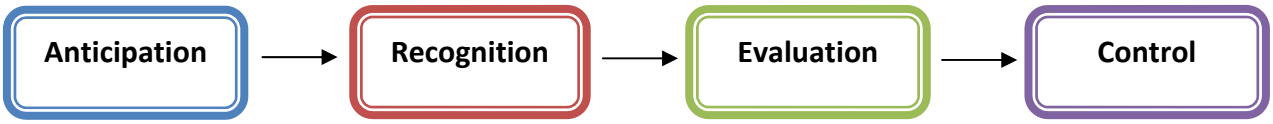
HAZARD RECOGNITION AND EVALUTION

A workplace hazard is any equipment, procedure, material, environment or situation that may result in injury, illness, impairment, and/or environmental or property damage. Management of these hazards can effectively be accomplished through the following process:



Laboratory hazards are to be anticipated, recognized, and evaluated based on the degree of risk and exposure.

HAZARDOUS MATERIALS IN THE WORKPLACE

Many chemicals and other hazardous materials used in the workplace can be harmful to your health and/or safety. The best way to protect yourself is to recognize the specific hazards of the materials you work with.

OVERVIEW OF CHEMICAL HAZARDS

Hazardous chemicals can be described under the following categories:

1. Flammable Chemicals
2. Reactive Chemicals
3. Toxic Chemicals
4. Corrosive Chemicals
5. Oxidizing Chemicals

1. Flammable Chemicals

Flammable and combustible liquids are liquids that can burn; where the mixture of released vapours and air burn, not the liquids themselves. They are classified as either flammable or combustible based on their flashpoints. Generally, flammable liquids will ignite (catch on fire) and burn easily at normal working temperatures. Combustible liquids have the ability to burn at temperatures that are usually above working temperatures. In general, as the temperature rises, the vapours are released at a faster rate, creating a more hazardous atmosphere.

Flashpoint

The flashpoint of a liquid is the **lowest temperature** at which the liquid gives off enough vapour to be ignited in the presence of an ignition source. **The lower the flash point, the greater the risk of fire**. Common laboratory solvents such as acetone, toluene and methanol all have flashpoints that are below room temperature. A liquid is classified as flammable or combustible depending on its flashpoint. A flammable liquid has a flash point below 37.8°C. A combustible liquid has a flashpoint greater than 37.8°C.

Flammable Limits
Flammable and explosive limits provide the range between the lowest and highest concentrations of vapour in the air that will burn or explode in the presence of an ignition source. These limits are usually expressed as the percent by volume of the material in the air.

The lower flammable limit or lower explosive limit (LFL or LEL) is the lowest vapour concentration that will burn or explode if ignited. Below the LFL/LEL, the mixture is too lean to burn (i.e. there is insufficient fuel). The upper flammable limit or upper explosive limit (UFL or UEL) is the highest vapour concentration that will burn or explode if ignited. Above the UFL/UEL, the mixture is too rich to burn (i.e. there is not enough oxygen).

Autoignition temperature
A material's autoignition temperature is the temperature at which the material will self-ignite, ***in the absence*** of an ignition source. **The lower the autoignition temperature, the greater the risk of fire**.

Vapour Density
The vapour density is the ratio of the density of the gas/vapour to the density of air (vapour density of air = 1). Generally, vapours from flammable liquids are denser than air and tend to sink to the ground level where they can spread over a large area. Therefore, a small spill has the potential to cover a large area and caution must be taken to prevent vapours from being readily released into the air (e.g. ensure adequate ventilation).

Source of Ignition
A source of ignition is one which presents a high enough temperature to ignite a fuel. Common sources of ignition include open flames, hot surfaces, static electricity, smoking material, cutting and welding operations, radiant heat, frictional heat, electrical and mechanical sparks, spontaneous combustion, and heat-producing chemical reactions.

2. Reactive Chemicals
Reactive chemicals are materials that are unstable or react with air or moisture to produce toxic or unstable products, heat or rapidly expanding gases. Highly reactive chemicals may undergo vigorous, uncontrolled reactions that can cause an explosion or a fire, or rupture sealed storage containers. Slow reactions can also be hazardous if they involve large amounts of material or if the heat and gases released are confined, such as in a sealed storage drum. The rate of reactions generally increases rapidly as the temperature increases. Examples of reactive chemicals include:

- Some chemicals decompose when heated
- Some materials are highly reactive when exposed to air
- Some substances react violently with water
- Incompatible chemicals

3. Corrosive Chemicals

Corrosive materials can readily attack exposed body tissues. Corrosives can also damage or even destroy metal. Most corrosives are either acids or bases. Common acids include hydrochloric acid, sulphuric acid, and acetic acid. Common bases include ammonium hydroxide, potassium hydroxide, and sodium hydroxide. In concentrated forms, both acids and bases have the potential for generating large amounts of heat when mixed with water or other reagents. Caution must be exercised to avoid splashing or spraying corrosive materials.

4. Oxidizing Chemicals

Oxidizing materials are liquids and solids that readily give off oxygen or other oxidizing substances. They also include materials that react chemically to oxidize combustible (burnable) materials, where oxygen combines chemically with the other material in a way that increases the chance of a fire or explosion. This reaction may be spontaneous at either room temperature or may occur under slight heating. Oxidizing liquids and solids must be used under carefully controlled conditions, as they can present serious fire and explosion hazards.

5. Toxic Chemicals

Toxic materials are substances that may cause harm to an individual if it enters the body. The potential hazard of a toxic chemical will depend on many factors including the substance involved, the route of exposure, the dose, the duration of exposure and individual susceptibility.

Toxicity is measured using experiments conducted on test animals. The LD50 (lethal dose) is the amount of a substance that, when administered by a defined route of entry (e.g. oral or dermal) over a specified period of time, is expected to cause death to 50% of the test population. LC50 is the concentration of a substance that, when administered by inhalation over a specified period of time, is expected to cause death to 50% of the population. **The lower the LD50 and/or LC50, the more toxic the material**.

Routes of Exposure

Many chemicals can cause direct effects at the point of contact, such as irritation of the skin, eyes, mouth or nose. Some chemicals can also be absorbed into the body and cause harmful effects on other systems like the blood, liver or nervous system. There are **four** main routes of exposure which chemicals can contact and/or enter the body:

1. **Inhalation.** The most common route of exposure for chemical gases, vapours, and aerosols (e.g. smoke, mists and fumes) is through inhalation. These materials may be transported into the lungs and exert localized effects, or be absorbed into the bloodstream.

2. **Ingestion.** The gastrointestinal tract is another possible route of exposure for toxic substances. Although direct ingestion of a laboratory chemical is unlikely, exposure may occur as a result of ingesting contaminated food or beverages, touching the mouth with contaminated fingers (e.g. nail-biting), or swallowing

inhaled particles which have been cleared from the respiratory system. Exposure by this route may be reduced by not eating, drinking, smoking, or storing food in the laboratory, and by washing hands thoroughly after working with chemicals, even when gloves are worn.

3. **Absorption (skin and eye contact)**. Chemicals can enter the body through direct contact with the skin or eyes. Skin contact with a chemical may result in a local reaction, such as a burn or rash, or absorption into the bloodstream. Absorption into the bloodstream may then allow the chemical to cause toxic effects on other parts of the body. Gloves and other protective clothing should be worn to minimize skin exposure to chemicals. Chemical contact with the eyes can result in painful injury or loss of sight. Wearing proper eye protection or a face shield can reduce the risk of eye contact.

4. **Injection.** Injection bypasses the protection provided by intact skin and provides direct access to the bloodstream, and therefore the internal organ systems. Injection may occur through mishaps with syringe needles, when handling animals, or through accidents with pipettes, broken glassware or other sharp objects that have been contaminated with toxic substances.

Acute and Chronic Exposure and Toxicity
Acute toxicity results from a single, short exposure and the health effects often appear quickly. Chronic toxicity results from repeated exposure over a long period of time and the onset of health effects is usually delayed and gradual.

Individual Susceptibility
Factors that influence an individual's susceptibility to toxic substances include nutritional habits, physical condition, obesity, medical conditions, drinking and smoking, and pregnancy. Due to individual variation and uncertainties in estimating human health hazards, it is difficult to determine a chemical dose that is completely risk-free.

Sensitization
Sensitization is the development, over time, of an allergic reaction to a chemical. The chemical may cause a mild response on the first few exposures but, as the allergy develops, the response becomes worse with subsequent exposures. Eventually, even short exposures to low concentrations can cause a very severe reaction.

Occupational Exposure Limits (OELs)
An occupational exposure limit is the airborne concentration of a chemical in the workplace which most people can be exposed to without experiencing harmful effects. Exposure limits should not be used as dividing lines between safe and unsafe exposures. It is possible for a chemical to cause health effects, in some people, at concentrations lower than the exposure limit. There are three different types of exposure limits that are commonly used:

1) **Time-Weighted Average Exposure Value (TWAEV):** The time-weighted average concentration of a chemical in air for a normal 8-hour work day and 40-hour work week to which nearly all workers may be exposed day after day without harmful effects.

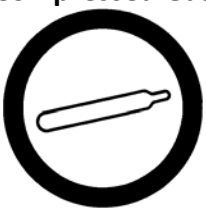
2) **Short Term Exposure Value (STEV):** The average concentration to which workers can be exposed for a short period (usually 15 minutes) without experiencing irritation, long-term or irreversible tissue damage, or reduced alertness.

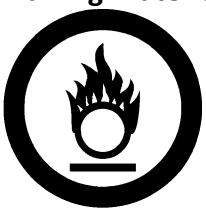
3) **Ceiling Exposure Value (CEV):** The concentration which should not be exceed at any time.

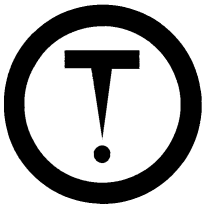
"SKIN": This notation means that contact with the skin, eyes and moist tissues (e.g. mouth) can contribute to the overall exposure. The purpose of this notation is to suggest that measures be used to prevent absorption by these routes of entry into the body.

CHEMICAL HAZARDS

Table 1: Chemical Hazard Classes

HAZARD	CHARACTERISTICS	PRECAUTIONS
Compressed Gas  Examples: nitrogen, hydrogen, argon	▪ Gas inside cylinder is under pressure ▪ Gas can be released by opening the cylinder valve, or accidently if the valve or cylinder is damaged ▪ May explode when heated or when cylinder is damaged ▪ May act as a potential projectile ▪ Hazards of the specific gas	▪ Never roll, drag, or drop cylinders ▪ Always store and transport cylinders with valve caps or other valve protection in place ▪ Always chain or securely restrain cylinders in an upright position to a wall, rack or other solid structure. Cylinders should be secured individually. ▪ When transporting cylinders, secure them to a suitable cylinder transporting device (e.g. handcart) ▪ Keep cylinders away from potential sources of ignition ▪ Cylinders should be protected from physical damage ▪ Never tamper with cylinders in any way (e.g. do not repaint them or interfere with safety devices) ▪ Unused and/or empty cylinders should not be stored in the lab ▪ Inspect cylinders regularly for corrosion, leakage, dents, etc. ▪ Regulators are not universal and have to be chosen based on the gas and cylinder being used. Always verify that the regulator is appropriate for the gas used and the pressure being delivered. ▪ Do not lubricate any cylinder valves, fittings, or regulators. ▪ Always open valves slowly. Do not use excessive force when opening or closing the valve. ▪ Cylinders containing flammable gases are to be grounded to prevent accumulation of electrostatic charge ▪ Never hang equipment or clothing over a cylinder

Flammable and Combustible Material Examples: acetone, propane	▪ Flammable and combustible liquids are liquids that can burn ▪ Generally, flammable liquids will ignite and burn easily at normal working temperatures. Combustible liquids can burn at temperatures that are usually above working temperatures	▪ Keep away from sources of heat and ignition ▪ Store, handle, and use flammable and combustible liquids in well-ventilated areas ▪ Use approved, properly labelled safety containers ▪ Keep containers closed when not in use ▪ Never dispense near ignition sources ▪ Ground and bond metal containers when transferring liquids from one container to another ▪ Store away from oxidizers ▪ Inspect containers regularly for any potential damage. Do not use safety containers that are damaged in any way.
Oxidizing Material  Examples: organic peroxides, nitrates, perchlorates	▪ Can be a severe fire and/or explosion hazard ▪ May or may not burn itself; readily gives off oxygen or other oxidizing substances to cause or contribute to the combustion of another material ▪ Can cause combustible materials to burn spontaneously without the presence of obvious, ignition sources such as a spark or flame ▪ Can cause substances that do not normally burn readily in air to burn rapidly ▪ May react with other chemicals to produce toxic gases	▪ Store, handle and use in well-ventilated areas ▪ Keep away from combustible materials and sources of heat and ignition ▪ Keep the amount of oxidizing materials in the lab as small as possible ▪ Store in designated areas clear of incompatible materials ▪ Wear proper protective equipment, including eye, face and hand protection, and protective clothing ▪ Keep containers tightly closed unless otherwise indicated by the supplier ▪ Store strong oxidizers in inert unbreakable containers; the use of corks or rubber stoppers is not permitted ▪ Mix and dilute according to the supplier's instructions
Poisonous and Infectious Material 	▪ Highly poisonous ▪ May cause death or serious injury if inhaled, swallowed, or absorbed through the skin ▪ May cause permanent damage ▪ May burn eyes or skin upon contact	▪ Handle with extreme caution ▪ Avoid skin or eye contact by wearing proper personal protective equipment ▪ Work in well-ventilated areas and/or wear respiratory protection ▪ Use local exhaust ventilation, such as fume hoods and other control measures and equipment where provided

Materials Causing Immediate and Serious Toxic Effects Examples: styrene, hydrogen cyanide		▪ Do not eat, drink or smoke near these materials ▪ Wash hands thoroughly after handling ▪ Store materials in designated areas only
Poisonous and Infectious Material  Materials Causing Other Toxic Effects Examples: acetone, asbestos,	▪ Poisonous substance that is not immediately dangerous to health ▪ May cause death or permanent injury following repeated or long-term exposure ▪ May irritate eyes, skin and breathing passages ▪ May cause an allergic reaction that affects breathing or the skin ▪ May cause liver or kidney damage, cancer, birth defects or sterility	▪ Avoid inhaling gas or vapours by working in well-ventilated areas and/or using proper respiratory protection ▪ Avoid skin and eye contact ▪ Wear the recommended personal protective equipment ▪ Do not eat, drink or smoke near these materials ▪ Wash hands thoroughly after handling ▪ Store materials in designated areas only
Poisonous and Infectious Material Biohazardous Infectious Materials Examples: bacteria, viruses, fungi	▪ May cause a serious disease resulting in illness or death	▪ Take every measure to avoid contamination. ▪ Wear the recommended personal protective equipment ▪ Handle the material in designated areas where engineering controls are in place to prevent exposure ▪ Wash hands thoroughly after handling
Corrosive Material Examples: hydrochloric acid, sodium hydroxide	▪ Can cause severe irritation, burns or tissue damage at site of contact ▪ Can attack metal, causing metal containers or materials to leak or collapse ▪ Can act rapidly upon contact	▪ Avoid skin and eye contact at all times by wearing proper personal protective equipment ▪ Work in well ventilated areas ▪ Keep the quantity of corrosives in the lab to a minimum ▪ Keep containers tightly closed ▪ Use proper container materials that cannot be weakened by the corrosives ▪ Inspect containers for damage or leaks before handling ▪ Add acid slowly to water; **never** add water to acid

		▪ Store acids and bases separately ▪ Be prepared for heat generation when diluting or dissolving in water
Dangerously Reactive Material Examples: plastic monomers such as butadiene and some cyanides	▪ Very unstable ▪ May explode under conditions of shock, friction, or increase in temperature or pressure ▪ May burn, explode or produce dangerous gases when mixed with incompatible materials	▪ Keep away from sources of ignition ▪ Inspect containers for damage or leaks before handling them ▪ Keep containers tightly closed ▪ Keep only the smallest amount possible in the lab ▪ Avoid conditions which can lead to an unstable reaction ▪ Work in well ventilated areas ▪ Wear proper personal protective equipment ▪ Store in a designated cool, flame-proof area ▪ Do not subject materials to any type of friction or impact
Water Reactives Example: sodium metal	▪ Reacts upon contact with water ▪ Can cause release of heat (potential ignition of the chemical itself or nearby flammable material) ▪ Release of flammable, toxic or oxidizing gas, metal oxide fumes (if involving water reactive metals)	▪ Ensure water reactive chemicals are stored away from sinks, water baths, or other sources of moisture
Air Reactives (Pyrophorics) Example: iron sulphide	▪ Chemicals which ignite spontaneously upon contact with air	▪ Must be handled within glove boxes and stored properly to prevent exposure to air

Designated Substances

Designated substances are defined as biological, chemical or physical agents, or a combination thereof, to which the exposure of an individual is prohibited, restricted, limited or controlled by regulation. There are eleven designated substances regulated by the Occupational Health and Safety Act:

- Acrylonitrile;
- Arsenic;
- Asbestos;
- Benzene;
- Coke Oven Emissions;
- Ethylene Oxide;
- Isocyanates;
- Lead;
- Mercury;
- Silica; and
- Vinyl Chloride

Use of designated substances in the laboratory should be avoided wherever possible. When a designated substance is present in the workplace, the employer is required to review the work methods and assess the likelihood of worker exposure. The University's Designated Substances Assessment Procedure is intended to evaluate:

1. Whether workers presently inhale, ingest, or absorb the Designated Substance, or may be likely to do so in the future; and
2. Whether a worker's health may be affected by exposure to the Designated Substance, taking into account
    a. A worker's actual and potential exposure to the substance; and
    b. The measures and procedures required to control the exposure.

Based on the conclusion of the assessment, if it is likely a worker will inhale, ingest or absorb the Designated Substance and it is likely to affect the health of the worker, then a Designated Substance Control Program is required. Components of the Control Program include engineering controls, work practices, hygiene practices, personal protective equipment, training, record keeping and medical surveillance.

If a laboratory uses any of the designated substances listed above, the Office of Environmental Health and Safety should be contacted to ensure compliance with the appropriate regulations.

Cryogenic Liquids

Cryogenic liquids are liquefied gases that are kept in their liquid state at very low temperatures. Cryogenic liquids are used in laboratories to achieve very cold temperatures (below -50°C). Examples include dry ice, liquefied air, nitrogen, helium, oxygen, argon and neon. The following hazards are associated with the use of cryogenic liquids:

- Asphyxiation due to the displacement of oxygen (does not apply to liquefied air and oxygen)
- Freezing and fracturing of materials from extreme cold

- Cold burns and frostbite
- Explosion due to pressure build-up
- Condensation of oxygen and fuel (e.g. hydrogen and hydrocarbons) resulting in an explosive mixture

The following precautions for handling cryogenics should be followed:

- Store, handle and use cryogen containers securely fastened in place in an upright position.
- Protect skin and eyes from contact; wear appropriate personal protective equipment (e.g. eye protection and insulated gloves) when handling cryogenic materials.
- Use only approved low-pressure containers equipped with pressure relief devices. Specially designed containers must be used to store, transport, or dispense these liquids; as many materials will become brittle due to the low temperature. Containers are usually double-walled and well insulated in order to minimize loss from evaporation and prevent the outside of the container from being dangerously cold.
- Transport containers in handcarts or other devices designed for moving cryogenic liquid vessels
- Use and store in cool, dry, well-ventilated areas, away from incompatible materials and ignition sources
- Watches, rings, bracelets or other jewellery that could trap fluids against flesh should not be worn when handling cryogenic liquids.
- To prevent thermal expansion of contents and rupture of the vessel, ensure containers are not filled to more than 80% capacity.
- Never store dry ice in a refrigerator/freezer.
- Proceed slowly when filling a container or inserting objects into a cryogen to minimize boiling and splashing.
- See University Standard for Inert Cryogenic Liquid Usage in the Laboratory

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS)

The Workplace Hazardous Materials Information System (WHMIS) is a legislated program that is applicable to all University of Toronto Scarborough employees and students who work in areas where hazardous materials are used. The purpose of this legislation is to ensure that everyone in a workplace is provided with the information needed to identify hazardous materials and to take the appropriate precautions when working with these materials. WHMIS delivers the necessary information by means of:

- Cautionary labels on containers of controlled products;
- Material Safety Data Sheets (MSDSs); and
- Training on how to use the information provided.

Labels

The requirements for label content are dependent upon whether the container is from a supplier or a workplace, and whether the hazardous material is a laboratory product, a sample for analysis or neither.

Supplier Labels

A supplier label is required for containers from the supplier containing 100 ml or more of the material.

Supplier labels must contain the following information in both English and French and be enclosed by a distinct WHMIS border:

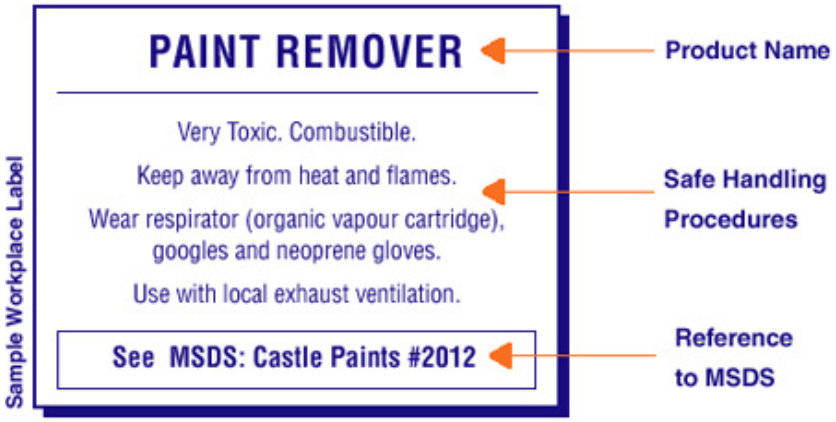
- Product identifier or name
- Supplier's name and address
- Reference to the MSDS
- WHMIS hazard symbol(s)
- Risk phrases – description of the main hazards of the product
- Precautionary measures
- First aid measures

Supplier labels for materials sold in a container with less than 100 ml do not need to include risk phrases, precautionary measures or first aid measures.

Workplace Labels

Workplace labels are required for chemicals used in the workplace (other than in the laboratory) that are not in their original supplier-labeled containers. A workplace label must contain the following information:

- Product identifier or name
- Precautionary measures
- Reference to the MSDS



Workplace Decanted Products

Decanted products are materials that have been taken from one container and put into another container for short-term use. This new container does not need a workplace label if:

- the container is portable and has been filled from a container to which a supplier or workplace label has been affixed; **AND**
- the material is under the control of and is used exclusively by the employee who filled the portable container; **AND**
- the container is used only during the shift in which the container was filled; **AND**

- the contents of the portable container are clearly identified; **OR**
- if the entire product is for **immediate** use.

Laboratory Labels

Laboratory Supply House Container
For product containers originating from a laboratory supply house, that are intended to be used solely in the laboratory and are of a capacity of less than 10 kg, the labels must include:

- Product identifier or name
- Reference to MSDS
- Risk phrases
- Precautionary measures
- First aid measures

Laboratory Container
Products intended solely for use, analysis, testing or evaluation in a laboratory that are in containers other than the ones received from the supplier need to be labeled with the **product identifier only**.

Samples for Analysis

1) In-House Analysis. Laboratory samples that are prepared solely for evaluation, analysis, or testing within the laboratory and remain under the control of the researcher producing the chemical need to be labeled with the **product identifier only.** The products are not to be removed from the laboratory.
2) Independent Lab Analysis. Products that are supplied solely for analysis, testing or evaluation, to an independent laboratory, in containers holding less than 10 kg need to be labeled with the following:
    - Product identifier
    - Chemical or generic name of any hazardous ingredient
    - Supplier name
    - Supplier emergency telephone number
    - The statement: "Hazardous Laboratory Sample. For hazard information or in an emergency, call [emergency telephone number]".

Laboratory sample refers to a sample of a controlled product that is solely intended to be tested in a laboratory but does not include a controlled product that is to be used:

a) by the laboratory for testing other products, materials or substances, or
b) for educational or demonstration purposes.

Material Safety Data Sheets (MSDSs)
MSDSs provide detailed information about the physical, chemical and toxicological properties and hazards, as well as recommended handling and emergency procedures. The laboratory supervisor must ensure that current (within 3 years of the preparation date) MSDSs are available for each

hazardous material in the workplace. The MSDSs must be accessible to workers during work hours. Expired MSDSs must be updated. Laboratory personnel should regularly review the MSDSs for all the hazardous materials being used.

Training

Laboratory supervisors must train laboratory workers on the purpose and significance of labels and MSDSs and their contents, procedures on how to safely use, store, handle and dispose of chemicals, and emergency procedures. The training needs to be specific to the hazardous materials used in the workplace. Generic WHMIS training is available from the Office of Environmental Health and Safety. Each supervisor is responsible for providing workplace-specific WHMIS training to their laboratory personnel.