The GHS Training Program

and

WHMIS 2015

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GHS Reference Manual

Training by Design Inc.
North Vancouver, British Columbia

Table of Contents for GHS Reference Manual

Safety Data Sheet

Note: NAP = not applicable
NAV = not available

sample for illustration only

Section 1 — Identification

Product Identifier Solve-All	**Other Means of Identification** S-A999
Recommended Use general purpose solvent	**Restrictions on Use** none
Supplier Solve-All Inc. 987 Any Street Anywhere City, Province X9X 1Z1	**Telephone** 1-800-XXX-9876 **Emergency Telephone** 1-XXX-234-5678 24/7 availability

Section 2 — Hazardous Ingredients

GHS Classification Flammable Liquid - Category 3; Acute Toxicity: Inhalation gas/vapour - Category 3; Specific Target Organ - Single Exposure: Narcotic Effects - Category 3; Aspiration Hazard - Category 1

Danger

Hazard Statements Flammable liquid and vapour. Toxic if inhaled. May cause respiratory irritation or drowsiness and dizziness. May be fatal if swallowed and enters airways**.** May be harmful in contact with skin.

Precautionary Statements Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. Avoid breathing gas, vapours, spray. No smoking. Keep container tightly closed. Bond and ground container and receiving equipment. Wear protective gloves/clothing/ eye/ face protection. If on skin or hair rinse with water. Take off immediately all contaminated clothing. In case of fire, use carbon dioxide, dry chemical, “alcohol foam” to extinguish. Use in well-ventilated area. Store in a well-ventilated place. Keep cool. Dispose in secure landfill. IF INHALED, remove person to fresh air and keep comfortable for breathing. Call a POISON CENTRE or doctor. IF SWALLOWED, immediately call a POISON CENTRE; do NOT induce vomiting.

Other Hazards Irritates nose, throat, eyes. Causes dry skin.

Section 3 — Composition/Information on Ingredients

Chemical Identity	Common Name	CAS	Other Unique Identifiers	Concentration %
Petroleum Distillate: 15 to 20% Aromatic 80 to 85% Aliphatic	paint thinner, mineral spirits	8052-41-3	NAP NAP	100 %
Chemical Impurities	NAP	NAP	NAP	NAP
Stabilizing Additives	NAP	NAP	NAP	NAP
Stabilizing Solvents (WHMIS 2015) none	NAP	NAP	NAP	NAP

Section 4 — First-Aid Measures

First-Aid Measures	Symptom/Effects of Acute or Delayed Exposure	Immediate Medical and Special Treatment
Inhalation Remove victim to fresh air. Call a Poison Control Centre. **Ingestion** If swallowed, immediately call a Poison Control Centre; do NOT induce vomiting. **Skin Contact** Wash skin with water for at least 15 min. Soap may be used. **Eye** Rinse eyes with water for at least 15 minutes.	**Acute** headache, dizziness, confusion. Death can occur at high concentrations. **Delayed** NAV	Follow instructions as noted for each route of exposure.

Section 5— Fire-Fighting Measures

Suitable Extinguishing Media carbon dioxide, dry chemical, alcohol foam

Unsuitable Extinguishing Media Do not use water as it may cause fire to spread.

Specific Hazards Arising from the Hazardous Product NAP

Special Protective Equipment and Precautions for Firefighters Wear NIOSH-approved Self-Contained Breathing Apparatus (SCBA) and turnout gear.

Section 6 — Accidental Release Measures

Personal Precautions, Protective Equipment and Emergency Procedures These apply to small quantities < 5L only. For larger quantities, call Emergency Response Services and ask for help from the HazMat Team. Extinguish all sources of ignition. Attempt this procedure only when equipment is available and workers have practised this activity. Wear PVA or NEOPRENE gloves to protect against skin contact. Wear NIOSH-approved organic vapour respirator if above TLV. Wear Safety glasses or goggles, and where splashing can occur, wear faceshield and PVA or NEOPRENE apron or chemical protective suit (TYVEK).

Environmental Precautions Prevent from entering sewer.

Methods and Materials for Containment and Cleaning Up Contain and cover using sand to suppress vapour emission or a product rated for use with spills of hydrocarbons. Using a shovel, collect into a 20 L metal pail containing a lid.

Section 7 — Handling and Storage

Precautions fo Safe Handling Use minimum quantity needed. Keep container closed. Bond and ground during liquid transfer.

Conditions for Safe Storage (including any incompatibilities) Store in cool ventilated area, no ignition sources. Bond and ground container. Incompatible with some rubbers/plastics.

Section 8 — Exposure Controls/Personal Protection

Exposure Limits ACGIH TLV -TWA 525 mg/m^3 (100 ppm)	**Engineering Controls** Use local exhaust to control below TLV. Use general ventilation to control below TLV.

Individual Protection Measures Wash hands before eating, drinking, or smoking. Wear hand cream or gloves to protect against skin contact. Do not smoke while working with this product.

Section 9 — Physical and Chemical Properties		
Physical State liquid	**Colour** clear, colourless	**Particle Characteristics** NAP Product is a liquid.
Odour kerosene or paint-like	**Odour Threshold** 4 to 5 mg/m^3	**Melting Point/Freezing Point** NAV
Boiling Point or Initial Boiling Point and Boiling Range 150° to 200° C		**Flammability** Flammable when liquid or sprayed.
Flash Point 38.7° to 60° C closed cup	**LFL** 0.9% **UFL** 6.0%	**Auto-Ignition Temperature** 226° to 260° C
Decomposition Temperature NAP		**Kinematic Viscosity** 0.0114 cm^2/s
pH NAP		**Solubility (in Water)** insoluble
Partition Coefficient, n-octanol/water (log value) 3.16-7.15		**Density and/or Relative Density (H_20 = 1)** 0.78
Vapour Pressure 2 mm Hg @ 20° C		**Relative Vapour Density (air = 1)** 5

Section 10 — Stability and Reactivity	
Reactivity Reacts with strong oxidizers, liquid oxygen, chlorine.	**Chemical Stability** stable
Possibility of Hazardous Reactions none known	**Conditions to Avoid** (electrostatic discharge, shock, vibration) (mechanical impact: stable); (static discharge: NAV)
Incompatible Materials some rubbers/plastics	**Hazardous Decomposition Products** carbon dioxide, carbon monoxide

Section 11 — Toxicological Information			
Route of Exposure		**Carcinogenicity** not known	**Germ Cell Mutagenicity** not known
Inhalation	✓	**Inhalation** Can cause irritation of nose, throat, and lungs.	
Ingestion	✓	**Ingestion** Coughing and choking almost immediately followed by vomiting, sore throat, and burning sensation in mouth.	
Skin Contact	✓	**Skin** Causes dry skin.	
Eye Contact	✓	**Serious Eye Damage/Eye Irritation** eye irritant	
Respiratory or Skin Sensitization none observed			**Reproductive Toxicity** none known
Aspiration Toxicity can occur if product is ingested and enters airways; pulmonary edema (fluid in lungs)			**Biohazardous Infectious Material** (WHMIS 2015 only) NAP
Specific Target Organ: Single Exposure (Acute Exposure) headache, dizziness, confusion. Death can occur at high concentrations.			**Specific Target Organ: Repeated Exposure** (Chronic Exposure) possible damage to liver, kidneys; possible effects on nervous system.
Delayed and Immediate effects, and Chronic Effects from Short and Long-Term Exposure not known			
Numerical Measures of Toxicity			
LD_{50} (Species/Route) NAP			**LC_{50} (Species)** 1340 ppm (cat); 1980 ppm (rat)

Section 12* — Ecological Information

Ecotoxicity (aquatic and terrestrial, if available) Not known.

Persistence and Degradability NAV

Bioaccumulative Potential If Solve-All enters water, soil, or sediment, microorganisms may break down the constituents

Mobility in Soil A large amount of Solve-All contaminating the soil will move through the soil into groundwater.

Other Adverse Effects NAV

*This section is not required by WHMIS 2015 or OSHA. Presented here for illustrative purposes only are the requirements for this section taken from Schedule 1 of the Controlled Products Regulation, 2015 and the GHS 7th revision, UN 2017.

Section 13* — Disposal Considerations

Waste Residues vapours, liquid contained in solid or mixed in the liquid including oil or volatile liquid

Safe Handling Refer to Section 6: Personal Precautions, Protective Equipment and Emergency Procedures or information relating to recovery of spilled product. Waste liquid packaged in a drum poses no hazard different from the new product described in this document.

Disposal Method This product is a fuel and can be incinerated provided that contamination by highly hazardous materials has not occurred. Where contamination by such substances has occurred, dispose in secure landfill. Product is a fuel. Incineration can occur. The user is responsible for hazard evaluation of the waste and compliance with applicable laws. Follow label warnings.

Section 14* — Transport Information

UN Number 1268			**UN Shipping Name** Petroleum Distillates, NOS
Transport Hazard Class(es) 3.1 Class 3: Flammable Liquid			**Packing Group** III
Environmental Hazards	**Yes**	**No**	**Transport in Bulk** Follow requirements of IBC Code. Follow requirement of Transportation of Dangerous Goods Act and Regulations (Canada).
marine pollutants	✓		
others	NAV		**Special Precautions** none

Section 15* — Regulatory Information

Safety, Health, and Environmental Regulations, Canada

- **WHMIS Classification** flammable liquid; acute toxicity**;** toxic (eye, skin, lung irritant; poison if ingested). This product has been classified according to the hazard criteria of the Controlled Products Regulation and includes all required information in the SDS.
- **Domestic Substances List/Non-Domestic Substances List**
- **CEPA -** National Pollutant Release Inventory

USA

- **Toxic Substances Control Act**

Other Jurisdictions NAP

Section 16 — Other Information

Prepared by I. M. Nophool	**Date of Revision** 2018 10 30
Telephone 800 - XXX - 9881	SDS updated to conform to the Canadian Hazardous Product Regulation SOR/2015-17

*Sections 12 to15 are not required by WHMIS 2015 or OSHA. Presented here for illustrative purposes only are the requirements for these sections taken from Schedule 1 of the Controlled Products Regulation, 2015 and the GHS 7th revision, UN 2017.

Section 1 – Identification

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Recommended Use general purpose solvent	**Restrictions on Use** none
Supplier Solve-All Inc. 987 Any Street Anywhere City, Province X9X 1Z1	**Telephone** 1-800-XXX-9876 **Emergency Telephone** 1-XXX-234-5678 24/7 availability

Figure 1.1 Section 1 of SDS for Solve-All.

Overview

This section specifies the name of the product and its intended use (Figure 1.1). It also indicates the origin of the product. This section is an important resource for obtaining further information about the product during normal use and emergencies. The chemical or product may not be a hazardous chemical product. That is, it may not contain hazardous ingredients to which the GHS and WHMIS 2015 applies. A manufacturer or supplier, importer or employer can produce a SDS voluntarily, even though not required to do so.

Product Identifier

Product identifier indicates the exact name of the product (Figure 1.2). A product can have many identifiers. Some examples include the chemical name, generic name, brand name, trade name, code number, or code name. The manufacturer or supplier must specify a unique identifier for each product. That is, two different products from a supplier cannot have the same product identifier. However, a supplier can sell a product under more than one name.

Companies sometimes market pure substances or generic mixtures under trade names rather than the chemical name. This strategy attempts to create loyalty to the product name. Marketers of household products have used this approach for many years. As a result, many aliases or alternate names exist for many pure substances and generic mixtures. These reflect the diverse origins of the chemical industry. A supplier could market a product in different industries under the name by which it is known in each. Thus, a supplier can sell the same product or chemical under different names.

The name of the Product Identifier in the SDS must match that in the GHS Label on the container. The receiver of the shipment should ensure that this is the case on arrival at the loading dock. This is the first point of assurance that no mismatch exists prior to use of the product.

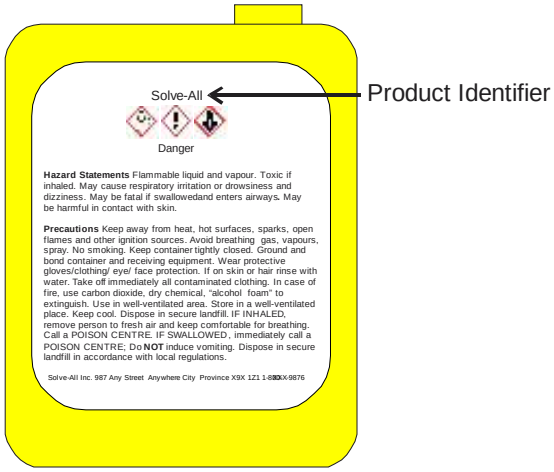

Figure 1.2 The product identifier is the name identifying the chemical product on the Label and in the SDS.

Other Means of Identification

This may refer to a reference number or name assigned to a product by the supplier or manufacturing company.

Recommended Use and Restrictions on Use

These boxes indicate the expected use of the product. When you receive a SDS, take the time to read this information (Figure 1.1 and Figure 1.3). The presumed use may not match the actual one. The importance of comparing the hazard between actual and presumed conditions cannot be overstated. Information presented later in the SDS reflects the level of hazard suggested by presumed use of the product. If the circumstances of actual use are too different, precautionary measures may not apply.

Consider the following example to illustrate this point. Many products have specific applications. A vapour degreaser normally is used in a contained environment. An experienced industrial hygiene professional can predict exposure under these conditions. This forms the basis of control measures stated in the SDS. Unusual uses of the product could include wiping with rags or brushing or spraying onto surfaces. Exposures occurring during these situations could differ considerably from those expected. If actual use produces greater exposure than anticipated, protective measures recommended in the SDS may not be adequate. Similarly, if actual use produces less exposure than anticipated, the protective measures may be too stringent. Follow Restrictions on Use, if any. If none, it is still very important to follow the Recommend Use as noted above.

✍ Have the students highlight this box. These terms tend to be overlooked when people scan the SDS. This box contains critically important information that indicates the focus taken by the author of the SDS in preparing this document.

Recommended Use, to a trained eye, indicates the potential for exposure during normal use of the product. This should be reflected in the protective measures.

Supplier

The supplier is the company from which the product is purchased. The manufacturer is the actual manufacturer of the product (Figure 1.4). This section may or may not disclose the name of the manufacturer provided that either the name of the manufacturer or supplier appears. For example, the manufacturer may supply the hazardous chemical product to the end-user. In this case, since there is no separate supplier, the name of the manufacturer must appear. Organizations producing a hazardous chemical product for future sale or disposal are the manufacturer or supplier.

The supplier sells or otherwise provides the product to the end-user. The supplier can be a manufacturer, processor, distributor, packager, importer, or seller.

Figure 1.3 Recommended use refers to the expected use of the product.

Figure 1.4 The manufacturer is the actual manufacturer of the product. The supplier can be the manufacturer, processor, distributor, packager, importer, or seller.

Emergency Telephone Number

The emergency telephone number provides a means of making contact with the manufacturer or supplier during an emergency situation.

Chemical manufacturers, suppliers, distributors, and importers utilize emergency telephone numbers in different ways. In large organizations during normal business hours, this number could reach a plant medical centre or industrial hygienist or safety professional. In smaller organizations, this number could reach a nurse or lab chemist or regulatory affairs office.

In some companies the number connects to the office of plant security during off-shifts. This provides a centralized contact who can summon resources who are more likely to be decentralized during the off-shifts. Other companies have out sourced this function to external medical service providers.

Some SDSs provide the telephone number for CANUTEC (613-996-6666 or 1-888-226-8832). CANUTEC is the Canadian Transport Emergency Centre. CANUTEC is part of the Regulatory Affairs Branch of the Surface Group, Transportation of Dangerous Goods Directorate of Transport Canada. CANUTEC provides prompt and effective assistance and advice to emergency response personnel in the event of an accident involving dangerous goods. CANUTEC will respond to calls from the public. CANUTEC operates 24 hours per day, seven days per week.

Another emergency number that may appear in SDSs is that of CHEMTREC™ (800-424-9300). CHEMTREC™ is the Chemical Transportation Emergency Center. CHEMTREC™ is provided as a public service by the Chemical Manufacturers Association and its members. CHEMTREC™ provides access to response information and technical assistance from experts in the chemical industry to first responders, the transportation industry, medical professionals, and others. CHEMTREC™ operates 24 hours per day, seven days per week.

The first point of contact at CHEMTREC™ is a communicator who provides information from a collection of SDSs numbering over one million. Second, the communicator may initiate a call to the 24-hour emergency contact of the manufacturer. This could lead to a teleconference involving industry experts, first responders, medical professionals, and specialists in poison control.

QUESTIONS AND ANSWERS

1. The product identifier in the SDS received for a shipment does not match the Label on the container. What should we do?

Call the supplier or manufacturer immediately to explain the situation. Ask them if a mistake has occurred. If this has happened, ask them to send the appropriate SDS. If they reply that no error has occurred, demand that they explain the discrepancy. If the explanation is not satisfactory, return the product, and look for another supplier.

2. A shipment of “Improved J-solvent” arrived in the plant without an SDS. However, we found one for the old J-solvent. Is it all right to use this SDS with the new shipment?

Absolutely not! The fact that the product is now “improved” suggests that the manufacturer changed the formula. The original SDS probably does not apply. For this reason, do not rely on the original. Cease using the product until the supplier has provided the updated SDS.

3. The Supplier section of the SDS is blank. Is this acceptable?

No. What is important is a reliable source of information that is available if needed.

4. During an emergency we telephone our supplier and find that their number has been disconnected. What should we do?

Several alternate sources of information could assist during emergencies. These include (no particular order)

- the manufacturer (if available)
- the distributor (if available)
- the importer (if available)
- federal, provincial, or territorial WHMIS 2015 co-ordinator
- poison control centres
- CANUTEC (613-996-6666)

- CHEMTREC (800-424-9300)
- HAZMAT responders (911)

Determining the most suitable alternative **before** an accident occurs is strongly recommended.

5. How can I determine if our use for a product is equivalent to the expected one?

Answering this question competently without the expertise of an industrial hygiene professional is virtually impossible. Attempting to answer this on one's own could produce serious consequences even assuming full disclosure of available information. If there is any doubt whatsoever, contact the preparer of the SDS or the emergency number and ask for assistance. This is a legitimate customer request.

6. Our use for a product does not match that indicated by the SDS. What should we do?

There are several options available:

- Change the application so that it matches the expected use.
- Change the product to one suited to the application.
- Contact the preparer of the SDS for assistance.
- Contact the emergency number contained in the SDS for assistance.
- Obtain assistance from an industrial hygiene professional.

Conducting this enquiry is extremely important. Recommendations contained in the SDS presume certain facts about the application. If the actual use is inconsistent with assumptions made in preparing the SDS, the recommendations may not apply.

7. If we follow the instructions contained in the SDS and GHS Label for using the product, are we complying fully with the requirements of WHMIS 2015 and other federal, provincial, or territorial regulations?

In a word, no. Federal, provincial, and territorial regulations require assessment and monitoring of worker exposure. This is independent of any recommendations contained in the SDS or GHS Label. The reasoning behind this requirement is that conditions of use vary widely. No one can predict with certainty the exposure of persons exposed to the hazardous chemical product. In addition, standards for workplace exposure can vary considerably from one jurisdiction to another. These may differ from those contained in the SDS.

8. Whom should we contact to assess our chemical handling procedure?

A number of organizations can provide assistance. Potential sources of assistance include

- the manufacturer or supplier
- trade and industry associations
- labour organizations
- university and college health and safety centres
- industrial hygiene consultants
- suppliers and manufacturers of protective equipment and clothing

Section 11 — Toxicological Information

Section 11 — Toxicological Information			
Route of Exposure		**Carcinogenicity** not known	**Germ Cell Mutagenicity** not known
Inhalation	✓	**Inhalation** Can cause irritation of nose, throat, and lungs.	
Ingestion	✓	**Ingestion** Coughing and choking almost immediately followed by vomiting, sore throat, and burning sensation in mouth.	
Skin Contact	✓	**Skin** Causes dry skin.	
Eye Contact	✓	**Serious Eye Damage/Eye Irritation** eye irritant	
Respiratory or Skin Sensitization none observed			**Reproductive Toxicity** none known
Aspiration Toxicity can occur if product is ingested and enters airways; pulmonary edema (fluid in lungs)			**Biohazardous Infectious Material** (WHMIS 2015 only) NAP
Specific Target Organ: Single Exposure (Acute Exposure) headache, dizziness, confusion. Death can occur at high concentrations.			**Specific Target Organ: Repeated Exposure (Chronic Exposure)** possible damage to liver, kidneys; possible effects on nervous system.
Delayed and Immediate effects, and Chronic Effects from Short and Long-Term Exposure not known			
Numerical Measures of Toxicity			
LD_{50} (Species/Route) NAP			**LC_{50} (Species)** 1340 ppm (cat); 1980 ppm (rat)

Figure 11.1 Section 11 of SDS for Solve-All.

Overview

This section presents toxicological information known about the hazardous product or its ingredients (Figure 11.1). Toxicology is the study of the poisonous effects of chemical and biological substances and physical agents on individual organs and tissues, as well as the whole animal (Figure 11.2). These effects can include the ability to cause disease, to produce sensitization, and to affect reproduction, as well as other effects.

Some substances affect the whole animal, while others affect individual organs such as the eye, liver, lungs, brain, and so on. A substance also may affect a specific tissue within an organ such as the cornea in the eye, certain nerves, white blood cells, or involuntary muscles.

Adequate information about effects of exposure exists for only a small number of substances. For the vast majority, there is little or no information. Many chemicals are mixtures. Often some information is available about individual ingredients, but not the mixture.

Despite this uncertainty, recent workplace experience is more positive than negative. Many substances, such as organic solvents, produce similar, reversible effects. The human body has the ability to modify many classes of chemical. These modifications usually detoxify the substance and enable rapid elimination.

In recent years the news media have bombarded the public about the negative aspects of chemicals. This constant barrage would suggest that people should be dying

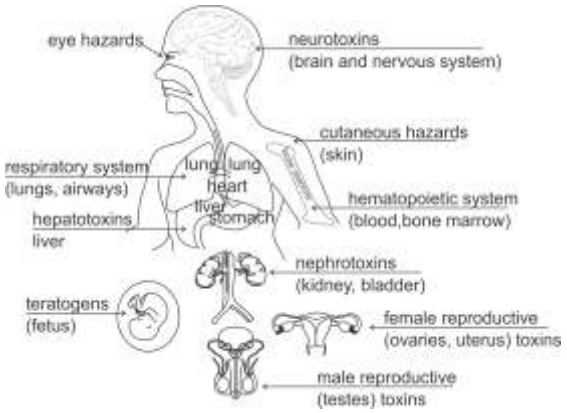

Figure 11.2 Hazardous chemicals often affect specific orgrans.

in epidemic numbers from exposure to small quantities of chemical substances in food, water, and air. We can't stop eating, drinking water, or breathing. See Table 11.1. Though dated 1985, this table still applies today. As well, the following facts suggest that the hypothesis of mass chemical poisoning is not correct.

Life expectancy for the average person has dramatically increased over the course of the last century. It is still increasing. Life expectancy reflects length of life lived. Consider the following:

- Almost without exception, people who work live longer than people who do not. This characteristic is known as the healthy worker effect. Epidemiological studies have shown the healthy worker effect in many industries for at least a century. (Epidemiology is the study of disease occurring in groups of people. It is a tool used to identify causes of disease.)
- Chemical exposures in the workplace have decreased considerably as control technologies have improved.
- Consumers are permitted to purchase many chemical products for uncontrolled use in the home.

There have been, of course, many tragic situations involving overexposure to chemicals in industry and the home. The home is a major location for accidents of various kinds. Tragedies in industry and the home have prompted considerable legislation over the last 150 years. Consumer-oriented legislation has improved the flow of information through labelling on packages. The intent of the GHS is to cover all hazardous chemical products whether used in industry or in the home.

Information provided in this section forms the basis for selecting control measures and personal protection that provide defence to prevent contact by the body with the material. This information also forms the basis for specifying first response and first-aid measures. These minimize the damage caused by accidental exposure. Large doses of any substance usually produce an effect within a short period.

Table I.1 in the Introduction chapter specifies the hazard classes and corresponding cut-off/concentration limits which determine whether a chemical product is considered to be hazardous. The use of chemicals meeting these specifications require the application of hazard communication elements as determined by the GHS, namely, labels and safety data sheets (SDSs). The GHS applies to all chemical products deemed hazardous.

Many hazardous chemical products are mixtures. Sometimes toxicological information is available for all components of the mixture. Usually the mixture itself is not tested. Where testing is incomplete, the GHS requires classification based on the known ingredients to represent the mixture. This is a hit and miss approach. Unfortunately, nothing better exists at this time. While this is hardly a satisfactory approach, there is no better alternative available. This statement may sound apologetic. However, many years of industrial experience prove that this approach has a reasonable basis. Many chemical substances were used for many years before toxicological testing became widely available. In those times, the only basis on which to draw conclusions was human experience.

Some products contain biologically active material. This can include life forms such as bacteria, fungi, yeasts, moulds, viruses, protozoa, and higher life forms. Other biologically active substances can include enzymes, secretions, wastes, and other contents formerly found in living cells. The effects of these life forms and cellular products on humans can range from negligible to causing disease or death.

Toxicological Information

Toxicology is the study of the effects of substances on living organisms. It derives from the Greek word *toxos* or poison. Toxicology is a young science. Major effort in the 20th century focussed on the area of **industrial toxicology**. Industrial toxicology is concerned with effects of chemicals used or produced in the workplace environment. Industry commonly uses several thousand chemicals. Yet, full or even partial information about their effects on humans exists for only very few. This frustrating lack of information appears repeatedly in Safety Data Sheets. The right to know has indicated to people in the workplace just how little is actually known about chemical substances. Yet, people have worked safely with many of the same substances both in the home and at work for many years. Lack of knowledge creates uncertainty. Uncertainty leads to fear. Fear can

Table 11.1

Risks in Everyday Life: Commins, B.T., The Significance of Asbestos and Other Mineral Fibres in Environmental Ambient Air. Maidenhead, England: Commins Associates, 1985. Reproduced with permission.

Selected risk situation, mainly U.S. data	Effect	Lifetime* risk (per 100,000)
Extra High Risk		
smoking	death (all causes)	21900
smoking	cancer only	8800
High Risk		
motor vehicle (U.S.A., 1975)	death	1600
Elevated Risk		
frequent airline passenger	death	730
cirrhosis of liver, moderate drinker	death	290
motor accidents, pedestrians (U.S.A., 1975)	death	290
skiing, 40 hours per week	death	220
Moderate Risk		
light drinker, one beer per day	cancer	150
drowning, all recreational causes	cancer	140
air pollution, (U.S.A.), benzo(a)pyrene	cancer	110
natural background radiation, sea level	cancer	110
frequent airline passenger, cosmic rays	cancer	110
Low Risk		
home accidents (U.S.A., 1975)	death	88
cycling	death	75
person sharing room with smoker	cancer	75
diagnostic x-rays (U.S.A.)	cancer	75
(risk level where few would commit their own resources to reduce risk; Royal Society, London, 1983)	death or injury	70
Very Low Risk		
person living in brick building, additional natural radiation	cancer	35
vaccination for smallpox, per occasion	death	22
one transcontinental air flight per year	death	22
saccharin, average U.S.A. consumption	cancer	15
consuming Miami or New Orleans drinking water	cancer	7
Risk level where very few would consider action necessary, unless clear causal links with consumer products; Royal Society, London, 1983)	death or injury	7
Extremely Low "Rare-Event" Risk		
one transcontinental air flight per year, natural radiation		
lightning	cancer	4
hurricane	death	3
charcoal broiled steak, one per week	death	3
environmental asbestos risk**, 1985 Commins report	cancer	3
World Health Organization for drinking water (1984)	cancer	1 or less
(Further control not justified; Royal Society, London, 1983)	death or injury	1
		0.7

*assuming a 73 year life-span

**excludes possible effects of smoking

lead to refusal to work. This scenario has already occurred with devastating consequences. This situation and the mandate through the GHS for worker education and training creates both a problem and an opportunity for employers. The problem is the need for organizations to conduct extensive training in chemical safety. The opportunity arises from the fact that the more that people learn about chemicals used in industry and the home, the more likely they are to realize that chemicals can be used safely.

Successful training requires more than superficial presentation of information about the effects of chemical products. The limitations of this approach have been evident for years to regulators and others involved with chemical hazard communication. This task requires sensitivity toward the perceptions and fears of people. The GHS can become highly political as people realize that industrial toxicology has many more questions than answers. Around 1530 Paracelsus, a Swiss physician, said that every substance, starting with the air we breathe and the food we eat is poisonous or toxic (Figure 11.3). All that separates a harmful effect from a tolerable or beneficial one is the dose. For example, the oxygen we must breathe for survival is toxic. Too little oxygen in air will kill us, as will too much. Pure water is toxic. Drunk in too large a quantity it too will kill us. Glucose, a natural component of blood and an important source of energy, also is toxic. Obviously we cannot stop breathing, eating, or drinking water. So then, what is happening here? How can substances essential for our survival be toxic?

Nicotine, a very potent drug contained in cigarettes and other tobacco products, is extremely toxic. Yet, very few smokers die from nicotine poisoning. Nicotine also is sold as a pesticide. Prescription and nonprescription drugs often are very toxic. They are the main killers in successful attempts at suicide. Many people have successfully poisoned themselves using barbiturates. Ethyl alcohol also is a toxic substance. Consumed quickly a large bottle of whisky or other spirits will kill. Periodically, we see reports about individuals who have died following rapid consumption of alcoholic beverages. These tragedies often follow acts of bravado and response to dares about ability to consume drinks rapidly. Yet, drunk slowly over a long period, the effects are almost unnoticeable.

The important factors here are the dose rate and the amount or dose. The dose rate (Figure 11.4) is the speed with which a substance enters the body. The dose is the amount of substance that enters the body. The effect produced by a substance depends on both the dose rate and the dose. Dose differs from exposure. Exposure is the quantity of substance outside the body available for entry.

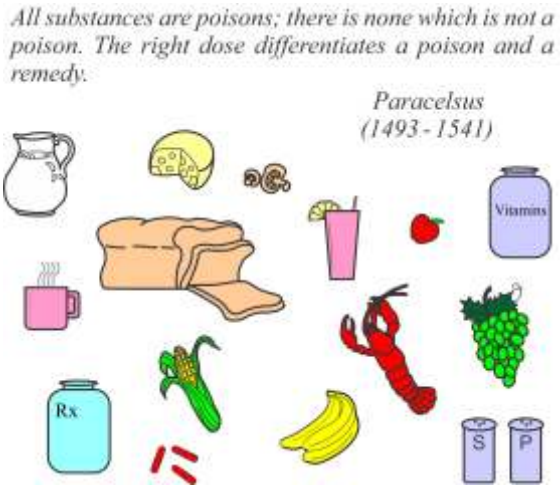

Figure 11.3 Anything that we consume can be poisonous depending upon the dose (amount) that enters the body.

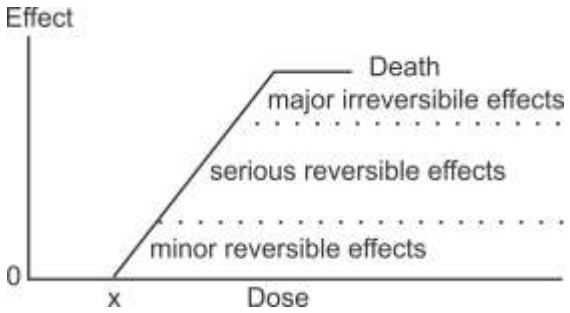

Figure 11.4 At dose x the first measurable effect occurs. As the dose increases the effects become more serious, and possibly irriversible. The most serious effect is death.

Information about the effects of substances results from both human and animal studies. Studies using laboratory animals have provided by far the largest amount of information. Obviously, testing using humans is limited due to the ethics involved. Human studies usually involve the following situations:

- controlled experiments using volunteers
- accidental or deliberate overdoses
- use in small-scale situations such as laboratories
- industries producing or using the substance

The other sources of information are studies carried out on biological test systems or animals. Obtaining useful information from these studies often is very difficult and frustrating. Biological test systems create uncertainty since they are isolated from the whole organism.

Single-celled organisms are vastly less complex than humans or even other animals. Laboratory animals often respond to a substance differently from humans. To make matters worse, different types of animals often respond differently from each other. For example, mice often respond differently from rats, guinea pigs, or hamsters. Large animals such as dogs, cats, or chimpanzees often respond differently from small rodents. Predicting which animal behaves the same as a human male or female in identical circumstances is not possible.

The goals of studies in industrial toxicology are to determine

- effects of the substance
- dose rate producing the effect
- amount of substance necessary to produce an effect
- limits for human exposure that avoid the appearance of adverse effects

The usual approach taken in animal testing is to introduce a known amount of substance into the body and to observe what happens. These studies employ groups, since individual animals do not behave equally in a given situation. Some animals are much more sensitive to the chemical than the main group. Other animals are much less sensitive than the main group. Predicting how a particular animal will react compared to the group is impossible. Some studies use **thousands** of animals and may run through several generations. The answer to the question posed may take **years** to obtain. This is small consolation for people who have become accustomed to receiving instant answers to questions. Toxicology poses complex questions that require considerable financial, human, and animal resources. No wonder so little is known about the many chemicals used in industry. Much of what is known is based on workplace experience.

The way in which the substance is introduced into the body is extremely important. This can have considerable influence on the results obtained. To illustrate, most testing involves a relatively small number of animals. One test for cancer-causing ability involves injection of a massive quantity of substance into the body cavity. The presence of a grossly abnormal quantity of substance itself causes considerable stress to the animal. Sometimes under these conditions excess levels of cancer occur. The question then becomes what caused the cancer, the substance or the stress caused by the presence of the gross amount of substance. This type of test is completely unrepresentative of normal exposure. The gross amount of substance involved may completely overload the body's ability to remove it. What is the relevance of such a test when normal exposure is so much lower? Needless to say, results obtained from this type of test are very controversial.

Following are routes of entry used in experimental studies:

- inhalation (inh)
- injection into the skin (intradermal or id)
- injection into muscle (intramuscular or im)
- injection into the abdominal cavity (intraperitoneal or ip)
- injection into the blood (intravenous or iv)
- injection into the organ of interest
- injection into the stomach (gavage)
- skin contact (dermal)
- contaminated water drunk by the animal (oral)
- contaminated food eaten by the animal (oral)

To be most useful from the perspective of the workplace, the test must reflect a plausible route of exposure of workers. The main routes of entry are inhalation, skin contact, and ingestion. A massive injection into the abdominal cavity (belly) of an animal is unlikely to reflect even accidental exposure of a person. Results obtained in unorthodox tests deserve cautious interpretation. At best, results from animal tests provide an educated guess

about the effect of substances on humans. For this reason a safety factor is built-in when the results are applied to humans.

Toxicological information provides the basis for classifying the product according to its relative toxicity (or ability to kill or injure by poisoning). The GHS does not define the term, "person". One view of the meaning of this term is that it could include the fetus. This viewpoint, however, has lost any foundation in law based on recent decisions from the Supreme Court of Canada. These decisions relating to so-called foetal rights have consistently upheld the view that the fetus has no rights to protection in Canadian law. Workplace exposure limits are intended for protection of adult workers, even though the fetus is considered to be considerably more sensitive to chemical agents than is the mother. Prudent employers, on learning about the pregnancy of a worker who is exposed to chemical substances, should seek medical advice and advise that individual to do the same.

Another outcome from the decision that one or more ingredients is a hazardous ingredient and that the product, material, or substance is hazardous, is that the GHS labelling requirements apply. This means that the GHS hazard pictograms (See Introduction, Figure I.1.) must be used to describe the nature of the hazard(s) posed by the ingredient(s). Some situations do not require a symbol. (See Introduction, Table I.2.).

Route of Exposure

This box indicates likely routes of exposure by the hazardous chemical product or its ingredients into the body (Figure 11.5). The most important routes of entry in workplace situations are inhalation, ingestion, skin contact, and eye contact.

Inhalation refers to the ability of the substance to enter the body through the respiratory system. Table HH 1.3 Acute Toxicity Inhalation describes criteria and other information regarding inhalation toxicity. Inhalation is the main route of entry of airborne substances. The reason is fairly simple. Gases and vapours penetrate to the site of gas exchange at the end of the respiratory tree (Figure 11.6). Depending on particle size, solid and liquid particles also can penetrate to this depth. The interior of the lung resembles a cluster of hollowed-out grapes that are attached to the stems. The area of these surfaces

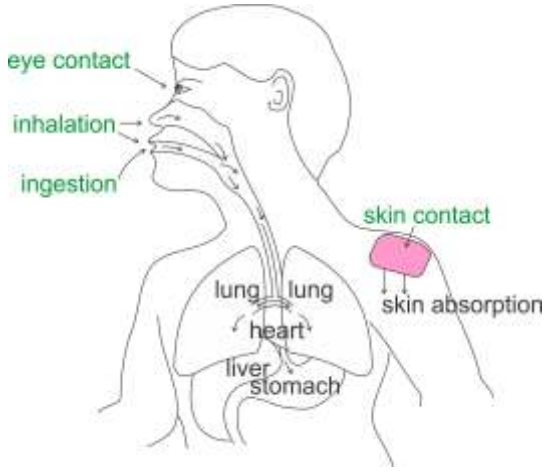

Figure 11.5 Routes of exposure are worded in green. Routes of entry are worded in black.

is about 70 m^2. These surfaces are completely unprotected against attack. The boundary between the interior of the lung and the blood is only one cell thick.

Ingestion refers to the ability of the substance to enter the body by mouth (Figure 11.7). This usually occurs during consumption of candy, food and drink, and cigarette smoking. Ingestion is an important route of entry for some substances. This is especially true where the hands and skin of the face become contaminated, and the person eats, drinks, smokes, or applies cosmetics on the job.

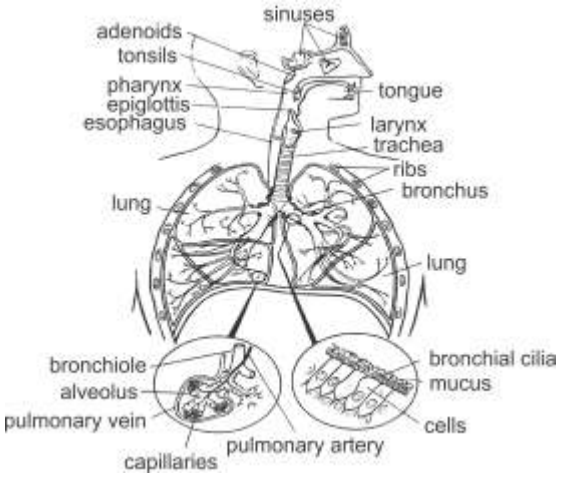

Figure 11.6 The respiratory system has a surface area of 70 m^2 (about 750 ft^2), about the size of a tennis court.

Figure 11.7 The interior of the stomach is a hostile, extremely acidic environment. Many substances undergo chemical change in the stomach before absorption into the body. Because of this, the actual substance that causes the damage may not be the one taken in by mouth.

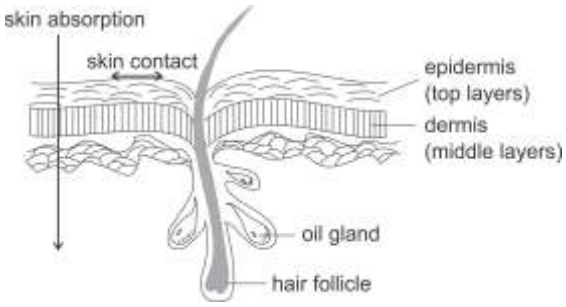

Figure 11.8 The skin consists of several layers. Skin contact refers to the ability of a chemical to enter the body by damaging the skin. Skin absorption refers to the ability of a chemical to enter the body by passing through intact skin. Skin surface is about 1.8 m^2 (20 ft^2).

Automotive battery scrapyards provide a vivid illustration of this situation. There is little lead in the air in these workplaces, yet workers have shown high levels in the blood. This situation can happen just as easily at home during home plumbing with lead-based solder. Lack of attention to personal hygiene is the basis for this problem. This applies in the workplace and in the lunchroom. People should not eat, drink, smoke, or apply cosmetics in workplaces without first washing their hands and faces. Careful attention to personal hygiene is extremely important.

The **skin** contains about 1.8 m^2 of partly protected surface. The skin is structured in layers starting with the epidermis on the surface. The epidermis contains layers of dead cells. These continuously shed as flakes. The epidermis is similar in function to a suit of armour. Penetrating the epidermis are sweat glands, sebaceous (oil) glands, and hair follicles. These provide a pathway into the deeper layers of the skin. Substances enter the skin by skin contact and skin absorption (Figure 11.8). **Skin contact** refers to the ability of the substance to enter the body by causing damage to the skin. Corrosives damage and destroy the skin. (See Table HH 2 Skin Corrosion for more information.) By destroying the various protective layers these substances gain access to the inner tissue where blood vessels are located. Some substances remove protective fatty materials from the skin. The skin dries and may crack open following prolonged contact. By so doing, these substances gain entry into underlying tissue. There are ample opportunities for substances to make contact with the skin when protective equipment is not used. Inappropriate equipment may fail to protect.

Skin absorption refers to the ability to enter the body by permeation across the intact skin. The term Skin Absorption was used in WHMIS but it is not used in WHMIS 2015 and is not discussed in the GHS. It appears that skin contact is an all encompassing term. That is, to be absorbed through the skin, a substance must first make contact with the skin. For better understanding of how substances enter the body, the concept is included here.

Permeation is a molecular process that occurs without causing apparent damage. The skin acts as an effective barrier against the entry of many substances. Fortunately, only a relatively small number have the ability to permeate the skin. Substances entering the body by this route pass through unaltered. There are many examples of substances that can permeate the skin including (but not limited to) liquids, such as benzene, methyl alcohol, mercury, nicotine, PCBs, and pesticides, and hydrogen cyanide gas (Figure 11.9).

Potential or actual skin absorption complicates the evaluation of exposure. Exposure evaluation in these situations could require monitoring of biological fluids.

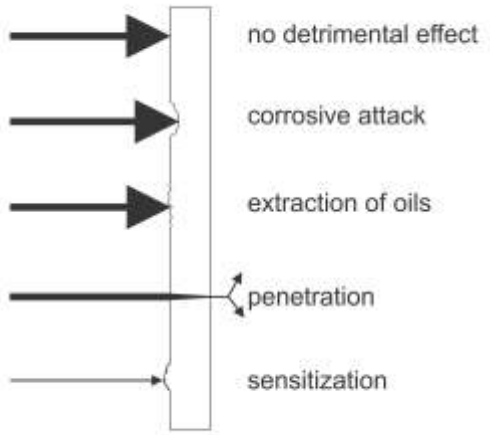

Figure 11.9 Examples of substances that can permeate the skin.

Eye contact (Figure 11.20) refers to the ability of the hazardous chemical product to enter the body by a path involving the eye or ability to damage the eye. Some substances dissolve into the fluids that bathe the eye. Others attack the membranes that surround the eye. The unprotected eye also is especially susceptible to attack by corrosives or irritants. Table HH 4 Serious Eye Damage/ Eye Irritation describes criteria and other information related to eye contact hazards.

Skin Corrosion

Table HH 2 Skin Corrosion describes criteria and other information regarding skin corrosion. Some substances are corrosive to biological materials and other substances (Table PH 17 Corrosive to Metals). A corrosive attacks a material and degrades or destroys its structure. pH is one indicator of the corrosiveness of a substance. Substances having a high or low pH are potentially corrosive. (See pH in Section 9.) There are other corrosives beyond acids or caustics.

Corrosive substances can cause considerable injury and damage to the respiratory system, the eyes, and the skin. A corrosive attacks human tissue, causing visible destruction (Figure 11.21).

Caustics cause greater damage in the eye than the same quantity of acid. Acids damage the surface layer of tissue and generally do not penetrate deeper. (One notable exception is hydrofluoric acid.) Caustics penetrate deeper than acids, thereby gaining access to more tissue. Hydrofluorine acid penetrates the skin in search of calcium.

Skin Irritation

Table HH 3 Skin Irritation describes criteria and other information regarding skin irritation. **Irritants** act first on the most sensitive surfaces of the body: the respiratory system and the eyes. Moistening by body fluids

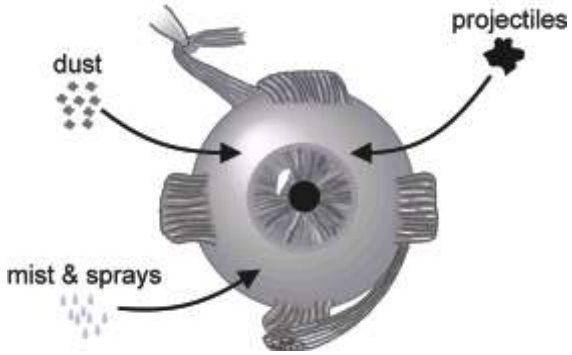

Figure 11.20 Eye contact can occur from various external substances when the eye is unprotected.

Figure 11.21 A corrosive chemical causes visible destruction of or irreversible alterations in living tissue by chemical action at the sire of contact.

enables contact with the various forms of materials in which irritants can occur: gas or vapour, mist, fume, dust or smoke, and bulk liquids. The greater the solubility of the substance in the body fluid, the greater is the potential for producing irritation.

Irritants also affect the skin (Figure 11.22). The skin, however, is less sensitive than the eye or the respiratory system because of the protective outer layer. Sweat and sebaceous glands moisten and lubricate the skin. These openings to the outside provide a potential route of entry. The gaps in the skin are especially sensitive to needle-like fibres such as found in fibrous glass. Many organic solvents degrease the skin by dissolving the oils. This can lead to dryness and irritation.

This information forms the basis of the need for selecting control measures and personal protection. These provide lines of defence to prevent contact by the body with the material. This information also forms the basis for specifying first response and first aid measures. These minimize the damage caused by accidental exposure.

Serious Eye Damage/ Eye Irritation

Table HH 4.1 and Table HH 4.2 describe criteria and other information regarding serious eye damage/ eye irritation, respectively. Serious eye damage refers to irreversible effects, while eye irritation refers to reversible effects.

Respiratory or Skin Sensitization

Table HH 5 describes criteria and other information regarding respiratory sensitizer. Table HH 6 describes criteria and other information regarding skin sensitization.

Some substances cause sensitization. Sensitization is an unpredictable process that involves the immune system (Figure 11.23). Sensitization occurs in a small proportion of people (around 10 percent) exposed to some substances. A relatively small number of chemicals used in industry are known sensitizers. Substances of biological origin form the larger group compared to inorganic materials. The main source of information about sensitization is workplace experience.

Sensitizers play no favourites on or off the job. They are present in consumer products including cosmetics, hair sprays, deodorants, food products, laundry and soap products, building materials, clothing fabrics, and so on. All of these products are produced by industry. Some of the sensitized people work in plants manufacturing these products. Sensitized users can discontinue use of the product. Sensitized workers must seek other employment.

Sensitizers affect the respiratory system and/or the skin. The skin is much less sensitive due to the layers of dead cells on the outside surface. The respiratory system possesses no armour. Sensitization occurs in an unpredictable manner. Some people are affected after one exposure. Others are affected after many exposures. Once

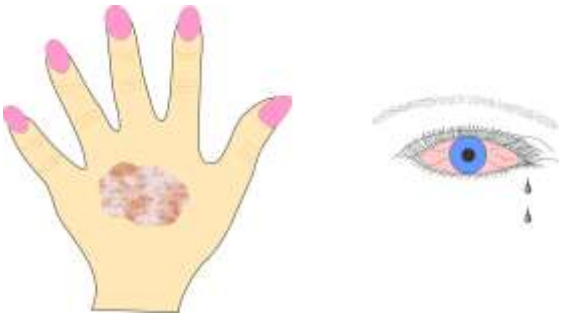

Figure 11.22 An irritant causes reversible inflammation of living tissue by chemical action at the site of contact. The irritant effect is not corrosive.

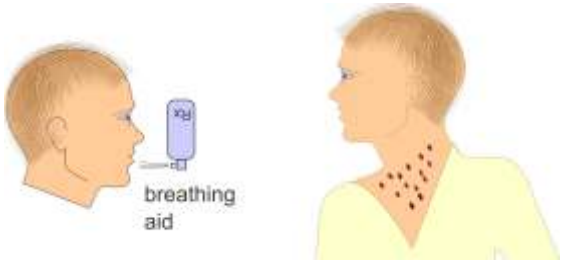

Figure 11.23 A sensitizer causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure.

the sensitization develops, it does not normally disappear. The only way to prevent onset of symptoms is to avoid or prevent exposure.

Sensitization of the respiratory system causes asthma-like symptoms. An episode involving the respiratory system occurs soon after exposure begins. This reaction could be triggered by the various forms in which the sensitizer may occur in the air: gas or vapour, fume, dust, mist or smoke. The airways decrease in diameter during an episode. Asthma causes extreme difficulty during exhalation.

Sensitization of the skin usually follows contact with the substance. Contact can occur during careless use or accidental spills or splashes, or contact with airborne forms. Further contact produces reactions similar to those caused by poison ivy: hives, reddening, blotchiness, swelling, and so on. The skin reaction is delayed by several hours following the beginning of contact. This indicates that a different immune mechanism is operative.

Medical dermatology (skin disease) and allergy journals continually report cases of allergy produced by exposure to an endless list of chemical substances. These incidents may be isolated, special cases. The question that arises is, when does an isolated, special case represent the initial warning about the sensitizing potential of a substance? Once again, this requires an application of professional judgment.

Germ Cell Mutagenicity

Table HH 7 describes criteria and other information regarding germ cell mutagenicity. Mutagenicity refers to the ability of an agent to produce a mutation or change in the genetic code of a cell. Mutation is a naturally occurring part of the process of human evolution. A number of agents, including ionizing radiation and some chemical substances, can cause mutation.

From the standpoint of survival, some mutations are beneficial, others are neutral, and still others are deleterious. The process of evolution is made possible by mutation. Organisms receiving beneficial mutations flourish. Some mutations, such as the colouration of certain flowers, have no effect. These are neutral, so long as pollinating insects have no preference about colour. Human hair colour is neutral. Change in the colour of an insect, however, can increase its visibility to prey. This mutation has a negative impact. Mutations are merely events. Interaction between the organism and its environment determines whether the mutation is beneficial, neutral, or deleterious.

In humans, the cells most affected by mutations are eggs in females and sperm-producing cells in males (Figure 11.24). These cells potentially affect future generations. As mentioned, mutation is a naturally occurring process.

A mutation in an egg is more likely to be expressed in a child. Eggs in human ovaries are produced prior to birth. Each woman has a finite number of several thousand from which her children will result. Usually one egg matures during each menstrual cycle. Not every egg that matures is fertilized. Hence, a mutation in a single egg may not be carried on to a child.

The sperm-producing cells in the testes continuously produce sperm. Each ejaculation contains millions of sperm. A mutation in a sperm cell, or even the cell that produced the sperm cell, is not likely to be passed on to a child.

About one person in 30 is born with a genetic disease. About 9% of people are seriously affected at some point in their lives by genetic diseases, such as diabetes, that run in families.

At this time many substances are known. Initial testing centred on workplace and other man-made chemi-

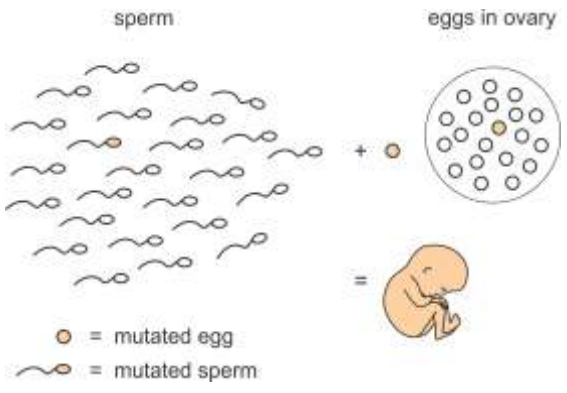

Figure 11.24 A mutation to a single sperm or a single egg is not likely to be passed on to a child.

cals. More recently these studies have examined foods and other substances in our diets. Naturally-occurring mutagenic substances form a part of the normal diet (Figure 11.25). Included in the list are such familiar substances as caffeine, theobromine (tea), charred substances in foods, natural products found in mushrooms, pepper, peanuts, and other plants. Some substances occurring naturally in edible plants (so-called health foods) are extremely potent. Among the known mutagens are some workplace chemicals. No one knows whether there is a level of exposure below which no effect occurs.

Carcinogenicity

Table HH 8 describes criteria and other information regarding carcinogenicity. Cancer is an example of a disease that results from exposure to some chemicals. Cancer is one of the most emotional of all topics for human discussion. The fear of getting cancer following a workplace exposure has prompted lawsuits. Why is this so?

Cancer is a fact of human existence. Cancer actually is a number of diseases. Some form of cancer will kill 20 to 25% of the people in our society. Said another way, the odds of our dying from cancer are roughly 2 in 10. Heart and circulatory diseases, which are the major killers, receive much less attention and considerably more acceptance than cancer. An undisputable truth is that everyone dies from something. Old age is not listed in mortality statistics as a cause of death. Yet, people generally are not aware that this is the case. Perhaps this is a part of the reason that cancer receives so much attention.

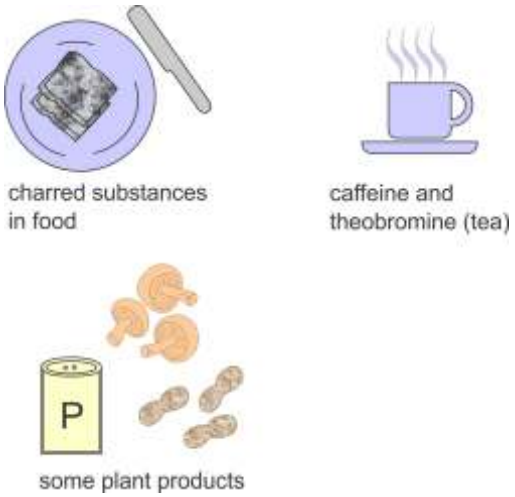

Figure 11.25 Common substances in the diet contain mutagens.

Carcinogenicity of a substance refers to its ability to cause cancer in various animals, including humans. Cancer is a naturally occurring process which, to this day, is only partly understood. Cancer affects many types of animals from fish to pets.

Health authorities have kept statistics on cancer in humans since the early part of the 20th century. They indicate that cancer is primarily a disease of old age. The longer people live, the greater is the probability of developing cancer. People are living longer. Life expectancy has increased dramatically since the beginning of the 20th century. The reasons include

- prevention and treatment of disease
- reduced infant mortality (death) rate
- reduced poisoning through better quality food
- better accommodation
- reduced frequency of accidents

Thus, as we live longer, more and more people are expected to die from the diseases of old age, cancer included.

Some facts about cancer are worth knowing. The occurrence of almost all forms of cancer has either remained constant or decreased slightly during at least the last 30 years. A notable exception, lung cancer, has increased dramatically in both genders, but recently, especially in women. The only reasonable explanation for this trend is the smoking of tobacco and other substances, since air and water pollution are less now than in previous years. The occurrence of skin cancer also is increasing, due in part to our suntanning habits and the thinning of the ozone layer.

The incidence of cancer in different parts of the body reflects where one lives. While certain forms of cancer occur at very low levels in Canada, others occur at very high levels. There is no single location on earth that has the lowest rate of all forms of cancer. On the other hand, the converse also is true. Ethnic groups emigrating to other parts of the world develop the same cancer rates as native inhabitants of the adopted country within one or two generations. Lifestyles of certain religious groups promote lower incidence of cancer.

Recent studies have shown the presence of naturally-occurring carcinogens in many food products including so-called health foods. Some examples of foods containing carcinogens include peanuts, pepper, mustard, germinating sprouts, mushrooms, corn, and others. Our diet is riddled with these substances. Yet, the incidence of cancer has either remained the same or decreased, except as noted earlier. Humans are exposed through their lives to a "sea of carcinogens", some of which are man-made and the rest of which are natural. This is the condition through which the human species evolved and through which it will continue to do so.

The vast majority of cancer specialists support the view that up to 80% of cancer is caused by only a small number of factors (Figure 11.26).

- unbalanced diet
- smoking
- excess consumption of alcoholic beverages
- exposure to the sun

Aging, genetics, and occupation account for the remaining incidence. Occupation is thought to be responsible for no more than 5% of cancer.

Determining carcinogenicity in a substance is difficult for a number of reasons. A particular animal species such as the mouse is not necessarily affected by a substance that causes cancer in humans. Some substances not affecting humans, cause cancer in mice. In addition, some substances affect males and females differently. To complicate things even further, cancer usually develops long after exposure first occurs. Cancer may develop even after exposure has stopped or been reduced below a level considered safe.

No one knows at this time whether there is a safe level of exposure to carcinogens (Figure 11.27). Experiments capable of answering this question require thousands to millions of test animals. This scale is necessary to separate natural events from those caused by exposure to the test substance. There is evidence that people can tolerate some exposure to certain industrial carcinogens. This is the basis for setting Threshold Limit Values for safe level of exposure to these substances.

A number of research organizations produce lists of carcinogens. There is disagreement from one list to another. Two sources are Appendix A of the Threshold Limit Values and Biological Exposure Indices published by ACGIH, and Group 1 or Group 2 in the IARC Monograph on the Evaluation of the Carcinogenic Risk of Chemicals in Humans published by the World Health Organization. IARC is the International Agency for Research on Cancer.

The criteria used by the GHS and WHMIS 2015 for classifying carcinogenicity likely will cause considerable difficulty for industry. This results from the

figure 11.26 Many experts believe that 80% of cancer is caused by unbalanced diet, excess alcohol, smoking, and suntanning. Aging, genetics, and occupation account for the remaining incidence.

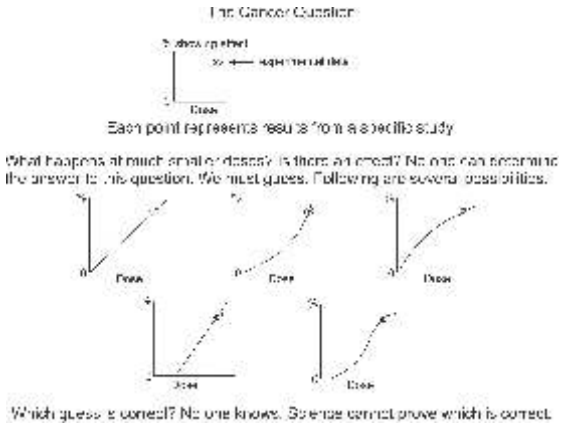

Figure 11.27 Science cannot predict what happens at low doses.

chain-like production and hierarchical distribution networks that exist. Certain petrochemicals, for example, contain trace quantities of benzene. Benzene is a known human carcinogen. Benzene may occur in the product above the cut-off of 0.1% for carcinogenicity. If the product is not tested for carcinogenicity, technically it becomes a suspected carcinogen. Yet, workplace experience with these products has produced no evidence of excess cancers consistent with exposure to benzene. On the other hand, exercising "professional judgment" and not following regulations to the letter could cause future repercussions.

Another situation similar to the preceding relates to use of chemicals whose ingredients are exempt from disclosure according to a Confidential Business Information (CBI) agreement and are used as ingredients in other products.

These situations highlight the potential for the GHS to work against itself. If products such as these are needlessly classified as potentially carcinogenic, fear over past and continued use could take quite a toll. On the other hand, failure to classify correctly, compounded by CBI, along with subsequent disclosure of this situation could provoke product liability suits.

Reproductive Toxicity

Table HH 9 describe criteria and other information regarding reproductive toxicity. Some substances interfere with reproductive processes in humans and other animals (Figure 11.28). Reproductive effects include sterility, or other adverse effects on the reproductive capacity of a person. This information usually is determined from animal studies due to the sensitive nature of the subject. Occasionally workplace experience has contributed the information.

Lead is a well-known reproductive toxin that affects females. Attempts on medical grounds to bar women of reproductive age from jobs that involve exposure to lead have clashed with human rights legislation regarding discrimination.

Dibromochloropropane or DBCP is a well-known reproductive toxin that produces sterility in males. DBCP is a pesticide. Evidence for the action of DBCP arose from coffee-table discussions by workers about their inability to father children.

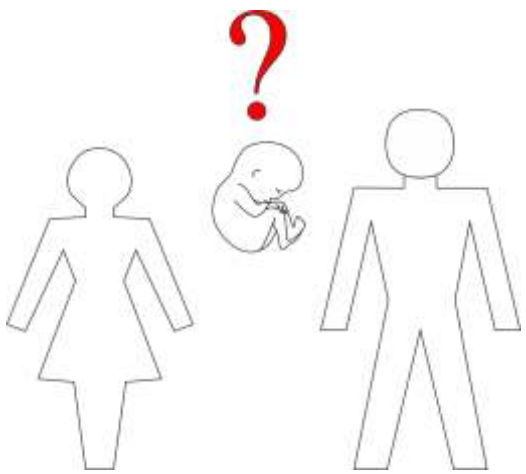

Figure 11.28 Some substances interfere with reproductive processes in women or men or both. Reproductive effects include adverse effects on the reproductive capacity of a person or even sterility.

Aspiration Toxicity

Table HH 12 describes criteria and other information regarding aspiration toxicity. Aspiration toxicity includes severe acute effects, such as

- chemical pneumonia
- varying degrees of pulmonary injury or death, following the entry of a liquid or solid directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system

Biohazardous Infectious Material (WHMIS 2015 only)

Table HH 13 describes criteria and other information regarding biohazardous infectious material. In WHMIS 2015 biohazardous infectious materials refer to biohazards caused by microorganisms or toxins produced by microorganisms (Table 11.2). This information will affect the fast-growing biotechnology industry. There is no limit noted on the content of products containing biohazardous infectious materials.

Specific Target Organ: Single Exposure

(Acute Exposure, Figure 11.29)

Table HH 10 describes criteria and other information regarding specific target organ: single exposure. This box provides information about effects of acute exposure to the product. Acute exposures in the workplace

Table 11.2 — Biologically Active Material Found in Some Products

Life Forms	Contents of Living Cells
• bacteria	• enzymes
• fungi	• secretions
• yeasts	• wastes
• mould	• cell structures
• virus	
• sporozoa	
• higher life forms	

are short-term. They often result from accident situations involving a large quantity of the chemical.

Acute exposures often occur during accident situations involving gross contact with solid, liquid, or gaseous materials. Accidental exposures during storage, handling, use, production, or disposal commonly involve failure of equipment or human error. Some examples of accident situations that lead to acute exposures include

- escape of compressed gases
- overflow, deluge, container rupture, dust clouds involving solids, splashes, overflow, sprays, deluge of liquids
- gas or vapour sprays or clouds

Massive short-term contact with many substances usually produces an acute effect. Acute effects may occur immediately at the time of exposure or following a delay possibly lasting hours. These effects often are reversible, disappearing after the exposure has ceased. They may, however, be permanent. Acute exposure produces effects on the part of the body most vulnerable to attack. The occurrence of reversible acute effects has played an important role in the setting of exposure limits for workplace exposure. (Refer to discussion about exposure limits in Section 8.) Acute effects utilized in setting exposure limits include irritation, narcosis (loss of sensation), drowsiness, nuisance, or other forms of stress.

The information presented in the SDS is most applicable to situations in which someone has received a suspected overexposure. In clear-cut situations, the symptoms may match information contained in the SDS. This detective work is best done by an industrial hygienist and physician after the victim is safely treated. The reason for this caution is that overexposure to many industrial products produces the same symptoms. The actual cause can differ considerably from that perceived by the untrained person.

Ingredients of consumer products often are the same as those found in industrial products. People use consumer products routinely at home, normally without incident. The effects of overexposure are the same in either case. The GHS considers the use of consumer products in the workplace to cause primarily acute exposure hazards.

The generic cut-off values (Table I.1 in the Introduction) apply uniformly in all jurisdictions. However, if there is information that an ingredient in a mixtures falls below the cut-off limit, the mixture should be classified as such. A mixture should not contain ingredients that would cause the product to increase the hazards of the pure substance. Any information pertaining to use of values other than the GHS cut-off limits must be readily available upon request.

Specific Target Organ: Repeated Exposure
(Chronic Exposure, Figure 11.29)

Table HH 11 describes criteria and other information regarding specific target organ repeated exposure. This box indicates effects of chronic or long-term expo-

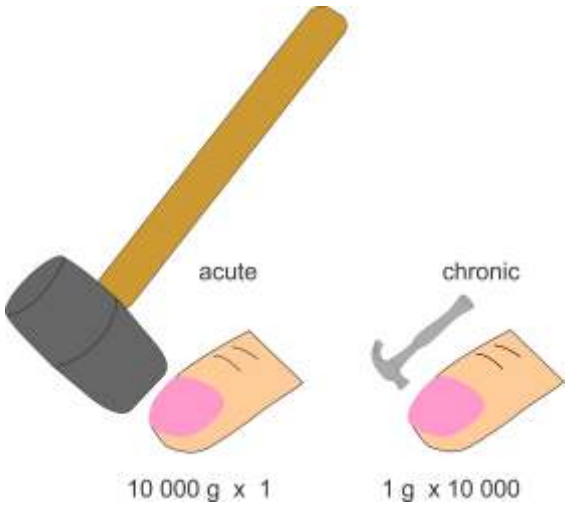

Figure 11.29 Acute and chronic exposure hazards. Which is worse, one blow from a 10 000 g (10 kg) hammer or 10 000 blows from a 1 g hammer?

sure to the product. More typically, workplace exposures are smaller-scale and long-term, or chronic exposures. Chronic exposures may occur over a prolonged period of time, possibly for many years. Chronic exposure levels usually are much lower than those experienced during accident situations. They likely are low enough that exposed workers experience no obvious signs or symptoms indicative of problems. This lack of warning creates resistance in some people about heeding preventive measures. The classic example is cigarette smoking. Despite an ironclad case against the safety of cigarettes, approximately 30% of the adult population still continues to smoke.

Delayed and Immediate Effects, and Chronic Effects from Short- and Long-Term Exposure

The lack of outward effect following long-term exposure is part of the conundrum regarding effects from chronic exposure. The latency period, the time between the start of exposure and onset of some effects, often is very long. Ten to twenty years is not uncommon. Hence, concern about effects from exposure to chemicals at levels low enough not to produce rapid indicators of problems is natural. A person chronically exposed could receive a total long-term dose far in excess of the amount needed to cause death during an acute exposure. Alcohol is a prime example of this. A large bottle of spirits or whisky consumed during a short time can and does kill. Yet, the same bottle consumed gradually by the same person during a period of several weeks would produce no obvious effect. Caffeine is another example. The caffeine equivalent of 250 cups of coffee taken in a short time in pill form has killed people. Yet, 250 cups of coffee consumed over a normal time-frame produces no deleterious effect.

Substances entering the body during chronic exposure undergo several possible fates. The body may eliminate them unchanged following the exposure. The body uses several approaches to eliminate substances. These include exhalation in the breath or excretion in the urine or sweat. The liver modifies some substances to make them easier to excrete.

The body metabolizes some substances and uses them as a source of energy. Ethyl alcohol and other alcohols are an example.

Some substances accumulate in the body. The amount that can accumulate during chronic exposure could easily exceed that needed to produce serious acute effects. Lead is a prime example. Small amounts of lead circulate in the blood. The body stores surplus lead in bone. If the amount circulating in blood decreases rapidly, stored lead dissolves to replace it. Lead can produce serious chronic effects because of this recurring exposure. Rapid release of large quantities of stored lead could cause serious acute effects.

The body can tolerate small exposure to many substances. When damage occurs, the body undertakes repair. Repair is a normal function occurring at all times. Small doses of some toxic chemicals produce no measurable effect, no matter how long the exposure. The problem occurs when the extent of damage exceeds the ability of the body to perform repair.

There are several types of chronic effects. Chronic effects usually differ from the acute effects produced by the same substance.

Some chronic effects are reversible. That is, they disappear gradually after exposure ceases. To illustrate, the body is able to repair some of the lung damage after smoking ceases. Other chronic effects are permanent. Damage produced by some substances is additive. This means that damage produced by each exposure adds to that produced earlier. The overall effect may not appear for many years. In some cases the damage becomes worse with increasing time.

Some chronic effects do not appear for many years after the start of exposure. Delayed effects can occur even after the exposure has ceased. Cancer and some types of lung disease, such as asbestosis and silicosis, are examples of delayed effects. Cirrhosis or scarring of the liver is an example of a delayed effect caused by prolonged over consumption of ethyl alcohol.

Testing to determine chronic toxicity is a complex and costly process. Thus, only a small number of products actually will be tested. Manufacturers likely will rely on data obtained for individual ingredients.

The preamble to the Threshold Limit Values (See Exposure Limits in Section 8.) indicates that a small percentage of workers may experience discomfort from some substances at concentrations at or below TLV™ levels (ACGIH 1998). The TLVs contain large safety

factors and are based on the lowest No Effect Level for a substance (Figure 8.2). This can occur due to variations in individual susceptibility. Individuals may be hyper-susceptible because of genetic factors, age, personal habits (e.g., smoking, alcohol, or drug consumption), medication, or previous exposure. These individuals may not be adequately protected from the adverse health effects. A smaller percentage can be affected due to aggravation of a preexisting condition or development of an industrial illness. Tobacco smoking is specifically mentioned for potentially enhancing the effect of a chemical and for reducing the body's defences. Preexisting medical conditions aggravated by chemical exposure include: asthma and bronchitis, angina, and liver and kidney conditions.

Numerical Measure of Toxicity

These may include LD_{50}, LC_{50}, acute toxicity estimates (ATEs), and others where applicable. Tables HH 1.1, HH 1.2, and HH 1.3 describe acute toxicity (oral, dermal, and inhalation respectively). These tables include range estimates, acute toxicity point estimates, and other information.

LD_{50} or lethal dose to 50% is the amount of a substance needed to kill 50%, or half, of a group of animals. LD_{50} is a standard measure in toxicology of the relative toxicity of pure substances and mixtures. The toxicity of substances varies over a wide range (Table 11.3). Acute toxicity described by the GHS is based on a single dose or multiple doses, oral or dermal, following 24 hours or by inhalation after 4 hours. Reference tests are published by the Organization for Economic Cooperation and Development (OECD) for LD_{50} oral (by mouth, Figure 11.30) and dermal (skin application, Figure 11.31).

The usual unit of dose is mg/kg (milligram per kilogram) of body weight (Figure 11.32). To illustrate the meaning of this unit, consider a crystal of coloured decorator's sugar. This weighs about 2 mg. Now grind the single crystal of sugar, that is dyed red, into a fine powder, and then spread the powder throughout a 1 kg bag of sugar. This is the same as administering a whole-body dose of 2 mg/kg to an animal.

Mice weigh only a few grams, while larger animals, such as rats, weigh in the kilogram range. Toxicologists express the units in mg/kg to maintain consistency.

Figure 11.30 LD_{50} oral is the amount of substance needed to kill 50% of a group of animals during a test lasting 24 hours.

There are several approaches to the requirement for reporting LD_{50}. The first is to determine the LD_{50} based on testing of the actual chemical product using the referenced test protocol. The reality of this approach is that testing of the actual product using the referenced test protocol is unlikely owing to the cost of determining this information. As desirable as this approach may seem, the relevance of the findings to worker exposure still remains an unanswerable question. There is no predictable link between human and animal susceptibility to a particular substance. This is learned by experience. A more likely approach to the requirement for reporting LD_{50} for untested mixtures is to use previously published information for individual ingredients.

WHMIS 2015 provides a formula to predict the LD_{50} of the mixture based on the LD_{50} for individual ingredients, be they pure substances or tested mixtures. In this formula each component must occur at or above the cut-off of 1 % of the overall composition of the mixture. This approach assumes that the overall toxicity is the sum of the toxicities contributed by each ingredient. That

Figure 11.31 LD_{50} dermal is the amount of substance entering the body through the skin needed to kill 50% of a group of animals.

Table 11.3
Approximate LD_{50} of a Selected Variety of Chemical Agents

Agent	Animal	Route	LD_{50} mg/kg)
• ethyl alcohol	mouse	oral	10000
• sodium chloride	mouse	IP	4000
• ferrous sulfate	rat	oral	1500
• morphine sulfate	rat	oral	900
• phenobarbital, sodium	rat	oral	150
• DDT*	rat	oral	100
• picrotoxin	rat	SC	5
• strychnine sulfate	rat	IP	2
• nicotine	rat	IV	1
• d-tubocurarine	rat	IV	0.5
• hemicholinium-3	rat	IV	0.2
• tetrodotoxin	rat	IV	0.10
• dioxin (TCDD)**	guinea pig	IV	0.001
• botulinus toxin	rat	IV	0.00001

IP = intraperitoneal, IV intravenous, SC = subcutaneous

LD_{50}s are listed according to averages of nearest round figures from many sources. The principal sources are Barnes, C.D. and Eltherington, L.G. Drug Dosage in Laboratory Animals - A Handbook. Berkely: University of Calif. Press, 1964. I. Spector, WS. (ed.), Handbook of Toxicology, Vol. 1. Philadelphia: W.B. Saunders Co., 1956. Goldenthal, E. I. Compilation of LD5o Values in Newbom and Adult Animals, Toxicol. and Appl. Pharmacol., 18:185 (1971).

*DDT = p,p' - DDT; dichlorodiphenyltrichloroethane

**TCDD = 2,3,6,7 tetrachlorodibenzodioxin

is, each ingredient is independent of the others. Again, the question of human and animal susceptibility arises.

Determining the LD_{50} of a mixture containing one or more untested ingredients is not possible. The GHS defines the value for the most acutely toxic tested ingredient(s) present in a concentration of 1% or more to represent the mixture. While there is no satisfactory way to deal with this problem, this is the only pragmatic approach available.

Figure 11.32 Grind a crystal of coloured sugar into a fine powder. Then spread the powder evenly throughout a 1 kg box of sugar. This is the same as a whole body dose of 2 mg/kg.

Determining the LD_{50} for the GHS purposes is a difficult task. The available sources from the technical literature may contain data from studies involving different types of animals. The results from one study may contradict those from another. Obviously, the decision about the appropriate value to choose for the LD_{50} of the mixture requires judgment from a competent professional.

LD_{50} is an extremely important quantity. Unfortunately, its direct usefulness in the workplace is very limited. As mentioned earlier, there is no confident link between human and animal susceptibility to a particular substance. This information (and that contained in the next subsection) provides a means to compare relative acute toxicity of different hazardous chemical products. The larger the LD_{50}, the less acutely toxic is the hazardous chemical product.

In practical terms, the best use for this information is to influence purchasing decisions. If several products are available, the one having the largest LD_{50} (least acutely toxic ingredients) would be best choice, all other things being equal. End-users should not base choice solely on the LD_{50}. There are many other factors to consider.

LC_{50} is the concentration of substance in air needed to kill 50%, or half of a group of animals during an exposure (Figure 11.33). LC_{50} is a standard measure in toxicology of the relative toxicity of pure substances and mixtures. LC_{50} can vary over a wide range. LC_{50} has greater potential importance than LD_{50}, since inhalation is by far the most important route of entry into the body and is also the basis for virtually all exposure limits for hazardous chemical substances. Inhalation provides a direct path into the interior surfaces of the lung. Unlike the stomach, the internal environment of the lung is not chemically hostile. Substances entering the body through the lung are unlikely to be altered during the process. Unlike the skin, the barrier between the inside surfaces in the lung and the interior of the body is extremely thin, only one cell thick. This permits easy access by chemical substances.

The GHS requires the LC_{50} to be based on acute or short-term exposure lasting four hours (or by converting existing data generated from 1 hour exposures by dividing by a factor of 2 for gases and vapours, and by 4 for dusts and mists. Tests may be referenced from those published by the Organization for Economic Cooperation and Development (OECD) for LC_{50}. The physical form of the substance, gas or vapour, dust, mist or fume complicates the testing and interpretation of the results.

Gas is the gaseous form of a substance. Gases have no shape and fill any container into which they are placed, given sufficient time. Gases are converted to liquids usually by simultaneously cooling and compressing. **Vapour** is the gaseous form of a solid or liquid. Vapours are converted to the solid or liquid form by cooling or compressing. **Dust** is an airborne suspension of solid particles. Dusts are produced by mechanically breaking down larger solid materials. Dusts may dissolve in body fluids or they may be insoluble. Large particles are trapped in various parts of the respiratory system. Small particles may enter the air sacs at the end of the respiratory tree. **Mist** is an airborne suspension of liquid droplets. Mists can develop from disruption of liquids, an example being spray painting, or by condensation from a vapour, an example being the formation of **fog** when moisture-laden warm air cools. As with dusts, the particle size of droplets in a mist can vary. However, since they are liquids, these particles can mix readily with body fluids following initial contact. **Fume** is an airborne suspension of solid particles produced by condensation of vapour. Welding is a major producer of metal fume.

Prior to the creation of the GHS, toxicity measurements were provided in mg/m^3 (milligrams per cubic metre of air) For many users, this may still be the preferred case. The GHS uses mg/l (milligram per litre). To convert mg/l to mg/m^3, multiply the figure for mg/l by 1000.

A cubic metre measures 1 m on each side. This is about the same as the volume of a bale of peat moss. To illustrate the meaning of milligrams per cubic metre, consider a small crystal of decorator's sugar (Figure 11.34). This weighs about 2 mg. Grind the sugar crystal into a fine powder and distribute this evenly into the cubic metre of air. This would produce a concentration of 2 mg/m^3.

Figure 1133 LC_{50} is the concentration of a chemical in air needed to kill 50% or half, of a group of animals.

To illustrate the concept of parts per million, consider a small eyedropper (Figure 11.35). This has a volume of 2mL (millilitres). There are 1000 mL in 1L and 1000 000 mL in 1 m^3. Filling the eyedropper with chlorine gas and emptying it into a container holding 1 m^3 of air produces a concentration of 2 ppm.

Calculating part per million quantities is the same as calculating percents. For example,

$$\frac{\text{2 green apples}}{\text{25 apples}} \text{ x } 100\% = 8\%$$

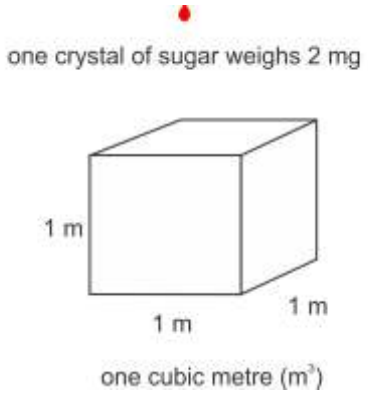

Figure 11.34 Grinding a crystal of sugar into a fine powder, then distributing the powder evenly throughout a box containing 1 m^3 of air produces a concentration of 2 mg/m^3.

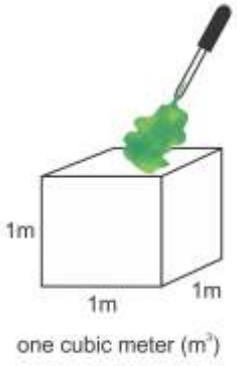

Figure 11.35 Emptying an eyedropper of chlorine gas (2 mL) into a box containing 1 m^3 air (1 000 000 mL) produces a concentration of 2 ppm.

Similarly,

$$\frac{\text{50 mL vapour}}{\text{2 000 mL container}} \text{ x 1000 000 ppm} = \text{25 000 ppm}$$

A more likely approach to the requirement for reporting LC_{50} for untested mixtures is to use previously published information for individual ingredients.

Values for dusts and mists are expressed as mg/l. Values for vapours also use mg/l unless the vapours including mixtures are approaching the gaseous phase. Then they are expressed as ppmV.

Determining the LC_{50} of a mixture containing one or more untested ingredients is not possible. The GHS defines the value for the most acutely toxic tested ingredient(s) present in a concentration of 1% or more to represent the mixture. While there is no satisfactory way to address this problem, this is the only pragmatic approach available. See. 3.1.3.4 in the GHS document..

Determining the LC_{50} for the GHS purposes is a difficult task. The available sources from the technical literature may contain data from studies involving different types of animals. The results from one study may contradict those from another. Obviously, the decision about the appropriate value to choose for the LC_{50} of the mixture requires judgment from a competent professional.

LC_{50} is an extremely important quantity. Unfortunately, its direct usefulness in the workplace is very limited. As mentioned earlier, there is no confident link between human and animal susceptibility to a particular substance. This information provides a means to compare relative acute toxicity of different hazardous chemical products. The larger the LC_{50}, the less acutely toxic is the hazardous chemical product.

In practical terms, the best use for this information is to influence purchasing decisions. If several products are available, the one having the largest LC_{50} (least acutely toxic ingredients) would be best choice, all other things being equal. However, end-users should not base choice solely on the LC_{50}. There are many other factors to consider.

Acute Toxicity Estimates (ATEs) generally are calculated from LD_{50}/LC_{50}. The GHS document provides a table of ATEs (Table 3.1.1) containing five categories for oral, dermal, gases, vapours, dusts and mists with supporting notes to explain the process of obtaining these measures.

While a valuable and interesting read, the table is useful mostly for those professionals involved in the actual classification of products but is beyond the scope of this document.

QUESTIONS AND ANSWERS

1. An SDS we received says the product meets OSHA requirements for hazard disclosure. The salesperson says that this SDS is satisfactory for meeting WHMIS 2015 requirements. Is this true?

It is possible that the statement is correct. However, legislation in Canada is different from that in the U.S. What meets requirements in the one country may not meet those in the other. A user should point out that this is not a satisfactory criterion for exemption from the requirements of WHMIS 2015. A supplier wishing to receive exemption must in all cases follow the formal application procedure pertaining to Confidential Business Information (CBI).

2. The information included in this section is frightening. We are learning that chemicals we have used for years could cause disease or kill. What do you feel about this?

There is no denying nor glossing over this fact. However, certain other facts need to be considered. Most, if not all hazardous chemical products can be handled in a safe manner. The proof of this is workplace experience. While this is not perfect for everyone, relatively few persons are affected adversely. The main cause of compensation claims is traumatic injury. Traumatic injuries include falls, trips, cuts and abrasions, amputations, back injuries, and so on. By far the largest single cause of occupational illness is skin disorders. These account for almost half the claims.

3. Our workers are learning about the dangers of chemicals that we have used for years. They are considering to refuse to work. What should we say to them?

Refusal to work is a worker's legal right. This decision rests solely with the person. No amount of persuasion should be tried, as this will make the situation worse.

The first step in this process is for management or supervision to see the area of use as it actually is, not as they might wish it to be. Management and the workforce work in the same environment and are ultimately exposed to the same hazards. Management must be convinced that they have done the right thing in the area of use. This means not exposing anyone including themselves to undue risk. For many hazards, conditions can be evaluated by relatively simple measurement. If all concerned thoroughly believe that the hazards are controlled, then it is possible to proceed to the next step.

Today's workplaces are a dramatic improvement over conditions existing even a few years ago. Hazards are controlled to some extent in most areas of use. Operating experience is an extremely important factor in completing this picture. Plants whose retirees live in good health to ages at least the industrial average can point out this fact. This reality counteracts the abstract fear created by information about potential hazards as presented in the SDS. Another way of looking at this question is the general experience found in a particular industry or trade group. This information is readily obtainable from occupational health and safety libraries, from trade associations, and from workers' compensation boards.

Statistics have shown that the home environment is more hazardous than the workplace environment. More accidents occur at home than at work. The average household also contains many chemical products. A cursory review of the labels demonstrates that many consumer products contain the same substances as found at work. One difference is that the label on a consumer product prior to the GHS did not provide the complete list of ingredients. This was not available to the consumer. The GHS extends to consumer products. As the GHS is adopted by industry, consumer products labelling will reflect its concepts.

Another difference is that a boss is responsible for the way in which a person uses a product at work. There is no such supervision at home. Industry pays dearly when accidents occur and an injured person files a compensation claim. These costs create a real incentive to prevent accidents. This incentive does not exist in the home. People behave differently at home than at work when using hazardous chemical products and materials.

Relatively simple and inexpensive means are available for evaluating some conditions present in workplaces. These can provide almost immediate answers to concerns. The solution to the problem of worker concerns is education. Education and demonstration of concern produce confidence and allay fears.

4. The phrase, "not available", appears many times in this section of the SDS. Is this acceptable?

Technical information is available for many hazardous substances. As mentioned earlier, many hazardous chemical products are mixtures of other substances. In most cases, the properties of the mixture reflect the properties of the ingredients. Toxicological testing is still very much in its infancy, even for pure substances. This lack of certainty produces many more questions than answers about individual products. Several research organizations and government agencies have assigned priorities for toxicological testing. This involves choosing the most suspicious candidates first. These groups have recommended testing for relatively few chemicals out of the extremely large number in existence.

The manufacturer or supplier bears the ultimate responsibility for verifying information presented in

SDSs. The best protection for the employer's interests is to scrutinize the SDS and to challenge the supplier. If there is any doubt, contact the Supplier or Manufacturer, if known, to determine the thoroughness of the research carried out.

5. The SDS says that the supplier has obtained Confidential Business Information exemption from disclosure of hazardous chemical ingredients. How can we determine whether there is an exposure problem in our plant?

This question is virtually impossible to answer. Without knowing what is actually present the employer cannot determine exposure. The occurrence of work-related effects in people exposed to the hazardous chemical product is one indication of a problem. Unfortunately, since the problem occurs only after the fact, this is not a desirable method of approach. Perhaps the Supplier or Manufacturer, if known, and the user can work out a method of approach. Many Manufacturers provide services to customers under the concept of Product Stewardship.

6. Which is the most important route of entry?

Inhalation (breathing) is the most important route of entry. The reason is the ease with which substances can enter the body by passing through the lungs.

7. I can't understand the terms used in some of the boxes in this section. They sound too medical. What can I do?

As you have identified, this subject is highly technical. Publications from the Canadian Centre for Occupational Health and Safety are written for the layman and appear to be helpful.

8. The SDS uses the term, "overexposure". How can we determine whether or not the conditions in our plant are all right?

Determining the level of exposure (and possible overexposure) requires a formal assessment. The assessment involves measuring the concentrations of airborne contaminants and comparing them against the exposure limits in your jurisdiction. This task requires technically qualified people. These resources may be available internally. Question 8 in Section 1 lists external resources. See also question 5 in this Section.

9. Why do manufacturers of household products use the same chemicals as those found at work. Aren't safer substitutes available?

While this request seems reasonable, the answer reflects the reality of our industrialized society. Virtually all chemical products can be handled safely, provided that their properties are known and appropriate precautions are taken. This applies both at home and at work. If a person disregards warnings and instructions about handling, then adverse consequences could happen. Even so-called safer substitutes have their own hazards and create their own problems. There are unfortunately no easy fixes, only choices.

10. We use toluols (toluene) in our plant. The SDS says that it contains 0.5% benzene. Benzene is a carcinogen. According to WHMIS 2015 an untested mixture of toluols must also be labelled as carcinogenic. Is this correct?

This is the case according to the protocol in WHMIS 2015. Considerable toxicological testing on toluene has occurred over the years. The preparer of the SDS could rely on analogies between commercial grades, such as the one described and purer forms when making the classification.

11. How is exposure evaluated for products having more than one route of entry?

Testing of biological fluids such as blood and urine is required in these circumstances. Workplace drug testing, a subject currently being hotly debated, uses similar sampling techniques. Unfortunately biological monitoring determines exposure only after the fact. Obviously, this approach is not the preferred first line of investigation.

12. If there is so little information available about substances, how can they possibly be safe to use?

As mentioned in the text, relatively few substances have received extensive toxicological testing. The main source of information is human experience. Many substances act in the body by the same mechanisms. What is true for one often is true for many others. This observation simplifies evaluations somewhat. It also supports an approach known as the method of analogy. This generally has produced satisfactory results. The approach taken in setting workplace standards is to permit no exposure beyond that causing minimal effects. Often these standards incorporate a safety factor to ensure further protection.

13. Would you provide a good example where the chronic effects of exposure were very different from the acute effects?

Benzene was widely used in the chemical industry, and at one time was considered to be the perfect solvent. The short-term effects of overexposure include dizziness, headache, and a sensation of lightheadedness (feeling high). These effects also are typically observed following overexposure to many organic solvents. Long-term exposure to low levels has produced blood disorders including anaemia and leukemia.

14. What is the best way to avoid the effects mentioned in this section?

Start by reading the SDS thoroughly. Each SDS costs considerable money and effort to produce. The sole purpose is to provide users with information for their protection. That said, follow the preventive measures exactly, unless proven unnecessary. Set up standard procedures incorporating the information in the SDS. Prepare for emergencies and other unexpected occurrences. Contact the Supplier or Manufacturer, if known, for guidance and further information whenever there is the slightest doubt about the use or handling of the product.

15. There is no LD_{50} or LC_{50} stated for several of the ingredients. How does the GHS treat this?

This situation creates problems for the GHS, as well as other chemical hazard information systems. What is asked here is information about the unknown. Providing this, of course, is plainly impossible. As a matter of policy the GHS uses data about the most hazardous chemical ingredient(s) to represent the mixture. Unfortunately, this approach cannot address ingredients whose toxicology is not known and that are more toxic than known ingredients. It does provide a position for comparison in individual situations until the knowledge base expands.

16. I have forgotten how to do percents. Would you explain their meaning. Let's assume that a product contains 6% w/w of a hazardous ingredient. What does this mean?

To calculate percent, divide one quantity by another having the same units and multiply by 100 percent. To answer the specific question:

$$\frac{6\ \text{kg}}{100\ \text{kg}} \times 100\% = 6\%$$

17. The LD_{50} of nicotine is approximately 1 mg/kg. A typical cigarette releases 2.5 mg of nicotine into the air. How many cigarettes release enough nicotine to kill?

The average man weighs 70 kg.This question, while a matter of interest, demonstrates some practical realities of toxicology. To begin, the amount of nicotine needed to kill the 70 kg man is

$$70\ \text{mg} \times \frac{1\text{mg}}{\text{kg}} = 70\ \text{mg}$$

The number of cigarettes required is

$$70\ \text{mg} \times \frac{\text{cigarettes}}{2.5\ \text{mg}} = 28\ \text{cigarettes}$$

Obviously, results of simple toxicological calculations such as this do not explain what occurs in real life. The reason is that the human body is an extremely com-

plex biological system. The results of toxicological tests must be interpreted only by experts.

18. Using the information discussed in this section pertaining to numerical measures, describe desirable qualities to look for in workplace products.

- large ATE(s)
- large LD_{50}
- large LC_{50}

REFERENCE

ACGIH: Threshold Limit Values for Chemical Substances and Physical Agents; Biological Exposure Indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1998.

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