ants, cutworms, fungus gnats and spiders. (2921-88-2) (*PE*)

Cholinesterase: One of many important enzymes needed for the proper functioning of the nervous systems of humans, other vertebrates, and insects. Certain chemical classes of pesticides, such as organophosphates (OPs) and carbamates (CMs) work by interfering with, or 'inhibiting' cholinesterase. While the effects of cholinesterase inhibiting products are intended for insect pests, these chemicals can also be poisonous, or toxic, to humans in some situations. (*PE*)

Chromate: A salt or ester of chromic acid. (*PP*)

Chromic acid: A solution of potassium dichromate in sulphuric acid. It is a strong oxidant, commonly used as a cleaning agent. *(PP)*

Chromosome 14q32 (or Band 14q32): A genetic locus on human chromosome 14 (an autosomal chromosome).

Chromosome 18q21: A genetic locus on human chromosome 18 (an autosomal chromosome).

Chromosome breaks: Chromosomes break and rearrange with heterologous and homologous chromosomes during both types of cell divisions (mitosis and meiosis).

CMM: See Cutaneous malignant melanoma.

Co-kriging: A version of kriging that predicts more than one response. (*AP*)

Co-mutagens: Mutagens that act together or synergistically.

Cobalt: (Co). A silver-white metallic element with a pinkish tint that occurs with and is similar to nickel and iron, used especially in alloys and for making pigments. (*MM*)

Cohort study: A study in which subsets of a defined population are identified who are, have been, or in the future may be exposed to the agent under investigation. The identified individuals are followed over time for the occurrence of disease.

Conazole: The active part of these compounds is the triazole ring which is a Cytochrome P450 inhibitor. A triazole ring is a five-membered ring of two carbon atoms adjacent to each other, and three nitrogen atoms. (*PE*)

Confidence interval (CI): A range of values for a variable of interest having a specified probability of including the true value of the variable (e.g., 95%). The end points of the confidence interval are called the confidence limits.

Confounder: A variable/factor, related to both the outcome of interest and the study factor, that can obscure the relationship being studied.

Confounding: A mixing of effects between the exposure, the disease, and a third factor (confounder) that is associated with the exposure and independently affects the risk of developing the disease.

Congeners: A group of chemical substances that share chemical properties and structure. They are derivatives of the same or a similar compound or element belonging to the same family in the periodic table. Unlike isomers, congeners do not necessarily have the same molecular formula. (*OC, PE*)

Conifer: Trees or shrubs bearing their seeds in cones (e.g., pines, spruces, firs, hemlocks, junipers and cypresses). (*PP*)

Contact metamorphism: The alteration of a rock due to the introduction of heat (no pressure effects), from an adjacent igneous rock (such as a lava flow). Contact metamorphism does not affect the entire rock, just a relatively thin zone next to the heat source. (*MM*)

Control: (noun) A person in a comparison group without the factor of interest – exposure in a cohort study, disease in a case-control study. (verb) During analyses, to adjust for or take into account extraneous influences and observations. (adjective) A "control variable" is a variable which has a potential effect on the outcome or disease under study, and which is subject to control by analysis. *See* Confounder.

Coplanar PCBs: PCBs with atoms arranged in a single plane, resembling dioxins, and with dioxin-like activity via binding with the Ah receptor. (*OC*)

Correlate: (noun) A variable that changes as another variable changes. (verb) Show the connection or relationship between two variables.

Correlation: The degree to which variables change together; the mutual relation of two or more things.

Correlation coefficient: A measure of association that indicates how closely two variables are linearly related.

Cotinine: $((C_6H_{12}N_2O_2)_2 C_4H_4O_4)$. A major urinary metabolite of nicotine, used as a biomarker of exposure to tobacco smoke. *(ET)*

Coumaphos: $(C_{14}H_{16}ClO_5PS)$. An organothiophosphate insecticide of moderate to high toxicity. All uses have been discontinued in Canada. (56-72-4) (*PE*)

Covariance: A measure of the joint variance of two or more variables.

Covariate: A variable that is possibly predictive of the outcome of the study. A covariate may be of direct interest to the study or may be a confounding variable or effect modifier.

Cox proportional hazards model: A statistical model in survival analysis that relates the time until death (survival time) to a series of measurements thought to influence an individual's survival.

Credible regions: Sets that contain an uncertain quantity or vector of uncertain quantities with a specific probability. (*AP*)

Creosote: A complex organic mixture produced from coal that contains more than 300 compounds, including polycyclic aromatic hydrocarbons (PAHs), which account for up to 90% of the total mixture. Creosote is one of the most popular wood preservatives used in Canada. (*PE*)

Cummingtonite: $((Mg, Fe)_7 Si_8 O_{22} (OH)_2)$. A common member of the amphibole mineral group, that contains more magnesium than iron. (*MM*)

Curie (Ci): The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion (3.7x10¹⁰) disintegrations per second, which is approximately the activity of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second. It is named for Marie and Pierre Curie, who discovered radium in 1898. (*MM*)

Cutaneous malignant melanoma (CMM): See melanoma. (*UR*)

Cyanazine: 2-(4-chloro-6-ethylamino-1,3,5-triazin-2-ylamino)-2-methyl propionitrile $(C_9H_{13}ClN_6)$. A triazine herbicide used for pre- and post-emergence weed control for corn, canola and mixed grains. All uses have been discontinued in Canada. (21725-46-2) (*PE*)

Cyclodines (cyclodienes): Chlorinated hydrocarbon insecticides (such as chlordane, aldrin, dieldrin, heptachlor, endrin and mirex). Cyclodienes have a positive temperature correlation – their toxicity increases with increases in the surrounding temperature. Cyclodienes appear to affect all animals in generally the same way, first with nervous activity followed by tremors, convulsions and prostration. (*PE*)

CYP1A1 gene: A gene whose enzyme induction and DNA adducts in placental tissue constitute useful biomarkers of early effects induced by environmental exposure to organochlorines. The gene is activated

by the binding of organochlorines to the Ah receptor. (*OC*)

Cytochrome: A respiratory enzyme, chemically related to haemoglobin, capable of alternate reduction and oxidation. (*OC*)

Cytochrome P450: A cytochrome that has been studied to monitor the bioaccumulation of dioxins and furans. Specifically, cytochrome P450IAI can be used as a measure of Ah receptor activation resultant from environmental exposure. (*OC*)

Daphnea: Minute freshwater brachiopod crustaceans. (*PP*)

DBCP: See 1,2-dibromo-3-chloropropane.

DBPs: *See* Disinfection by-products.

DCM: See Dichloromethane.

DDE: *See* 1,1-dichloro-2,2-bis (p-chlorophenyl) ethylene.

DDT: *See* 1,1,1-trichloro-2,2-bis (4-chlorophenyl) ethane.

Deoxyribonucleic acid (DNA): The basic hereditary material in all cells. DNA contains all the information necessary for protein synthesis. (*R*)

Diallate: S-2,3-dichloroallyl di-isopropyl (thiocarbamate). A thiocarbamate herbicide that inhibits growth of broad-leaf weeds, such as wild oats, in croplands. (2303-16-4) (*PE*)

Diazinon: *O*,*O*-diethyl *O*-2-isopropyl-6methylpyrimidin-4-yl phosphorothioate $(C_{12}H_{21}N_2O_3PS)$. Also known as dimpylate. An organothiophosphate insecticide used on outdoor lawns and gardens or as a soil drench to control most insects, such as ants, cutworms, gnats and springtails. Diazinon is a colourless oil that is stable in sunlight and unstable in acid and alkali media. It can pollute surface and ground waters. (333-41-5) (*PE*)

Dibenzofurans: Furans with two benzene groups attached to carbon atoms that normally bind hydrogen. (*OC*)

Dibromochloromethane: (CHBr₂Cl). A volatile organic compound found in chlorinated water supplies as a consequence of the reaction between chlorine during water treatment and naturally occurring substances. (*DB, PP*)

Dicamba: 3,6-dichlororo-*o*-anisic acid $(C_8H_6Cl_2O_3)$. Also known as Disugran and dianat. A benzoic herbicide used in large quantities for broad leaf weed control on lawns, grain crops, pastures and non-crop areas. It should be stated which salt or ester is present: dicamba-dimethylammonium (2300-66-5), dicamba-potassium (10007-85-0), dicamba-sodium (1982-69-0), or dicamba-methyl (6597-78-0). *(PE)*

Dichlorodiphenyltrichloroethane (DDT): A synthetic insecticide that was introduced for agricultural purposes in 1945. Although DDT is no longer manufactured in North America, trace amounts still enter our environment as a result of leakage from waste sites and long-range transport in the atmosphere. Registrations of the remaining uses of DDT in Canada were discontinued in 1985. (*OC, PE*)

Dichloromethane (DCM)/methylene chloride: (CH_2Cl_2) . A colourless liquid with a sweet, chloroform-like odour, used as a solvent in a variety of industries and as a fumigant for strawberries and grains. (75-09-2). (*PP*)

Dichlorvos: 2,2-dichlorovinyldimethylphosphate ($C_4H_7Cl_2O_4P$). An organophosphate insecticide used in no-pest strips. (62-73-7) (*PE*)

Diclofop-methyl: Methyl 2-[4-(2,4-dichlorophenoxy) phenoxy] propanoate $(C_{16}H_{14}Cl_2O_4)$. A diphenylether/chlorphenoxy selective post-emergence herbicide. (51338-27-3) (*PE*)

Dieldrin: ($C_{12}H_8Cl_6O$). A cyclodiene insecticide that was a popular pesticide for crops such as corn and cotton. It breaks down very slowly. In the 1970s use was restricted to licensed pest control operators for the removal of underground termites. Dieldrin is no longer registered for use in Canada. (60-57-1) (*PE*)

Digester fluid: A digester is a vessel in which substances are softened or decomposed, usually for further processing. In chemical pulping, chips and chemicals (sulphates or sulphites) in aqueous solution are cooked together in a pressure vessel (a digester) from which de-lignified pulp is produced for further processing. The cooking mixtures are also called "liquors" (white or black, depending on the process used). (*PP*)

Dimethoate: *O*, *O*-dimethyl-Smethylcarbamoylmethyl phosphorodithioate $(C_5H_{12}NO_3PS_2)$. Also known as phosphamide, dimethoate has many trade names. An organothiophosphate insecticide and nematicide used on field and orchard crops and on ornamentals, as a residual wall spray for house flies in farm buildings, and to control botflies on livestock. It is biodegradable and breaks down quickly in soils. In water it is highly soluble and therefore subject to leaching. (60-51-5) (*PE*)

Dimethyl sulphide: A reagent used in the wood pulping process to break down the carbon bonds in lignin. (*PP*)

Dimethylbenz[a]anthracene: A polycyclic aromatic hydrocarbon (PAH) in tobacco smoke. (*ET*)

Dimethylcarbamoyl chloride: (C_3H_6 ClNO). A colourless liquid that decomposes in the presence of water to dimethylamine, carbon dioxide and hydrogen chloride. Three registered pesticides derived from it are Tandex (Karbutilate), dimethilan and Pirimor (primicarb). It is an air pollutant and a chemical intermediate in the production of dyes, pharmaceuticals and pesticides. (79-44-7) (*PE*)

Dinitroaniline herbicides: Also known as dinitrobenzenamines, these herbicides act by inhibiting the steps in plant cell division responsible for cell wall formation and chromosome separation. The most commonly used dinitroanalines in Canada are trifluralin and ethalfluralin; both are selective, pre-emergence herbicides used to control annual grasses and broadleaf weeds in a variety of crops. (*PE*)

Dinitrobenzenamines: A group of compounds having two hydrogen atoms of the benzene ring replaced by nitro groups (NO_2) and another hydrogen atom replaced by an amino group. (*PE*)

Dioxins: *See* Polychlorinated dibenzo-p-dioxins.

Diphenyl aliphatics: Aliphatic compounds having two phenyl groups as part of their structure. (*PE*)

Direct standardized comparison: A mathematical method for removing the potential confounding effect of age when comparing rates in two populations with differing age structure. The observed age-specific rates in the two populations are applied to a third "standard" population with a known age structure to calculate the expected number of deaths in each of the comparison populations.

Disinfection by-products (DBPs): A group of chemicals that can form in drinking water when chlorine or another disinfectant reacts with the naturally occurring organic matter. Examples of DBPs are haloacetic acids and trihalomethanes. (*DB*)

Dithiocarbamates: Typically fungicides with a carbamate structure, where sulphurs replace both oxygens in the amide functional group. They are also used as accelerators in the vulcanization of rubber, as antioxidants in polymer chemistry, and as drugs. The most frequently used dithiocarbamate fungicide in Canada is mancozeb. (*PE*)

Diuron: 3-(3,4-dichlorophenyl)-1,1-dimethylurea (C₉H₁₀Cl₂N₂O). Also known as dichlorfenidim, trade names include Crisuron, Diater, Di-on, Direx, Karmex and Unidron. A phenylurea herbicide used to control broadleaf and grassy weeds as well as mosses by inhibiting photosynthesis on field and orchard crops and ornamentals. It is moderately to highly persistent in soils and relatively stable in water. (330-54-1) (*PE*)

DNA: See Deoxyribonucleic acid.

DNA adduct: DNA modified by external chemicals added onto its molecule. (*OC*)

Dolostone: A sedimentary rock composed of more than ninety percent dolomite $(CaMg(CO_3)_2)$ and less than ten percent calcite $(CaCO_3)$. (*MM*)

Dose, absorbed: The amount of energy from ionizing radiation deposited in any substance per unit mass. It is expressed numerically in grays (the international system of units).

Dose, effective: A measure of the total potential harm from ionizing radiation over different organs, expressed in Sv (sieverts) or mSv (millisieverts). It is obtained by summing the products of the *equivalent dose* multiplied by the tissue weighting factor for each organ. Weighting factors account for the different potentials for adverse effects in different tissues.

Dose, equivalent (or biological dose): A measure, expressed in sieverts (Sv), of the potential biological damage to living tissue from various types of ionizing radiation exposure. It is obtained by summing the products of the *absorbed dose* of each radiation type multiplied by its weighting factor. Weighting factors account for the different potentials for adverse effects of the different types of radiation.

Dose-response relationship: A relationship in which a change in amount, intensity and duration of exposure is associated with a change – either an increase or a decrease – in a specific outcome.

Dysplastic nevus syndrome: A hereditary condition in which affected family members have dysplastic (abnormally developing) nevi (moles) and greatly increased risk of malignant melanoma. (*UR*)

Ecologic(al) correlation: A correlation in which the units studied are populations rather than individuals. Correlations found in this manner may not hold true for the individual members of the population(s).

Ecologic(al) fallacy: Bias that may occur because an association observed between variables on an aggregate level may not

represent the association that exists at an individual level.

Ecologic(al) study: Study in which the units of analysis are populations or groups of people rather than individuals.

Effluent: The liquid waste of sewage and industrial processing. (*PP*)

Electrical field: A space throughout which an electric force operates. (*EF*)

Electrical field strength: The force on a stationary positive charge per unit charge at a point in an electric field. Also known as electric field vector, electric field intensity. Electric fields are measured in volts per metre (V/m). (*EF*)

Electrolytic tanks: Tanks containing an electrolyte (a substance, such as water, that conducts electricity by dissociation into positively and negatively charged ions) and negatively and positively charged electrodes apart from each other. Positive ions in the electrolyte migrate to the negative electrode (cathode), where they combine with one or more electrons; negative ions move to the positive electrode (anode) and transfer one or more electrons to it. Used in the extraction and purification of metals from ores, in electroplating, and to separate compounds (e.g., NaCl (salt) into sodium metal and chlorine gas). (*MM*)

Electromagnetic field (EMF): Electrical devices and systems produce two different fields— an electric field and a magnetic field. These fields, in combination, are referred to as electromagnetic fields or EMFs. Electromagnetic fields are generated by current-carrying electric wiring, (especially if the conductors are apart, as in the wiring in old homes, or are poorly grounded), radio or TV station transmitters, microwave ovens, power transmission lines and generators, and electrical appliances, especially those with electric motors. (*EF*)

Electron: An elementary particle with a negative charge and a mass 1/1837 that of the proton. Electrons surround the positively charged nucleus and determine the chemical properties of the atom. (*R*)

Endocrine disruptors: Chemical substances that mimic the structure and activity of a natural hormone. It is suggested that some chemicals acting as hormonal disrupters may lead to infertility, some cancers, and other hormonally-induced disorders. (*PE*)

Endrin: $(C_{12}H_8Cl_6O)$. Also known as nendrin. A cyclodiene insecticide that is a highly toxic chlorinated hydrocarbon; if ingested or absorbed through the skin, it can cause potentially fatal neurotoxicity such as tremors and convulsions. Endrin is no longer registered as an active ingredient in Canada. (72-20-8) (*PE*)

Epidermal Langerhans' cells: Langerhans cells can be looked upon as "sentinel" cells of the immune system. They are among the first cells to come into contact with foreign particulate substances encountering the skin. By means of specialized receptors on the cell membrane, the Langerhans cell recognizes invading as opposed to host molecules. By conveying this information to the lymphoid system, the body is able to mount a defensive immunological response to the foreign material. (*UR*)

Epigenetic events: Events that do not initiate a tumour but, rather, influence the time to the appearance of the tumour.

Erythema: An abnormal redness of the skin due to capillary congestion as in inflammation (sunburn). (*UR*)

Ester: A compound resulting from the reaction of an acid with an alcohol, so that the hydrogen of the acid is replaced by the hydrocarbon radical of the alcohol. Animal and vegetable fats and oils are esters. (*PE*, *OC*, *PP*)

Estrogen receptor agonist activity: A chemical compound similar to estrogen (in structure) can bind with estrogen's natural receptor and compete with estrogen for space on the estrogen receptors.

Estrogen receptor-negative cases: Breast cancer cases with levels of estrogen receptor protein equal to or less than 10 fmol/mg; as measured in breast cancer cells.

Estrogen receptor-positive cases: Breast cancer cases with levels of receptor protein above 10 fmol/mg as measured in the cytoplasm of breast cancer cells.

Ethalfluralin/ethyl fluralin: *N*-ethyl- α , α , α -trifluoro-*N*-(2-methylallyl)-2,6-dinitro-*p*-toluidine (C₁₃H₁₄F₃N₃O₄). A dinitroaniline selective pre-emergence herbicide commonly used in Canada to control annual grasses and broadleaf weeds in a variety of crops. Trade names are Sonalan and Curbit. (55283-68-6) (*PE*)

Ethoprop: *O*-ethyl *SS*-dipropyl phosphorodithioate ($C_8H_{19}O_2PS_2$). A thiophosphate insecticide and nematicide. Trade names: Mocap, Ethoporphos, Prophos, Rovokil. It acts by inhibiting photosynthesis and is used on sugar cane, potatoes, tobacco, corn, pineapples, beans and cucumbers and for golf course and industrial lawn applications. (13194-48-4) (*PE*)

Ethyl mercaptan: Mercaptans are thiols. They are analogs of alcohols, having a sulphur atom instead of the oxygen atom in the alcohol. The sulphur atom gives them a strong disagreeable odour, akin to the smell of skunk. Ethyl mercaptan (CH₃CH₂SH) is the analog of ethanol (CH₃CH,OH). (*PP*)

Ethylan: 1,1-dicholro-2,2-bis(4-ethylphenyl) ethane ($C_{18}H_{20}Cl_2$). An organochlorine insecticide. It is also called Perthane and ethyl-DDD. It has been discontinued. Practically insoluble in water. It was used for home mothproofing and for moths and carpet beetles in the dry cleaning and textile industries. It was also used on fruit and vegetable crops. (72-56-0) (*PE*)

Ethylene dibromide: $(C_2H_4Br_2)$. A soil and post harvest fumigant insecticide. (106-93-4) (*PE*)

Ethylene oxide (Oxirane): (C_2H_4O) . Used as a fumigant. (72-21-8) (*PE*)

Etiological period: A period of exposure, prior to the onset of disease, during which the disease process was likely initiated.

Excess relative risk model: A mathematical model derived to calculate relative risks of developing the disease based on

multiplicative effects (multiple causes). The model implies that the risk is greater than the sum of the risks calculated independently.

Exposure-response relationship: The intensity, duration, and the onset of the response (or manifestation) caused by the exposure. The science of toxicology is based on the principle that there is a relationship between a toxic reaction (the response) and the amount of poison received (the dose). An important assumption in this relationship is that there is almost always a dose below which no response occurs or can be measured. A second assumption is that once a maximum response is reached any further increases in the dose will not result in any increased effect. The toxic effects on an organism are related to the amount of exposure.

Extractives: Products of industries that specialize in obtaining natural substances, such as fossil fuels, from the Earth. Extractive industries include mining, and coal and gas production. (*PP*)

Familial atypical multiple mole – melanoma syndrome: *See* Dysplastic nevus syndrome.

Fatty acids: Any of a large group of organic acids made up of molecules containing a carboxyl group (COOH) at the end of a long hydrocarbon chain; the carbon content may vary from C_2 to C_{34} . The more common fatty acid residues that occur in higher plants and animals are palmitic, oleic, linoleic and stearic acids. (*PP*)

Fenitrothion: *O*,*O*-dimethyl *O*-4-nitro-*m*-tolyl phosphorodithioate ($C_9H_{12}NO_5PS$). A thiophosphate insecticide and selective acaricide of low ovicidal properties. (122-14-5) (*PE*)

Fibroblasts: The principal nonmotile cells of connective tissue. Fibroblasts produce an amorphous, gel-like substance that fills the spaces between cells and fibres in connective tissue. (*UR*)

Fibrotic lung: Formation of fibrosis tissue in the lung. (*MM*)

Fluorite: (CaF_2) . A transparent, crystalline mineral that occurs in many colours; calcium fluoride. It is used for fusing metals, making glass etc. (*MM*)

Fmol (femtomole): One quadrillionth of a mole or 10⁻¹⁵ mole.

Folpet: *N*-(trichloromethylthio)phthalimide $(C_9H_4Cl_3NO_2S)$. A carboximide compound and protective foliage fungicide. Its mode of action inhibits normal cell division of a broad spectrum of microorganisms. It is used to control cherry leaf spot, rose mildew, rose black spot, and apple scab. Used on berries, flowers, ornamentals, fruits and vegetables, and for seed- and plant- bed treatment. Also used as a fungicide in paints and plastics, and for treatment of internal and external structural surfaces of buildings. (133-07-3) (*PE*)

Fonofos: *O*-ethyl *S*-phenyl(*RS*)ethylphosphonodithioate $(C_{10}H_{15}OPS_2)$. A soil organophosphate insecticide primarily used on corn. It is also used on sugar cane, peanuts, tobacco, turf, and some vegetable crops. Fonofos controls aphids, corn borer, corn rootworm, corn wireworm, cutworms, white grubs, and some maggots. All uses have been discontinued in Canada. (944-22-9) (*PE*)

Formaldehyde: (CH₂O). An unclassified fungicide and bactericide. (50-00-0) (*PE*)

Formic acid: (CH_2O_2) . A colourless caustic liquid found especially in ants and in many plants and used chiefly in the dyeing industry. (*PP*)

Free radicals: Reactive molecular fragment with one un-paired electron. (*PE*)

Fugitive emissions: Toxic emissions released by the pulp and paper and other industries. They include the group of reduced sulphur compounds (collectively called total reduced sulphur or TRS) and the oxides of sulphur and nitrogen. (*PP*)

Fumigant: Small, volatile, organic molecules that become gases at temperatures above 40°F. They are usually heavier than air and commonly contain one or more of the halogens (Cl, Br, or F). Most are highly

penetrating, reaching through large masses of material. They are used to kill insects, insect eggs, nematodes, and certain microorganisms in buildings, warehouses, grain elevators, soils, and greenhouses and in packaged products such as dried fruits, beans, grain, and breakfast cereals. (*PE*)

Fungicide: An agent that destroys fungi including their spores. (*PE*)

Furans: *See* Polychlorinated dibenzofurans (PCDFs).

Furfural: A furan ring having an aldehyde group attached to it. Furan is a five-member ring having four carbons and one oxygen atom in it. (*PP*)

Galena: (PbS). A grey metallic ore consisting of lead sulphide. It is the most important source of lead. (*MM*)

Gamma rays/radiation: High-energy, short wavelength, electromagnetic radiation emitted from the nucleus. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead or depleted uranium. Gamma rays are similar to X rays. (*R*)

Garnet: A brittle silicate mineral occurring mainly in red crystals. The transparent, deep-red variety is used as a semiprecious gemstone; other varieties are used as abrasives. (*MM*)

Generalized estimating equation: A unified and flexible approach to estimating model parameters when it is not desirable and/or possible to make particular distributional assumptions about the observed data. (*AP*)

Genetic epidemiology: The science that deals with the manifestation, distribution and control of heritable diseases in populations.

Genotoxic effects/genotoxicity: Damage of cellular DNA by a chemical or other agent, resulting in mutations or cancer.

Genotype: An individual's genetic makeup underlying a specific trait or constellation of traits.

Geological-tectonic setting: A description of the conditions (climate, faulting, etc.) that were in force at the particular place and time that the rocks were formed. (*MM*)

Geometric mean: A measure of central tendency based on the logarithm of the individual values.

Germline mutation: A change in the genetic material (DNA) of the germ cells (sperm and ovum) with a potential to transmit the change from one generation to the other.

Glioma: A type of brain cancer. (ET)

Gluconic acid: $(C_6H_{12}O_7)$. A crystalline acid obtained by oxidation of glucose and used chiefly in cleaning metals. (*PP*)

Glutathione depletion: Glutathione is a compound in the body that prevents oxidative stress in most cells and helps to trap free radicals that can damage DNA and RNA. As individuals grow older, glutathione levels drop, and the ability to detoxify free radicals decreases. (*MM*)

Glyphosate: *N*-(phosphonomethyl) glycine $(C_3H_8NO_5P)$. A broad-spectrum non-selective systemic herbicide used to control annual and perennial plants. (1071-83-6) It should be stated which salt or ester is present glyphosate-isopropylammonium (38641-94-0), glyphosate-sesquisodium (10393-85-0), or glyphosate-trimesium (81591-81-3). (*PE*)

Granulomatous lung disease: A granuloma (tumour-like mass or nodule) in the lung. (*MM*)

Gravimetric sampling: A method of quantitative chemical analysis in which the constituent sought is converted into a substance of known composition that can be separated from the sample and weighed, or a weight difference can be applied without any separation. (*MM*)

Gray (Gy): The international system (SI) unit of *absorbed dose*. One gray is equal to an absorbed dose of 1 Joule/kilogram.

Ground water: That portion of the water below the surface of the ground whose pressure is greater than atmospheric pressure. (*DB*)

Guanine: ($C_6H_6N_4O$). One of the bases in DNA and RNA. It is a purine, an aromatic heterocyclic compound made up of two fused rings, a six-membered ring of four carbon atoms and one nitrogen atom with an oxygen attached to one of the carbons and an amino (NH₂) group attached to a nother of the carbon atoms, fused to a five-membered ring that shares two carbon atoms with the six-membered ring. This ring is made up of three carbon atoms and two nitrogen atoms. (73-40-5) (*PE*)

Gymnosperms: Vascular plants that bear naked seeds not enclosed in any specialised chambers such as ovaries. Softwoods, such as pines and firs, are gymnosperms. (*PP*)

Gypsum: $(CaSO_4 \cdot 2H_2O)$. A mineral used for making plaster of Paris, fertilizer, etc.; hydrated calcium sulphate. Alabaster is one form of gypsum. (*MM*)

Half-life: The period required for half of the atoms of a particular radioactive isotope to decay and become an isotope of another element. Half-lives can range from less than a millionth of a second to millions of years depending upon the element concerned. After one half-life, the level of radioactivity of a substance is halved, after two half-lives it is reduced to one quarter, after three half-lives to one-eighth and so on. (*R*)

Halocarbon: Any compound of carbon and one or more halogen (bromine, chlorine, iodine, fluorine) atoms. (*PE*)

Halogen: Any one of the chemical elements, iodine, bromine, chlorine, fluorine and astatine, that combine directly with metals to form salts. The halogens are the most active elements. (*DB*)

Halogenated: Containing one or more halogen atoms, i.e., fluorine, chlorine, iodine, bromine or astatine. (*DB*)

Halogenated acetic acids (HAAs): Acetic acid in which one or more hydrogen atoms

are substituted with appropriate numbers of halogen atoms (e.g., chlorine). HAAs are formed along with other disinfection by-products when chlorine or other disinfectants used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water. The major haloacetic acids are: mono-, di-, and trihaloacetic acids, and mono- and dibromoacetic. (*DB*)

Halogenated acetonitriles: Various halogenated acetonitriles have been detected in chlorinated drinking water samples, the brominated acetonitriles being formed when bromide is present in the water during chlorination. Dichloroacetonitrile is the most abundant of the acetonitriles. (*DB*)

Halogenated hydrocarbons: One of a group of halogen derivatives of organic compounds. (*DB*)

Halogenated volatile organics: See Volatile organic compounds. (VOCs)

Halogenation: The introduction of a halogen atom (flourine, chlorine, bromine, iodine and astatine) into an organic compound (or molecule) by addition or substitution. (*DB*)

Hazard ratio (relative rate, rate ratio, incidence density ratio, instantaneous relative risk): A useful measure in etiological research that quantifies the strength of the relationship between exposure and risk.

HCB: See Hexachlorobenzene.

HCH: See Hexachlorocyclohexane.

Healthy worker bias: A bias resulting from generalizing findings from studies conducted on occupational groups because working people are relatively more fit and healthy compared to the population in general.

Hemicellulose: $(C_6H_{10}O_5)_n$. A type of polysaccharide in plant cell walls whose chemical composition is more complex than sugar and less complex than cellulose. (*PP*) **Heptachlor:** $(C_{10}H_5Cl_7)$. A cylcodiene insecticide first isolated from technical chlordane in 1946. During the 1960s and 1970s, it was used primarily by farmers to kill ants, and soil insects in seed grains and on crops, as well as by exterminators and homeowners to kill termites. Before heptachlor was banned, formulations available included dusts, wettable powders, emulsifiable concentrates, and oil solutions. It acts as a nonsystemic stomach and contact insecticide. (76-44-8) *(PE)*

Heterocyclic aromatic compounds: Aromatic compounds with an atom other than carbon (e.g., oxygen, nitrogen or sulphur). (*OC*)

Heterogeneity: The condition or state of being different in kind or nature. The quality of certain genetic disorders that consist of two or more fundamentally distinct entities.

Hexachlorobenzene (HCB): (C_6Cl_6) . An aromatic compound used as a selective fungicide for seed protectant treatment (usually for wheat) against common and dwarf bunt. It acts as a fumigant on fungal spores. It is highly persistent. Registration in Canada was discontinued in 1976. Today, trace amounts continue to enter our environment through long-range atmospheric transport, the manufacture and use of industrial chemicals that contain HCB and various industrial and municipal emissions. (*OC, PE*)

Hexachlorocyclohexane (HCH): $(C_6H_6Cl_6)$. An organochlorine (also known as benzehexachloride - BHC) which has five isomers, alpha, beta, gamma, delta and epsilon. The gamma isomer was isolated and sold as an insecticide under the name lindane. HCH acts in the body similarly to DDT, but much more rapidly. (58-89-9) (*OC, PE*)

Host factors: Host factors are traits which make an individual at risk (or susceptible) of acquiring a particular disease or health disorder. For instance, the host factors for melanoma are: racial/ethnic origin, pigmentation, skin reaction to sunlight, nevus and freckle density.

HPV: *See* Human papilloma virus.

Human papilloma virus (HPV): A group of relatively small DNA viruses, many of which are oncogenic or potentially oncogenic.

Human T-lymphocytes: Lymphocytes (white blood cells) originate, in postnatal life, from stem cells in the bone marrow; these stem cells divide continuously, releasing immature lymphocytes into the bloodstream. Some of these travel to the thymus, where they multiply and differentiate (i.e., acquire special properties and functions). The term T lymphocyte (or T cell) stands for thymus-derived lymphocyte (or cell). Once they have left the thymus, T cells join the bloodstream and circulate to and within the rest of the lymphoid organs, where they can multiply further in response to appropriate stimulation. About half of all lymphocytes are T cells.

Hydrocarbons: A class of organic compounds composed entirely of hydrogen and carbon atoms. (*DB, OC, PE, PP*)

Hydrogen sulphide: (H₂S). An ill-smelling, colourless, flammable, highly toxic gas, used as a reagent in chemical manufacturing. (*MM*, *PP*)

Hydrometallurgy: The extraction of metal from ore by using aqueous solutions. It usually involves dissolution of the metal or metal compound by water (sometimes with additional agents such as dilute sulphuric acid), purification of the solution, and recovery of metal from the solution by chemical or electrolytic means. Gold, silver, copper, zinc and many other metals are extracted in this way. (*MM*)

Hydroxymethylfurfural: Furfural with an hydroxyl methyl (CH₂OH) group attached to the ring. (*PP*)

Hypochlorite: A salt of hypochlorous acid used during the treatment of pulp to remove lignin and bleach the pulp. The velocity of this reaction is directly proportional to the amount of hypochlorite used, but the risk with a fast reaction with high concentrations of hypochlorite is a subsequent decrease in paper strength. (*PP*)

Hypochlorous acid: (HOCl). An unstable acid used as a bleach and disinfectant. (*PP*)

IARC: International Agency for Research on Cancer.

Imide: A compound containing the -CO-NH-CO- group. (*PE*)

Immunosuppression: The artificial prevention or diminution of the immune response.

In-vivo: Within a living organism: metabolic studies conducted *in vivo; in vivo* techniques. As opposed to *in vitro* in which the experiment is conducted in a laboratory environment or in a test tube.

Induction period: See Latency period.

Interaction: The effect of one factor varies according to the level of another factor.

Interpolate: To infer or to estimate the value of a variable within the range sampled.

Interpolation error: Unwarranted high confidence in the interpolated values.

Intrusions/intrusive rock: Rock that was forced into fissures or between strata when molten. (*MM*)

Inverse exposure/dose-rate effect: For equal total exposure, a high exposure rate and short duration is less harmful than a low exposure rate and long duration. When a more protracted dose is delivered, a higher percentage of the cells have the potential to be affected during a sensitive part of their cell cycle. This results in a higher chance of malignant transformation. (R)

Ionizing radiation: Highly penetrating radiation that results in the formation of ions by displacement of electrons from their path of orbit. Ionizing radiation is capable of breaking chemical bonds, thus causing damage to living tissue through which it passes. (*EF*, *R*)

Iron oxides: The main types of iron ore that can be mined profitably for iron. The most common forms are hematite (Fe₂O₃), goethite (α -FeO(OH)), magnetite (Fe₃O₄) and siderite (FeCO₃). (*MM*)

Isomers: Two or more compounds identical in molecular formula, but having different structural arrangements and exhibiting different properties. (PP, OC, PE)

Isoprene: (C₁H₂). A volatile liquid hydrocarbon used in synthetic rubber and turpentine. (PP)

Isotopes: Any two or more forms of an element having identical or very closely related chemical properties and the same atomic number but different atomic weights or mass numbers. (*R*)

Isotropy: The condition of having the same or similar values in all directions. For air pollution studies it states that the closer the distance between the two locations, the more similar the concentration levels are. (AP)

Job-exposure matrix: An array of data in rows and columns specially designed to present the duration and intensity of exposure(s) associated with a particular job and to translate job task histories into estimates of exposure to specific agents. It consists of jobs on one axis and specific exposures on the other, with the matrix elements describing the likelihood of an individual's exposure to a specific substance in a given job either in binary or polytomous categories.

Joule: A unit for measuring energy. One joule is the amount of work done, or energy used, in applying one newton of force to move a body one metre in the direction of the force. (EF)

K-ras gene: K-ras is one member of the Ras family of genes. These genes code for a group of closely-related proteins that are involved in the regulation of normal cell growth and proliferation. K-ras is located on chromosome 12, and is involved in cell cycle control. Mutations in this gene have been associated with several types of cancer, including lung cancer, such that it is considered to be a proto-oncogene. Kras oncogene activation is known to occur at an early stage in tumorgenesis and maybe an important diagnostic marker. See Biomarkers.

Kaiser Permanente cohort: A cohort LET: See Linear energy transfer. of individuals enrolled in the Kaiser Permanente health insurance plan that has been extensively studied by epidemiologists.

Ketones: Any of a class of organic compounds having a carbonyl group (CO) linked to hydrocarbon groups. (PP)

Komatiitic: Like a komatiite or containing komatiite. A komatiite is a series of verv old (older than 590 million years) lava flows that were very hot (> 1600 degrees C) when they were extruded onto the Earth's surface. (MM)

Konimeter: A device for measuring the number of particles in the air, as in a mine or cement plant. (MM)

Kraft (sulphate) pulping process: The principal method of chemical pulping. It involves using sodium hydroxide and sodium sulphate to break down the wood and separate the cellulose fibre from the lignin. (PP)

Kriging: A weighted moving average interpolation (extrapolation) method that minimizes the estimated variance of a predicted point (node) with the weighted average of its neighbors. (AP)

Latency/induction period: Delay between the exposure to a disease-causing agent and the appearance or manifestation of the disease.

Lateritic: Similar to, or containing, a laterite. A laterite is a red soil with large amounts of iron and/or aluminum oxides created by weathering. It forms in forested areas in tropical or temperate climates. (MM)

Leaching: Preferential dissolution of a component using an aqueous solution in order to separate it from other components. (MM)

Lead-210: In the series of unstable products from the radioactive decay of uranium-238, lead-210 results from the decay of radon-222 and is a precursor of the stable isotope lead-206. (R)

Lignin: After cellulose, the complex polymer, lignin, is the largest component of wood, accounting for about 25% of wood composition. (PP)

Lime: Calcium oxide (CaO). Manufactured by heating limestone, coral, sea shells, or chalk (made of CaCO₂) to drive off the carbon dioxide (CO₂), leaving CaO. (PP)

Lime kiln: A furnace used to calcinate limestone. (PP)

Lindane: (C,H,Cl,). Gamma HCH. One of the eight isomers of hexachlorocyclohexane (HCH) and the only organochlorine insecticide still licensed for use in Canada. An ingredient in Kwell® shampoo used to control head lice. (58-89-9) (PE)

Linear energy transfer (LET): The amount of energy deposited by an ejected particle per unit of the track length over which it is deposited. Generally speaking, high LET radiation is more effective at inducing cell damage than low LET radiation. (*R*)

Linear regression analysis/model: A method of describing the relationship between two or more variables by calculating a best fitting straight line.

Linuron: 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea (C₀H₁₀Cl₂N₂O₂). A phenylurea herbicide. Controls broadleaf and grassy weeds by inhibiting photosynthesis. Used on crop and non-crop sites for a variety of vegetable and fruit crops as well as for wheat. It is slightly to moderately soluble in water and is not readily broken down in water. (330-55-2) (PE)

Lipid fractionation: The procedure for separating lipids from other cellular constituents, using organic solvents (e.g., chloroform, methanol), in which they dissolve.

Lipophilic: Tending to combine with or dissolve in lipids. PCBs, for example, dissolve in the lipids of cells.

Lode gold deposits: Veins of gold. (MM)

Logistic regression: Statistical analysis estimating the magnitude of the association between an exposure and a binary outcome after adjusting simultaneously for a number of potential confounding factors.

Long-Evans cinnamon rat: A mutant strain displaying hereditary hepatitis and spontaneous hepatocellular carcinoma, and showing abnormal hepatic copper accumulation, similar to Wilson's disease in humans.

Macrophage: A large mononuclear cell that ingests degenerated cells, blood tissue, and small exogenous particles; found in large numbers throughout the body, with the greatest accumulation in the spleen, where they remove damaged or aging red blood cells from the circulation.

Mafic-ultramafic: One of three classifications of igneous rocks based on chemical composition (the others are alkaline and calc-alkaline). These rocks are typically dark in colouration, and make up most oceanic crust. They are also found on continents, typically in rift valleys (where continents are pulled apart and new ocean basins form the break), and in flood basalts (a type of lava flow involving a very large volume of lava). (*MM*)

Magmatic bodies/hosts: See Intrusions.

Magnetic field: The region of magnetic influence or force around a magnet, a magnetic body such as the Earth, or a body carrying an electric current. Also the magnetic forces present in such a region. (*EF*)

Magnetic flux density: A measure of magnetic field strength per unit area, quantified by units of tesla (T) or gauss. *(EF)*

Malathion: diethyl (dimethoxythiophosphorylthio) succinate ($C_{10}H_{19}O_6S_2$). Also known as carbophos, maldison, and mercaptothion. A wide-spectrum aliphatic organophosphate insecticide commonly used in Canada to kill insects on fruits and vegetables, for mosquito control and to kill head and body lice. (121-75-5) (*PE*)

Mammary tumours: A mass or a tumour located in human breasts or mammary glands.

Mancozeb: Manganese ethylene bis(dithiocarbamate) (polymeric) complex with zinc salt. A dithiocarbamate fungicide that has a very low acute toxicity to mammals. The major routes of exposure to mancozeb are through the skin or from inhalation. Mancozeb sprays and dusts are moderately irritating to the skin and respiratory mucous membranes. (8018-01-7) (*PE*)

Matched case-control study: A casecontrol study in which the controls are matched to the cases on factors that could confound the results, should they differ between the two groups. Some commonly matched variables are age, gender, race, and socio-economic status.

Matching: The process of making a study group and a comparison group comparable with respect to variables such as age and sex.

MCPA: *See* 4-chloro-2-methylphenoxy acetic acid.

Meiotic chromosomal aberrations: Germline mutation resulting from meiosis (cell division whereby each daughter cell receives half the number of chromosomes). These mutations may be transmitted to the progeny.

Melamine formaldehyde: A thermosetting resin made from melamine (a white crystalline compound, $C_3H_6N_6$) and formaldehyde (a colourless, pungent gaseous aldehyde, CH_2O) used in solution as a disinfectant and preservative. (*PP*)

Melanoma: A spreading and frequently recurring cancer of specialized skin cells (melanocytes) that produce the protective skin-darkening pigment melanin. Although it represents approximately five % of all cases of skin cancer, melanoma is responsible for nearly three-quarters of all skin cancer deaths.

Meningioma: A common type of benign brain tumour that infiltrates adjacent brain tissue, but does not metastasize. Includes astrocytoma, oligodendroglioma and ependymoma.

Mercaptans: Any substance containing the radical –SH bound to carbon; analagous to alcohols and phenols, but containing sulphur instead of oxygen. (*PP*)

Mesothelioma: A benign or malignant tumour affecting the lining of the chest or abdomen. Pleural mesothelioma has been associated with exposure to asbestos. (*MM*, *PE*)

Meta-analysis: The process of using statistical methods to combine the results of several different studies to produce a weighted summary estimate of risk.

Metabolites: Substances produced by metabolism or metabolic processes. Any substance involved in metabolism (either as a product of metabolism or as necessary for metabolism).

Metallic nickel: A silvery white metal that is moderately hard. It is both malleable and fairly ductile. Metallic nickel is an important industrial metal used in the manufacture of special alloy steels and cast irons. (*MM*)

Metam sodium: Sodium methyldithiocarbamate ($C_2H_5NS_2Na$). Also known as metham, methyldithiocarbamic acid, carbam and carbathion. A leading broad spectrum fumigant used in Canada, primarily as a liquid fumigant for pre-planting control of soil-borne fungi. It is also used to control nematodes and weeds affecting a variety of important fruit and vegetable crops. It degrades rapidly to methyl isothiocyanate the primary bio-active agent. (137-42-8) (*PE*)

Metamorphic rock: Rock derived from either igneous or sedimentary rock that has undergone changes in composition, texture, or internal structure through the action of pressure, heat, moisture, etc. Slate is a metamorphic rock formed from shale. (*MM*)

Methidathion: $(C_6H_{11}N_2O_4PS_3)$. An organothiophosphate insecticide and acaricide. The compound is used to control a variety of insects and mites in many crops such as fruits, vegetables, tobacco, alfalfa and sunflowers and is also used in greenhouses. All uses have been discontinued in Canada. (950-37-8) (PE)

Methyl isothiocyanate: (CH_3NCS) . Also known as MITC, Methyl Mustard, Isothianic Acid Methyl Ester, Vorlex and MIT. A colourless solid, the vapors are heavier than air and it can cause severe burns. It is an unclassified fungicide, herbicide and nematicide. All uses have been discontinued in Canada. (556-61-6) (*PE*)

Methyl mercuric chloride/methyl mercury chloride: Methyl mercury (II) chloride (chloromethyl mercury) (CH₃ClHg). White crystals used in the manufacture of pharmaceuticals and pesticides. (115-09-3) (*PE*)

Methylene chloride: See Dichloromethane.

Metolachlor: (α -*RS*, 1*RS*)-2-chloro-6'ethyl-*N*-(2-methoxy-1-methylethyl) acet-*o*toluidide ($C_{15}H_{22}NO_2$). Trade names are Bicep, CGA-24705, Dual, Pennant, and Pimagram. A chloroacetanilide general use herbicide used in Canada primarily for the control of grasses in corn, beans, soybeans and other crops. It is often used in formulations with other pesticides, often herbicides that control broad leaf weeds. (51218-45-2) (*PE*)

Mirex: $(C_{10}H_{12})$. A chlorinated cyclodiene insecticide used especially against ants. It is no longer registered as an active ingredient in Canada. (2385-85-5) (*OC*) (*PE*)

Misclassification: The erroneous classification of an individual, a value, or an attribute into a category other than that to which it should be assigned. The probability of misclassification may be the same in all study groups (non-differential misclassification) or may vary between groups (differential misclassification).

Mitotic chromosomal aberrations: Mutations or chromosomal changes (sister chromatid exchange, chromosome breakages) during mitosis (cell division without dividing the number of chromosomes). These mutations are typically not transmitted to the progeny. (*PE*)

Modelling: The act of representing or describing a phenomenon or set of relationships in mathematical terms to aid understanding; set assumptions about relationships used to study their interactions.

Mole: A unit for measuring amounts of substances that take part in chemical reactions. (*OC*)

Molecular epidemiology: A branch of epidemiology where the researcher studies specific gene behaviour (or other biological molecules) with the aim of associating cancer-related genetic alterations with specific exposures.

Monomer: A chemical compound consisting of single molecules that can join together to form a polymer. (*PP*)

Monotonically increases: A sequence is said to increase monotonically if each value is greater than or equal to the previous one, and monotonically decreasing if each value is less than or equal to the previous one.

Moving average: A method of smoothing the curve representing the data. Each observation is replaced by a mean of the observation and the observations on either side of it.

Multiple traversals: Multiple 'hits' of individual cell nuclei by alpha particles. (*R*)

Mutagen: An agent (e.g., radiation) capable of altering the genetic material in living organisms, causing chromosomal damage, point mutations, sister chromatid exchanges, or functional defects in gene replication or cell division.

Mutagenic: Capable of inducing alteration (mutation) in genetic material.

Mutagenicity: The property of an agent (e.g., chemical substance, radiation) to induce mutation.

Mutation: A structural change within genetic material of an organism resulting in the creation of a new character or trait not found in the parental type.

MX: *See* 3-chloro-4-(dichloromethyl)-5hydroxy-2(5H)-furanone. **N-acetylation phenotype:** The geneticallydetermined rate at which the liver enzyme N-acetyltransferase detoxifies compounds in the body. (*ET*)

N-nitroso-di-n-propylamine (NDPA): An unavoidable contaminant in trifluralin-containing products. (621-64-9) (*PE*)

Nabam: Disodium ethylene bis(dithiocarbamate) ($C_4H_6N_2Na_2S_4$). A dithiocarbamate fungicide/fumigant. (142-59-6) (*PE*)

Natural killer (NK) cells: Cells produced by the body's immune system to destroy or damage a variety of malignant target cells.

NDPA: See N-nitroso-di-n-propylamine.

Nested case-control design study: A casecontrol study in which cases and controls are drawn from the population in a cohort study.

Neutron: An uncharged elementary particle with a mass slightly greater than that of the proton, and found in the nucleus of every atom heavier than hydrogen. (R)

Newton: A unit for measuring force. One newton is the force required to give an acceleration of one metre per second to a mass of 1 kg. (*EF*)

Nickel carbonyl: (Ni(CO)₄). Carbon monoxide reacts with nickel to produce the volatile compound nickel carbonyl. (*MM*)

Nickel carbonyl process: A process used to separate nickel from other metals and impurities. After iron and copper have been removed by smelting the ore and slow-cooking the nickel matte, the impure nickel is combined with carbon monoxide at 60° C to make the compound tetracarbonylnickel, Ni(CO)₄, which is subsequently decomposed at above 200°C to yield metallic nickel that is 99.8% pure. (*MM*)

Nickel matte: An impure mixture of sulphides produced during the smelting of nickel sulphide ore. (*MM*)

Nickel subsulphide: (Ni₃S₂). A major component in the refining of nickel ores.

Synonyms: heazlewoodite, nickel sulphide (3:2), and trinickel disulphide. (*MM*)

Nickel sulphate hexhydrate: (NiSO₄· $6H_2O$). A water-soluble compound of nickel that is used in nickel plating, as a mordant in dyeing and printing textiles, as a blackening agent for zinc and brass, and in the manufacture of organic nickel salts. (*MM*)

Nitriles: Compounds containing the cyano (CN) group. (*PE*)

Nitrogen oxides: Inorganic oxides that contain nitrogen (e.g., nitrogen oxide (NO), nitrous oxide (N_2O) , and nitrogen dioxide (NO_2)). (*AP*)

Nitrophen: 2,4-dichlorophenyl 4nitrophenylether $(C_{12}H_7Cl_2NO_3)$. Also known as NIP and niclofen. A nitrophenyl ether herbicide. A pre- and post emergent herbicide for grasses and broadleaf weeds. It was used on food and ornamental crops but is no longer sold or manufactured in the US and Canada. (1836-75-5) (*PE*)

Nitrophenyl: A benzene ring where one of the hydrogen atoms has been replaced by a nitro (NO₂) group. (*PE*)

Nitrosamines: A group of chemical compounds with the structure $R_N - N = O$. (*ET*)

Nitrosomethylurea (NMU): $(C_2H_5N_3O_2)$. A solid material with a half life of 2-20 days in water. It degrades in ultraviolet and visible light. It is potentially explosive at room temperature and when heated gives off toxic fumes of nitrogen oxides. (684-93-5) (*PE*)

NK: See Natural killer cells.

NMU: See Nitrosomethylurea.

No-observed-(adverse-)effect level (NOEL)/ **(NOAEL):** A term from toxicology, meaning the highest dose at which no health effects are detected in the animal population. (*PP*)

NOEL(NOAEL): *See* No-observed-(adverse-) effect level.

Non-asbestiform amphibole: A mineral of the amphibole group that is not in the form

of fibrous needle-like crystals. The general definition of asbestos can include any fibrous mineral from the amphibole and serpentinite mineral groups. (*MM*)

Non-Hodgkin lymphoma: A group of lymphomas (cancer of the lymphatic system) which differ in important ways from Hodgkin lymphoma (also a type of lymphoma) and are classified according to the microscopic appearance of the cancer cells. The disease is classified as either low grade (slowly growing), intermediate grade or high grade (rapidly growing) and may be treated in a variety of ways depending on the exact diagnosis. Previously called lymphosarcoma.

Non-ionizing radiation: Radiation insufficient to split the chemical bonds of compounds. (*EF*)

Non-linear regression: A regression problem in which the parameters are nonlinear, which prevents the use of least squares criteria.

Non-parametric model: A statistical model that assumes that the population contributing the sample is not normally distributed regarding the variable under study i.e., the resulting statistical test is distribution free.

Non-selective herbicide: A herbicide that kills any vegetation. (*PE*)

Nucleotide: One of the compounds into which nucleic acid splits on hydrolysis, consisting of a nitrogenous base, a sugar, and a phosphate group. (*PE*)

Null hypothesis (H_o): The statistical hypothesis that two or more variables are not related or that two or more populations do not differ from one another. The null hypothesis states that the results observed in a study or an experiment are no different from what might have occurred just by chance.

Octachlorodibenzodioxin: A compound having eight chlorine atoms on the two

benzene rings that are attached to either side of the dioxin ring. This compound has no hydrogen atoms in its structure. (*PP*)

Odds ratio (OR): Main measure of risk derived from case-control studies that quantifies the relationship between an exposure and a health outcome. The ratio of two odds. Mathematically it is represented as ad/bc: a = number of people exposed who have the disease, b = number of people not exposed but have the disease, c = number of people exposed but do not have the disease, and d = number of individuals who have not been exposed and do not have the disease.

Ohm: Unit for measuring the resistance of a conductor to an electric current. A conductor has a resistence of one ohm if it takes one volt of pressure to send a current of one ampere through it. (*EF*)

Olfactometer: An instrument to test the sense of smell. (*PP*)

Olfactometry: A procedure to assess the sense of smell. (*PP*)

Oncogene: A mutated and/or overexpressed version of a normal gene of animal cells (the proto-oncogene) that, in a dominant fashion, can release the cell from normal restraints on growth and thus, alone or in concert with other changes, convert a cell into a tumour cell.

OPs: *See* Organophosphates.

Optical radiation: Optical radiation (10 nm-1 mm) is radiant energy within the broad region of the electromagnetic spectrum that includes ultraviolet radiation (UR), visible light, and infrared radiation. One nanometre [nm] is one billionth (10⁻⁹) of a metre, or 10 angstrom units. (*UR*)

OR: See Odds ratio.

Organic compound: A compound containing carbon. (*DB, OC, PP*)

Organic materials: Natural substances derived from organisms and containing compounds of carbon (e.g., hydrocarbons, such

as crude oils and fossil fuels, or plant decay in soils). (*DB*)

Organobromides: Organic compounds, also known as brominated hydrocarbons, brominated organics and brominated synthetics, that contain hydrogen and bromine strongly bound to carbon. (*PE*)

Organochlorines: Organic compounds (also known as chlorinated hydrocarbons, chlorinated organics and chlorinated synthetics) that contain hydrogen and chlorine strongly bound to carbon. Many organochlorines are strongly lipophilic (fatseeking) and tend to build up in the fatty parts of living creatures where they become more concentrated and toxic. (*PP, OC, PE*)

Organohalide: Any organic compound having one or more halogen atoms in its structure. *See* halocarbon. (*PE*)

Organophosphates (OPs): A class of insecticides (including also one or two herbicides and fungicides) derived from phosphoric esters. With the decision to phase out many of the persistent organochlorines, there was an increase use of organophosphates, despite their much greater acute human toxicity. Organophosphates are generally divided into three groups based on chemical similarities: aliphatics (e.g., malathion, dimethoate and dichlorvos), phenyl derivatives (e.g., parathion, fenitrothion) and heterocyclic derivatives (e.g., azinphos-methyl, chlorpyriphos, phosmet). OPs inhibit certain important enzymes of the nervous system, namely cholinesterase (ChE). This inhibition results in the accumulation of acetylcholine (ACh) at the neuron/neuron and neuron/muscle (neuromuscular) junctions or synapses, causing rapid twitching of voluntary muscles and finally paralysis. (*PE*, *OC*)

Organophosphorous: A compound containing phosphorous bound to an organic compound; several organophosphorous compounds are insecticides, as they are highly toxic cholinesterase inhibitors. (*PE*)

Organothiophosphate: An organic compound having a thiophosphate group in its structure. (*PE*)

Outlier: A subject or other unit of analysis that has extreme values on a variable. Outliers can distort the interpretation of the data and result in misleading statistics.

Oxidative damage: The action of free radicals on DNA.

Oxidative stress: A harmful condition that occurs when there is an excess of free radicals, a decrease in antioxidant levels or both.

Oxidic nickel: Nickel compounds that contain oxygen (e.g., NiO, (NiCu)O). (*MM*)

Oxime: Compounds containing the group C-NOH. (*PE*)

Ozonation: The application of ozone to water, wastewater, or air, generally for the purposes of disinfection or odour control. (*DB*)

Ozone: (O_3) . A form of oxygen, containing three oxygen atoms per molecule. A very powerful oxidant which destroys small organisms in water, including cryptosporidium. Used in water treatment for disinfection or for taste and odour control. Ozone is an key indoor and outdoor air pollutant, and is associated with deleterious human health and environmental effects. (*DB*)

p53 gene: A gene involved in the control of the cell cycle. p53 is considered to be a tumour suppressor gene, because when the protein function is lost due to a mutation, tumour cells may be more likely to continue to grow and proliferate.

PAB: See Para-aminobiphenyl.

PAHs: See Polycyclic aromatic hydrocarbons.

Para-aminobiphenyl (4-aminobiphenyl/ PAB): ($C_{12}H_{11}N$). A colourless solid with characteristic odour, used as a herbicide and also found in tobacco smoke. (92-67-1) (*PE*)

Parathion: 0,0-diethyl 0-4-nitrophenyl phosporodithioate ($C_{10}H_{14}NO_5PS$). Also known as thiophos. An organothiophosphate insecticide. These chemicals act by interfering with the activities of cholinesterase. (56-38-2) (*PE*)

Parenchymal cells: Cells forming the parenchyma. Parenchyma is the essential or functional elements of an organ, as distinguished from its stroma or framework.

Particulate: Referring to, or produced by, particles (a tiny mass of material.), such as dust, minute germs, etc. (*AP*, *PP*)

Particulate matter (PM): Microscopic particles that vary in size and chemical makeup. For monitoring purposes, PM levels are classified as total suspended particulates (TSP), particles with diameters of 10 micrometers (μ m) or less (PM₁₀), particles between 10 and 2.5 μ m (PM_{10-2.5}), and particles with diameters of 2.5 μ m or less (PM_{2.5}). Major sources of outdoor PM include industrial and vehicle emissions, road dust, agriculture, construction, wood burning, forest fires, pollen, spores, bacteria and volcanoes. PM can also be formed through atmospheric chemical reactions.

PCBs: See Polychlorinated biphenyls.

PCDFs: See Polychlorinated dibenzofurans.

PCP: See Pentachlorophenol.

Penetrance: The frequency with which a heritable trait is manifested in individuals known to carry the gene that causes it. Clinically, definition of penetrance often depends on the quality of clinical methodologies; for example, magnetic resonance imaging might demonstrate findings not previously recognizable. In the medical context, the gene is usually considered penetrant if diagnostic abnormalities can be demonstrated even if the individual is asymptomatic. In the biological context, the gene can be considered penetrant if it affects the function of the individual.

Pentachlorophenol (PCP): (C₆HCl₅O). A chlorinated hydrocarbon insecticide and fungicide. Pentachlorophenol is phenol with five chlorine atoms in place of the five hydrogen atoms on the ring. It is a solid that is used primarily to protect timber from fungal rot and wood-boring insects. PCP products are very toxic to plants and are used as pre-harvest defoliants and general herbicides. Their use as herbicides is currently restricted to nonagricultural uses

along drainage ditches, driveways, and fence rows. PCP, which is found throughout our environment, has been voluntarily withdrawn by manufacturers of wood for domestic use. PCP is classified as a possible human carcinogen, as it can cause cancer in male mice. (87-86-5) (*PE, PP*)

Pentlandite: $((FeNi)_{9}S_{8})$. The main mineral that is mined for nickel, typically found in association with other sulphide ores such as chalcopyrite. (*MM*)

Peroxisome: A liquid-filled sac surrounded by a single membrane. Peroxisomes break down fatty acids and amino acids. These reactions produce hydrogen peroxide, which could harm cells if it were allowed to persist. An enzyme (catalase) breaks down the hydrogen peroxide to water and oxygen, both of which can be used by the cell. Peroxisomes also break down alcohol. The peroxisomes of the liver and kidneys break down nearly half of the alcohol that a person consumes.

Peroxisome proliferation: Increase in the number of peroxisomes as a result of an environmental hazard (e.g., insecticide).

pH: A measure of the acidity or alkalinity of water.

Phagocyte: Any cell that ingests microorganisms, other cells or foreign bodies.

Phenol: (C_6H_5OH). A benzene ring with an hydroxyl group (OH) in place of one of the hydrogen atoms. Phenols/phenolic compounds are caustic, poisonous and crystalline aromatic organic compounds present in coal tar and wood tar that, in dilute solution, are used as a disinfectant. (*DB, PE, PP*)

Phenotype: In genetics, the visible appearance of an organism, produced by the interaction of its genetic constitution with the environment.

Phenoxy herbicides: A class of herbicides containing the radical (C_6H_5O) . (*PE*)

Phenyl: (C_6H_5) . A univalent radical derived from benzene that forms the basis of phenol, and other aromatic compounds. (PP)

Phenyl propane: A form of propane with a phenyl group attached at one of the hydrogen bonding locations. Monomers of phenyl propane make up the lignin macromolecule, which is aromatic. (*PP*)

Phenylurea: $(C_6H_5NHCONH_2)$. A benzene ring where one hydrogen is replaced by a urea group. (64-10-8) (*PE*)

Phorate: *O,O*-diethyl S-ethylthiomethyl phosphorodithioate $(C_7H_{17}O_2PS_3)$. An organothiophosphate insecticide and nematicide. Trade names: Thimet, Rampart, Granutox and Agrimet. Used on corn, potatoes and cotton. Half-life in the soil is 2-173 days. In water it hydrolyzes and one of the products is formaldehyde. (298-02-2) (*PE*)

Phosmet: *0*, *0*-dimethylS-phthalimidomethyl phosphorodithioate ($C_{11}H_{12}NO_4PS_2$). An organothiophosphate insecticide. Also known as phthaliphos and PMP. (732-11-6) (*PE*)

Phosphates: Esters of phosphoric acid. (*OC*, *PE*)

Phosphinic acid: (H_3PO_2) . A weak monobasic acid, also called hypophosphorous acid, that is used as a herbicide. (6303-21-5) (*PE*)

Phosphoric esters: See Phosphates.

Photon: A quantum (or packet) of energy emitted in the form of electromagnetic radiation. Gamma rays and X rays are examples of photons. (*R*)

Phthalate: The di-ester of phthalic acid. (PE)

Phthalic acid: $(C_8H_6O_4)$. A benzene ring having two COOH groups attached to the carbon ring in place of hydrogen. (*PE*)

Phthalimides: Imides of phthalic acid. The N-trihalomethyl dithio derivatives are referred to as phthalimides (e.g., folpet and captofol). They are fungicides and are structurally similar to thalidomide. They act as germination inhibitors. (*PE*)

Pigmentary factors: Host factors, such as fair skin, light eye and hair colour, that put an individual at increased risk of acquiring CMM (Cutaneous Malignant Melanoma). (*UR*)

Pitchblende: One of the primary mineral ores of uranium, containing three chemical elements – uranium, polonium and radium. (*R*)

PM₁₀: An airborne particle with a diameter of no more than 10 μm. *See* Particulate matter. (*AP*)

Point sources: Situations, places and events which increase the risk of exposures (e.g., concentrations of air pollutants may be higher in a heavily travelled road or an industry producing noxious fumes).

Point-in-time measures: Measurements (usually made under as-is conditions) taken at one time, as opposed to continuous measurements.

Polyaromatic hydrocarbon: Hydrocarbons having more than one aromatic (likely benzene) ring. (Hydrocarbons are a class of organic compounds composed entirely of hydrogen and carbon.) (*OC*)

Polychlorinated: A chemical compound with more than one chlorine atom. For example, a hydrocarbon with three chlorine atoms attached to either the main carbon chain or a side chain, would be polychlorinated. (*PP*)

Polychlorinated biphenyls (PCBs): A family of 209 structurally related chemical compounds consisting of two benzene rings and one to ten chlorine atoms. PCBs are stable and non-flammable, appearing as either a clear mobile oil (12%-48%) chlorine content) to a white or off-white powder (68% chlorine content). They are hydrophobic (lack affinity to water) and lipophilic. Most are environmentally persistent. PCBs were first produced for industrial purposes in 1929 and were used for several decades in capacitors and transformers, hydraulic fluids, adhesives, plasticizers, heat exchange equipment, inks, lubricants, sealants, caulking compounds and carbonless copy paper. In 1968 an outbreak of PCB poisoning in Japan raised concerns about the toxicity of these substances. Significant quantities remain in certain types of electrical equipment. (OC)

Polychlorinated dibenzofurans (PCDFs): Any of a class of organic compounds of the heterocyclic aromatic series characterized by a ring structure composed of one oxygen atom and four carbon atoms. The simplest member of the furan family is furan itself, a colourless, volatile, and somewhat toxic liquid. Furans are like dioxins, but they have one oxygen atom instead of two. They have a similar range of toxicity as dioxins. (*OC, PP, MM*)

Polychlorinated dibenzo-p-dioxins: Any in a family of over 200 chlorinated organic chemicals of which 2,3,7,8-tetrachloro-pdibenzo-dioxin (2,3,7,8-TCDD or TCDD) is the most toxic. TCDD was an impurity in the defoliant AgentOrange and in the pesticide 2,4,5-T. Dioxins are also produced when chlorinated materials, such as some plastics, are burned. (*OC, MM, PE, PP*)

Polychloroterpene: A terpene is any of a group of hydrocarbons made up of building blocks of isoprene (C_5H_8). A polychlorinated terpene would have more than one chlorine atom in its structure. (*PE*)

Polycyclic aromatic hydrocarbons (PAHs): A family of complex organic compounds derived by fusion of two or more benzene rings. PAHs are naturally present in fossil fuels and are also formed by the partial combustion of fossil fuels, organic matter and garbage. Canadians are exposed to PAHs primarily through tobacco smoke, wood smoke, contaminated air and food, particularly meat and fish. In Canada, the highest levels of PAHs in soil are found near former gas plants, coking plants and wood-preserving facilities.(*AP, ET, MM, PE*)

Polycyclic hydrocarbons: Hydrocarbons having two or more rings sharing at least one carbon atom. (*OC*)

Polymer: Any of a large number of natural or synthetic, organic or inorganic compounds composed of very large molecules that are made up of many light, simple molecules chemically linked together. Cellulose and proteins are naturally-occurring polymers; concrete, plastics and glass are synthetic polymers. (*PP*)

Polymerization: The chemical process that enables the bonding of two or more single unit or simple compounds (monomers) to form a larger compound (polymer) usually of high molecular weight. (*PP*)

Polymorphisms: Variant forms of a particular gene that occur simultaneously in a population. (*AP*)

Polysaccharide: A carbohydrate containing a large number of saccharide units, such as starch and glycogen. (*PP*)

Pooled analysis: The process of combining epidemiological data from several different studies at the level of the individual to produce a summary estimate of risk.

Population attributable risk: A measure of the proportion of disease in a population that can be attributed to a particular exposure.

Porphyry copper deposit: A low grade ore, less than one percent copper, that can be mined in bulk for copper. A porphyry is an igneous rock containing more than 25% large crystals (phenocrysts) embedded in a 'ground mass' of much smaller crystals. The copper is typically present in the form of chalcopyrite (CuFeS₂) within the ground mass. (*MM*)

Post-emergence herbicides: Herbicides used to destroy or inhibit plant growth after emergence. (*PE*)

Power boiler: See Recovery furnace.

Power frequency: The frequency at which power is generated and distributed; in most of North America it is 60 HZ (hertz). (*EF*)

ppb: Parts per billion; a measure of concentration. May represent the concentration of a residue in soil, water or whole animals. For example, one ppb is equivalent to one second in 32 years.

ppm: Parts per million; a measure of concentration. May represent the concentration of a residue in soil, water or whole animals. For example, one ppm is equivalent to one minute in 2 years.

Pre-emergence herbicides: Herbicides used to destroy the plant before emergence. (*PE*)

Profluralin: N-cyclopropylmethyl- α , α , α ,trifluoro-2,6-dinitro-N-propyl-p-toluidine (C₁₄H₁₆F₃N₃O₄). A dinitroaniline herbicide. Trade name: Tolban 4E. Used on cotton, vegetable, turf and woody ornamentals to control grasses and broadleaf weeds. It is strongly absorbed to organic matter and clay and therefore does not leach. (26399-36-0) (*PE*)

Propane side chain: Polymers may have side chains that are other hydrocarbons. One such side chain is the hydrocarbon propane, C_3H_8 . On its own, propane is a colourless gas found in natural gas and petroleum that is used as a fuel. (*PP*)

Propoxur: 2-isopropoxyphenyl methyl carbamate ($C_{11}H_{15}NO_3$). A carbamate contact insecticide used against silverfish, hornets and wasps. (114-26-1) (*PE*)

Prospective cohort: Any designated group of persons who are followed or traced over a period of time.

Proteases: A class of enzymes capable of splitting the peptide bonds of a protein. (*MM*)

Proxy/surrogate respondent: One who speaks for a subject in a study (e.g., when a subject has died or is too ill to participate).

Pulsed electromagnetic field exposure: Electromagnetic fields that deliver their exposures in short pulses as opposed to a continuous flow. (*EF*)

Pyrethroids: Synthetic forms of pyrethrins. Pyrethrins are two highly insecticidal compounds that were isolated from pyrethrum flower heads in 1924: Pyrethrin I ($C_{21}H_{28}O_3$) (121-21-1) and Pyrethrin II ($C_{22}H_{28}O_5$) (121-29-9). Natural pyrethroids are expensive and unstable in sunlight. Synthetic pyrethroids are very stable in sunlight and are effective at extremely low rates of application. They function as axonic poisons. Type I Pyrethroids include allethrin, tetramethrin, resmethrin, d-phenothrin, bioresmethrin, and permethrin. Type II Pyrethroids include cypermethrin, cyfluthrin, deltamethrin, cyphenothrin, fenvalerate and fluvinate. (*PE*)

Pyrite: (FeS₂). A common mineral consisting of iron sulphide having a yellow colour and a metallic glitter that suggests gold; "fool's gold". (MM)

Pyrrhotite: A bronze-coloured, slightly magnetic iron sulphide, sometimes containing nickel. (*MM*)

Quasi-controls: A control group in which members have not been assigned randomly along with the experimental group. Quasi controls are used when it is impossible to achieve random assignment of subjects to both experimental and control groups.

Quetelet index: An anthropometric measure of body mass defined as (weight)/ (height)². This measure has the highest correlation with skinfold thickness or body density. Also known as body mass index (BMI).

Radiation: The emission and propagation of energy by means of electromagnetic waves or particles. (*R*)

Radical: An atom or group of atoms acting as a unit in reactions. For example, ammonium (NH_4) is a radical in ammonium hydroxide (NH_4OH) and ammonium chloride (NH_4Cl). (*OC*, *DB*, *PP*)

Radioactive decay: Breakdown of atoms of radioactive substances into other radioactive products (e.g., radium 226 decays to radon-222). Atoms in a radioactive substance decay in a random fashion but at a characteristic rate. The length of time this takes, the number of steps required and the kinds of radiation released at each step are well known. (R)

Radioactivity: The spontaneous decay of an unstable atomic nucleus, giving rise to the emission of radiation. (R)

Radioisotope: A radioactive isotope, i.e., one whose atoms undergo radioactive decay emitting alpha, beta or gamma radiation. Radioisotopes are produced by decay of other radioisotopes or irradiation of a stable isotope. (*MM*)

Radium: (Ra). A radioactive metallic element with atomic number 88. As found in nature, the most common isotope has a mass number of 226. It occurs in minute quantities associated with uranium in pitchblende, camotite, and other minerals. (MM, R)

Radon: (Rn). A radioactive element that is one of the heaviest gases known. Its atomic number is 86. It is a decay product of radium. (MM, R)

Radon daughters/progeny: Short-lived decay products of radon-222. Radon progeny are gasses that become attached (adsorbed) to solid particles that are inhaled and trapped within the lungs. The progeny can thereby irradiate cells in the immediate vicinity of the particles to which they are attached. While most of the progeny attach to larger aerosols immediately after forming, a variable proportion remains unattached and is referred to as the "unattached fraction". (*R*, *MM*)

Random-digit dialling: The procedure for selecting a population sample from telephone subscribers in a region. It is based on every possible permutation and combination of seven digits from a set of 10 (0-9). The area code is constant and unlisted numbers can be accessed.

Rat liver activation system: In a standard Ames assay a rat liver homogenate is used to provide the P450 cytochromes necessary for activation of mutagens to their reactive forms. (*PE*)

Raw water: Water that has not been treated in any way; it is generally considered to be unsafe to drink. (*DB*)

Recall bias: The distortion in the results respondents' foggy memories about their exposure history.

Receptor: A cellular protein that binds with a specific drug, chemical or hormone, effecting a change in the cell's function.

Recovery furnace/power boiler: Spent digester liquors are sent here to recover and reconstitute digestion chemicals from the spent cooking liquor, and to recover heat energy by burning the dissolved organic material from the wood. (*PP*)

Reduced sulphur compounds: The vilesmelling gases emitted from the kraft process. They include include hydrogen sulfide (H_2S), Methyl mercaptan (CH_3 -SH), Dimethyl sulfide (CH_3 -S- CH_3), and Dimethyl disulfide (CH_3 -S- CH_3). (*PP*)

Regionalized variable: A variable that has properties that are intermediate between a fully random variable and a fully deterministic one. This means that although they are continuous over an entire surface, the complexity of the surface is such that it cannot be described easily by a deterministic function such as a trend surface. (*AP*)

Regression statistics: The relationship between the mean value of a random variable and the corresponding values of one or more independent variables.

Relative risk: A ratio of the risk of disease or death among the exposed to the risk among the unexposed.

Repeated sampling paradigm: A sequence of two or more cross-sectional studies conducted within the same dynamic target population generally spaced at least a few years apart. In this model the investigator follows the population rather than individuals. It is unlikely that a single respondent will appear in more than one sample.

Resins: Sticky yellow or brown substances that flow from certain plants and trees, especially the pine and fir, and normally harden upon exposure to air into brittle, amorphous, solids that are insoluble in water. They are soluble, however, in alcohol, ether and other organic solvents. There are three types of resins: hard resins, oleoresins, and gum resins. The oleoresins are perhaps the most commercially important. The most widely used of the oleoresins being rosin, used in sizing paper, soap making and for the bows of stringed instruments. It is obtained by the distillation of the oleoresin, turpentine.

Resmethrin: 5-benzyl-3-furylmethyl (1RS, 2RS; 1RS, 3SR)-2,2-dimethyl-3-(2-methylprop-1-enyl) cyclopropane carboxylate ($C_{22}H_{26}O_3$). A pyrethroid ester insecticide used to control flying and crawling insects and for fabric protection, pet sprays and shampoos. (10453-86-8) (*PE*)

Robertson-Berger metre: A metre used to measure ultraviolet radiation. (*UR*)

Saccharomyces cerevisiae: A yeast that is an ideal eukaryotic (having a nucleus) micro-organism for biological studies because the complete sequence of its genome is known and genetic manipulation is relatively easy. It can be used to functionally dissect gene produces from other eukaryotes. (*PE*)

Salmonella typhimurium: A strain of gram negative bacteria belonging to genus *Salmonella*. It is responsible for food poisoning in man. (*PE*)

SCE: See Sister chromatid exchange.

Schist: A crystalline metamorphic rock that splits easily into layers. (*MM*)

Serum: The clear portion of any liquid separated from its solid particles. The pale yellowish fluid which exudes from the clot formed in the coagulation of the blood; the liquid portion of the blood, after removal of the blood corpuscles and the fibrin.

Siderite: $(FeCO_3)$. An iron ore composed of iron carbonate. Siderite occurs in various forms and colours. (*MM*)

Sidestream smoke: The stream of smoke from the burning end of a cigar, cigarette, or pipe. (*ET*)

Sievert (Sv): The international system (SI) unit for *equivalent* dose equal to 1 Joule/ kilogram.

Silica: Silicon dioxide (SiO_2) . The main ingredient in sand and a compound of the two most abundant elements in the Earth's crust, silicon and oxygen. The crystalline form exits in three different forms or morphs (i.e., it is polymorphic) namely

quartz, cristobalite, and tridymite. Quartz is mainly diffused in the planet as sand. The other two occur in lava and are formed by heating quartz or amorphous silica. (MM, R)

Silicosis: A disease of the lungs caused by continued inhalation of the dust of minerals containing silicon; characterized by progressive fibrosis and a chronic shortness of breath. (R)

Sintering: Fusing together fine particles to form larger masses by the combined action of heat and pressure. (*MM*)

Sister chromatid exchange (SCE): A genetic exchange between two sister chromatids or genetic material in the prophase of mitosis (cell division in the body cells – as opposed to the germ cells) thereby producing different genetic architecture between the two daughter cells. The frequency of such exchanges in an experimental biological system (e.g., Chinese hamster cells) indicates the degree of carcinogenicity of an exposure.

Sister chromatids: In the prophase of mitosis of eukaryote organisms (cells containing nuclei), each chromosome in each cell replicates to constitute a pair of daughter chromosomes, called sister chromatids at this stage, that are in close association with each other.

Skarn: A rock, created from limestone or dolomite by contact metamorphism, that contains large amounts of silicon, aluminum, iron and magnesium that have moved from the adjacent igneous rock (typically granite). Skarns can be economically mined for iron and copper. (*MM*)

Small cell carcinoma: A type of cancer in which the tumour cells have endocrine-like characteristics and may secrete one or more of a wide range of hormones.

Smelting: A complex set of chemical reactions that result in the formation of slag (waste) and a valuable matte (an impure mixture of sulphides that is processed further). (*MM*)

Smelting dissolving tanks: The unburned inorganic component that collects at the bottom of the recovery boiler/furnace is molten smelt. The smelt flows out of the furnace and is dissolved in a weak caustic solution producing "green liquor". (*PP*)

Sodium hydroxide: A brittle, white, opaque solid with the chemical formula NaOH. It is strongly alkaline, and is used in the making of wood pulp for paper, and in the manufacture of soap. Sodium hydroxide is also known as sodium hydrate, caustic soda, and lye. (*PP*)

Sodium sulphide (Na₂S): A reddish brown amorphous solid that is deliquescent (becomes liquid by absorbing moisture from the air) and is used in the manufacture of dyes. *(PP)*

Soil sterilant: A chemical that kills everything growing in the soil where it is applied. Can be carried by water and persist in the soil for several years. (*PE*)

Soluble nickel: All forms of soluble nickel salts: nitrates, citrates, acetate, sulfamates.

Somatic mutation: A change in the genetic material in the somatic cells (or body cells) which does not transmit to the next generation.

Spatial interpolation: Interpolation carried out on a spatial or geographic domain.

Sprague-Dawley rats: A strain of rats commonly used to conduct toxicological experiments into the health effects of various exposures.

Squamous cell carcinoma: A skin cancer that is less common than basal cell carcinoma but has a higher rate of metastasis (spread). It is estimated that 90-95% of SCCs are caused by sunlight exposure. Squamous cell carcinoma is also an occupational hazard, occurring in workers who distill tar vapour in the manufacture of coal gas and in machinery operators whose clothes and skin become soaked in mineral oil.

Standardized (standardised) incidence/ morbidity/mortality ratio (SIR/SMR): The ratio of the number of events observed in the study group or population to the number that would be expected if the study group had the same age-specific rates as the standard population.

Statistical power/power of a statistical test: A gauge of the sensitivity of a statistical test; i.e., its ability to detect effects of a specific size, given the particular variance and sample sizes of the study.

Statistical significance: The probability, expressed as a p-value, that an observed effect has occurred purely as a result of chance. The smaller the p-value, the less likely the observed effect is the result of chance, and the greater the statistical significance.

Sub-multiplicative interaction: Unmeasurable and complex interaction between two or more factors (e.g., between smoking and radon exposure in lung cancer).

Substituted amides: A class of herbicide also known as chloracetamides that act as shoot inhibitors, and are used as preemergence herbicides. The leading examples of amide herbicides used in Canada are alachlor and metolachlor. (*PE*)

Sulphallate: 2-chloroallyl diethyldithiocarbamate ($C_8H_{14}CINS_2$). A thiocarbamate herbicide. (95-06-7) (*PE*)

Sulphanilamide: *p*-aminobenzenesulphonamide ($C_6H_8N_2O_2S$). The amide of sulphanilic acid (sulphanilamide) and certain related substituted amides are of importance as the *sulpha drugs*. Antibacterial activity and toxicity of the substituted sulphanilamides depend on the nature of the group attached to the amido nitrogen. It is nearly always heterocyclic-a ring structure in which one or more of the carbon atoms is replaced by a different atom (nitrogen, oxygen or sulphur). (63-91-2) (*PE*)

Sulphates: Salts of sulphuric acid (H_2SO_4) that occur naturally in numerous minerals and have numerous practical uses (e.g., in

the manufacture of chemicals, dyes and fertilizers). (*AP*)

Sulphide matrix breccias: A sedimentary rock containing very large angular grains held together by a matrix (thick glue) of very small grains of some type of sulphide. Some common sulphides are galena (PbS), sphalerite (ZnS), pyrite (FeS₂). (*MM*)

Sulphidic nickel: Nickel compounds that contain sulphur, including nickel subsulphide and nickel sulphide. (*MM*)

Sulphite pulping process: An alternative to the Kraft (sulphate) pulping process, that uses sulphuric acid and one of its base salts. One of the major drawbacks of this alternative is that it creates more pollutants, uses more water, and produces a poorer quality product than the sulphate process. (*PP*)

Sulphonation: Treating wood chips with hydrosulphide, and exposing them to increased acidity in a bisulphate solution to remove the lignin. (*PP*)

Sulphonyl ureas: Herbicides with a urea functional group having a sulfonyl substituent. Examples include BensulfuronmethylandChlorsulphuron ($(C_{12}H_{12}ClN_5O_4S)$ 1-(chlorophenylsulphonyl)-3-(4-methoxy-6-methyl-1,3,5-triazin-2-yl) urea) (6490-27-23), trade names Glean® and Telar®. Used to control many broadleaf weeds and some annual grass weeds, sulphonyl urea herbicides block the synthesis of essential branched chain amino acids. They have a high potential to contaminate ground water. (*PE*)

Sulphur: A lemon-yellow-coloured nonmetallic element sometimes known as "brimstone". (*PP*)

Sulphur dioxide: (SO₂). A colourless, non-flammable, extremely irritating gas or liquid used in many industrial processes. (*MM*, *PP*)

Summary relative risks: Relative risk calculated by pooling relative risks emerging from meta-analysis.

Suppressor T-cells: Antigen-specific suppressor T lymphocytes (white blood cells) that diminish an organism's immune response.

Surface water: Water which is open to the atmosphere and subject to surface runoff; generally lakes, streams, rivers. (*DB*)

Surfactants: Surface-active lipoproteins that normally serve to decrease the surface tension of fluids. In the lung, they thereby permit the pulmonary tissues to expand during inspiration. (*PE*)

Susceptibility genes: Genetic loci that put individuals into a higher risk of morbidity or mortality from a specific condition.

Synergistic effect: A situation in which the combined effect of two or more factors is greater than the sum of their solitary effects.

Tankhouse: Where the electrolytic tanks are located in a smelter. (*MM*)

TCDD: *See* 2,3,7,8-tetrachlorodibenzo-p-dioxin.

TCP: See 2,4,5-trichlorophenol.

Terbuphos: *S-tert*-butylthiomethyl-*0*,*0*-diethyl phosphorodithioate $(C_9H_{21}O_2PS_3)$. A highly toxic aliphatic organo thiophosphate insecticide and nematicide used to control soil pests on corn and sugar beets. Primarily formulated as granules, it is applied at planting. Terbufos controls wireworms, seed-corn maggots, white grubs, corn rootworm larvae and other pests. It breaks down rapidly. Two of the primary degradation products, terbufos sulphoxide and terbufos sulphone are highly toxic and more persistent in terrestrial and aquatic environments than the terbufos itself. Use is being phased out in Canada. (13071-79-9) (*PE*)

Tesla: The unit of magnetic flux density, equal to one weber per square meter and symbolized as T. A micro-tesla (μ T) is one millionth of a tesla. (*EF*)

Tetrachlorodioxins: Pesticide by-products/ contaminants. (*PE*)

Tetrachloroethylene: (CCl₂; CCl₂). A halogenated volatile organic compound (VOC) organic solvent that can become airborne from pulp and paper mill waste water. (*PP*)

Thiocarbamate: Typically herbicides with a carbamate structure where sulfur replaces one of the oxygens in the amide functional group (-S-CO-N- instead of -OCO-N-). They are weak cholinesterase inhibitors. (*PE*)

Thiocyanate: A compound having the SCN group in its structure. (*PE*)

Thiol-containing molecules: An organic compound containing SH (sulphydryl). (*MM*)

Thiophanate methyl: Dimethyl 4,4'-(*O*-phenylene) bis (3-thioallophanate) $(C_{12}H_{14}N_4O_4S_2)$. A carbamate fungicide. (23564-05-8) (*PE*)

Thiophosphate: A phosphate in which one of the oxygen atoms has been replaced by a sulphur atom. (*PE*)

THMs: See Trihalomethanes.

Threshold-limit value (TLV): Air borne concentration of substances which represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day, for the entire working life, without adverse effects. (*MM*)

Threshold-limit value time-weighted average (TLV-TWA): Average concentration of an airborne substance for a normal eight hour work day or 40-hour work week to which nearly all workers may be repeatedly exposed day after day without adverse effects. (*MM*)

TLV: See Threshold limit value.

Toxaphene: $(C_{10}H_{10}C_{18})$. Polychlorcamphene, camphechlor. A reaction mixture of chlorinated camphenes containing 67-69% chlorine. A polychloroterpene (organochlorine) insecticide. The use of toxaphene on Canadian crops was discontinued in 1970. It is a common fish contaminant in the Yukon and NWT. For Canadians, the principal route of exposure is eating contaminated fish. (8001-35-2) (*PE*)

Transition: A mutation in which a chemical in DNA is replaced by a different chemical but of a similar type.

Translocation: An exchange of chromosomal fragments between two nonhomologous chromosomes in a diploid organism during cell division.

Transversion: A mutation in which a chemical in DNA is replaced by a chemical of a different type.

Treated water: Disinfected and/or filtered water served to water system customers. (*DB*)

Triadimefon: 1-(4-chlorophenoxy)-3,3-dimethyl-1-(1*H*-1,2,4-triazol-1-yl)butan-2-one. A triazole fungicide used to control powdery mildews, rusts, and other fungal pests on cereals, fruits, and vegetables. (43121-43-3) (*PE*)

Triallate: *S*-2,3,3-trichloroallyl diisopropylthiocarbamate ($C_{10}H_{16}Cl_3NOS$). A thiocarbamate herbicide used to control wild oats, primarily in wheat and barley and one of the thiocarbamate herbicides used most commonly in Canada. (2303-17-5) (*PE*)

Triazines: Herbicides that act by stopping photosynthesis, used on fruit, grain and vegetable crops. They include Atrazine (AATREX), Cyanazine (BLADEX), Hexazinone (VELPAR), Metribuzin (LEXONE, SENCOR) and Simazine (PRINCEP). Triazine is a heterocyclic aromatic 6-membered ring made up of 3 nitrogen atoms and 3 carbon atoms. (*PE*)

Triazoles: A class of herbicide and fungicide/fumigant including Amitrole, Fluconazole, Guanazole, Itraconazole, and Trapidil. Triazole is a heterocyclic aromatic 5-membered ring made up of three nitrogen atoms and two carbon atoms. (*PE*)

Trichloroethylene: (CHCl; CCl₂). A halogenated volatile organic compound (VOC) in the form of a heavy, stable toxic liquid with a chloroform aroma, slightly soluble in water. (*PP*) **Trichlorophenol:** ($C_6H_3Cl_3O$). An organochlorine fungicide/fumigant. A man-made chemical no longer made in the US. It is a germicidal agent used to preserve wood and glue as well as to protect textiles against mildew. (88-06-2) (*PE*)

Trifluralin: α,α,α-trifluoro-2,6-dinitro-*N*, *N*-dipropyl-*p*-toluidine ($C_{13}H_{16}F_3N_3O_4$). One of the dinitroaniline herbicides most commonly used in Canada; a selective, preemergence herbicide used to control annual grasses and broadleaf weeds in a variety of crops. (1582-09-8) (*PE*)

Triflusulfuron:2-[4-dimethylamino-6-(2,2,2-trifluoroethoxy)-1,3,5-triazin-2-ylcarbamoylsulfamoyl]-*m*-toluic acid ($C_{16}H_{17}F_{3}N_{6}O_{6}S$). A sulfonyl urea herbicide. (*PE*)

Trihalomethanes (THMs): Halogen-substituted single-carbon compounds with the general formula CHX₃, where X may be one or a combination of chlorine, bromine, fluorine, or iodine. These compounds are formed in treated water primarily as a result of chlorination of organic matter present naturally in raw water supplies. The THMs most commonly present in drinking water are chloroform, bromodichloromethane, chlorodibromomethane, and bromoform. (*DB*)

Trivalent arsenicals: Arsenic compounds possessing a valence of three (e.g., Arsenic trichloride (AsCl₃), Arsenic Trioxide (As₂O₃)). (*MM*)

Tumour-promoting agent: A stimulus or substance (chemical or otherwise) which has the potential to stimulate the growth of either benign or malignant tumours.

Turpenes: Any of the group of isomeric unsaturated hydrocarbons with the formula $C_{10}H_{16}$, also known as turpentines. They have a pleasant aromatic odour, and occur in essential oils and oleoresins of plants, especially conifers. Terpenes are emitted from outside chip piles in the pulp and paper industry and they constitute a group of volatile organic compounds that have no practical collection or disposal method. Forest trees also emit vast amounts of terpenes, and in the typical rural kraft mill, terpenes emitted by a chip pile are negligible compared to natural terpene emissions. (*PP*)

Turpenoids: A group of plant secondary metabolites based on one or more isoprene units, and constituents of many essential oils. (*PP*)

Ultraviolet radiation (UVR): That portion of the electromagnetic spectrum extending from the violet, or short wavelength, end of the visible light range to the X ray region. Ultraviolet (UV) radiation is undetectable by the human eye, although when it falls on certain materials it may cause them to fluoresce; i.e., emit electromagnetic radiation of lower energy, such as visible light. (*UR*)

Uncertainty factor: All those factors (or confounders) for which the investigator has only probabilistic data.

Unit risk: The excess probability of developing a disease, given continuous exposure to one unit (e.g. $1 \ \mu g/m^3$) of a substance over a lifetime. (*MM*)

Uracil: $(C_4H_4N_2O_2)$. One of the bases in RNA. It is a pyrimidine(1,3-diazine), an aromatic heterocyclic compound that is a six-membered ring made up four carbon atoms and two nitrogen atoms. There are two oxygen atoms attached to two of the carbons in the ring. Uracil herbicides, derived from Uracil, can cause ground water contamination. Examples of Uracil herbicides include Bromacil (314-40-9) and Teracil (5902-51-2). (*PE*)

Uranium: (U). A heavy silvery-white metallic element with the atomic number 92, radioactive and toxic, easily oxidized, and having 14 known isotopes of which U 238 is the most abundant in nature. The element occurs in several minerals from which it is extracted and processed for use in research and nuclear fuels and weapons. (*R*)

Urea: $(CO(NH_2)_2)$. A water-soluble crystalline compound, that is the major nitrogenous end product of protein metabolism and is the chief nitrogenous component of the urine of mammals and other organisms. Also called carbamide. Urea is manufactured synthetically for use in making fertilizers. (57-14-7) (*PE*, *PP*) **Uvea:** The portion of the eye composed of the iris and ciliary bodies together with the choroid coat.

Uveal melanoma: Melanoma which occurs in human uvea.

UVR: *See* Ultraviolet radiation.

Valence: A measure of the possible ways an atom can combine with other atoms. It is dependent on the electron configurations of the reacting elements.

Variable penetrance: In the medical context, penetrance is the proportion of individuals with a given genotype who present with any phenotypic features of the disorder (i.e., it is an all-or-none phenomenon). However, in one sense penetrance may vary with age, as in the case of Huntington's disease. Variation in age of onset is most often considered as an aspect of variable expression.

Variance: A measure of the variation shown by a set of observations.

Variogram: A plot reflecting several measurements of a spatial or regionalized variable along a specified area or distance. Measurements are taken at a number of locations and the relationship between observations at the various locations can be explored by variogram analysis. (*AP*)

Vitamin D photochemistry: Cutaneous exposure to UV-B converts epidermal previtamin D3 (7-dehydrocholesterol) to the stable hormone vitamin D3. This compound then diffuses through the skin to blood vessels and circulates systemically, where it is converted to the functional hormone 1,25-dihydroxy vitamin D3[1,25(OH)2D3]. Aging substantially decreases the ability of human skin to produce vitamin D3. This, coupled with the widespread use of sunscreens that filter out UV-B, has led to concern that vitamin D deficiency may become a significant clinical problem in the elderly. Indeed, studies have shown that the use of sunscreens can prevent the production of vitamin D3 in human skin. (UR)

VOCs: See Volatile organic compounds.

Volatile organic compounds (VOCs): Organic compounds that convert into vapour or gas without a chemical reaction. (*DB, AP, PP*)

Volt: The electrical unit equal to the potential difference between two points on a conductor carrying a current of 1 ampere when the power dissipated between the two points is 1 watt; equivalent to the potential difference across a resistance of 1 ohm when 1 ampere of current flows through it. *(EF)*

Watt: The unit for measuring electric power or energy available per second. One watt is equal to one joule of energy per second. (*EF*)

Weber: The unit of magnetic flux. (EF)

Wertheimer-Leeper wire code: A categorization of wiring configurations developed by Nancy Wertheimer and Ed Leeper. Power lines close to residences are categorized according to the number of conductors and their diameters, location of transformers and service drops, as well as the distance of the conductors from the home. (*EF*)

Wood volatiles: Extractives naturally present in wood that vapourize over time. (*PP*)

Working level month: A WL (Working Level) is any combination of radon progeny in one litre of air that results in the average emission of 1.3×10^5 MeV of alpha energy during decay. Exposure to 1 WL for 170 hours equals 1 Working Level Month (WLM) of exposure, a unit developed to describe exposure sustained by miners during the average number of hours spent underground. (*R*)

Xenoestrogen hypothesis: A convention that states: "some environmental chemicals (e.g., organochlorines) exhibit estrogen receptor agonistic activity." It is unclear whether this is an important mechanism whereby cancer is induced in humans. (*PE*)

Xiphophorus fish model: Heavily pigmented backcross hybrids of the genus Xiphophorus (platyfish and swordtails) are very sensitive to melanoma induction by single exposures to UVR. They are therefore used in experiments involving melanoma induction by UVR. (*UR*)