Part B: Chemical Hazards in Laboratories

Safe work in a laboratory requires you to become aware of the properties and hazards of chemicals and equipment. This part will help you identify chemical hazards and understand Safety Data Sheets (SDS). SDS's are prepared by the chemical manufacturer and are available online or through request to the University of Wisconsin La Crosse (UWL) Environmental Health and Safety Office. SDS's aid in identifying hazards and providing guidance to protect user health and safety. Later parts of this Guide describe the appropriate control measures to reduce the hazards of laboratory chemicals.

This Part describes common hazards of chemicals and provides examples of some chemicals that have the hazard characteristic being described. **You should review each Safety Data Sheet to determine the hazards associated with any chemical you use. The examples included in this Part are not inclusive.** Many chemicals present <u>multiple</u> physical and/or health hazards.

PHYSICAL HAZARDS OF CHEMICALS

Any chemical presents a physical hazard if it is flammable, combustible, corrosive, explosive, pyrophoric, an oxidizer, a peroxide-forming material, a cryogenic liquid, or if it reacts with air or water.

Flammable or Combustible Chemicals

Flammable and combustible chemicals are those that evaporate fast enough to generate sufficient vapor to ignite in the presence of an ignition source. The temperature at which this can occur is the chemical's flash point. In addition, flammable and combustible chemicals are those that can react with oxidizers, to cause a fire or explosion. Combustible materials will generate sufficient vapors at or above 100^{o} F (38^{o} C). Flammable chemicals will generate sufficient vapors at temperatures below 100^{o} F (38^{o} C). SDS' may also list a chemical's auto-ignition temperature, which is the lowest temperature at which there is enough heat energy to ignite vapors spontaneously.

Other important characteristics of flammable and combustible chemicals are their explosive limits. The Lower Explosive Limit (LEL or lower flammable limit) is the lowest concentration of the substance in air that will produce a flash of fire when an ignition source is present. The upper explosive limit (UEL or upper flammable limit) is the highest concentration of the substance in air that will produce a flash of fire when an ignition source is present. At higher concentrations than the UEL, the mixture is too rich to burn. At concentrations lower than the LEL, the mixture is too lean to burn. Note that, for flammable chemicals that are also toxic, concentrations at which the flammability is a hazard are usually well above the toxicity hazard concentrations.

Check the flash point of each organic solvent you use. If the flash point of a solvent is below room temperature, invisible vapor can form and be ignited by a spark, causing a fire or explosion.

The flammable liquids of most concern in laboratories are those that have flash points below room temperature or 77° F (25° C). The flash points for some common solvents include:

Acetone (-20° C or -4° F)	Carbon disulfide (-29°C or -20 ° F)
Petroleum ether (-40° C or -40° F)	Ethyl acetate (1° C or 34° F)
Methanol (12° C or 54° F)	Benzene (-11° C or 12° F)
Ethyl ether (-45° C or -49° F)	Toluene (10° C or 50° F)
Ethanol (13° C or 55° F)	Hexane (-18° C or 0° F)

Xylene, which is often used as a less toxic and safer substitute for benzene, has a flash point of 29° C or 84° F, or just above room temperature. The vapors of flammable chemicals are invisible, and a vapor trail to an ignition source away from the immediate area can result in a flashback.

Flammables are more hazardous at elevated temperatures due to more rapid vaporization.

REACTIVE CHEMICALS

Reactive chemicals have a propensity to undergo vigorous, sometimes spontaneous, reactions. Under certain conditions, reactive chemicals may spontaneously generate large quantities of heat, light, gases, or toxic chemicals. Reactive chemicals include explosives, acid sensitives, oxidizers, reducers, water sensitives, and pyrophorics.

Oxidizers

Oxidizers are chemicals, which react with other substances and leave them electron deficient. This reaction may result in fire or explosion. Oxidizers can supply oxygen to a fire. Two examples are combustion in the presence of air (oxygen in air is an oxidizer) and nitrate salts spilled on paper or wood.

Water-reactive Chemicals

Water-reactive chemicals react with water, water vapor or moist air to produce a flammable or toxic gas, or other hazardous condition. A fire or explosion may result. Examples of water-reactives include the alkali metals (such as lithium, sodium, and potassium), silicon tetrachloride, acid anhydrides, and acid chlorides.

Pyrophoric Chemicals

Pyrophoric chemicals ignite on contact with air. The flame is sometimes invisible. Examples of pyrophoric chemicals are boranes, triethylaluminum, alkyl lithiums and, white or yellow phosphorus.

Peroxide-forming Chemicals

There are many compounds that have "peroxide" in their name. Some are hazardous and some are relatively safe at ambient pressure and temperature. Some chemicals become peroxides when exposed to air, when in storage, and during use. The commercially available reagent peroxides are prepared and contained so that they can be used safely.

Most commercially available peroxide formers have a use before date. Once this date is reached, the best option is to contact UWL Environmental Health and Safety to request disposal. Additional inhibitor can be added to extend shelf life, but if doing so check peroxide levels on a regularly scheduled basis.

The peroxides that form unintentionally are of great concern because of their unpredictability, explosivity, and often-grave consequences. These occur mainly in liquids but can also form in solids and even bottled gases.

Explosion Hazard. What all peroxides have in common is the oxygen-to-oxygen bond in their molecular arrangement. Upon initiation, the molecule can rearrange its structure to bond oxygen to other atoms (more stable bonds) or produce an oxygen molecule, thus reducing the excess oxygen balance of the substance. A violent reaction can be initiated easily; mechanical shock, excessive or rapid heating, or surface to surface friction, such as removing a cap or lid from a bottle can initiate an explosion.

Peroxide Formation. When a substance takes on oxygen from the atmosphere, there are a number of different courses that it could take. Many peroxide-formers will rearrange to non-peroxide oxidized forms and cause no trouble beyond their eventual lack of usefulness. Examples of these are: benzaldehyde and other aldehydes, amines, mercaptans, sulfides, and alkyl amides.

Other peroxide-formers will slowly polymerize and eventually become solid plastic. Examples of these substances include styrene, vinyl acetate, and ethyl acrylate. Since these chemicals may be packaged in air, peroxides can form even if the container has not been opened.

Most common in peroxide formation is that of soluble (they remain dissolved) hydroperoxides and ketone peroxides from secondary alcohols, ethers, tertiary carbons (as in decalin), and allylic and benzylic carbons (as in alkenes and alkyl benzenes). See Part D (Page 19) for a more extensive list of peroxide-forming chemicals and safe storage and use practices.

Oxygen-oxygen bonds are inherently unstable.
Heat and sunlight can accelerate the formation of peroxides.

Shock-Sensitive Explosives

Shock-sensitive explosives can spontaneously release large amounts of energy under normal conditions, or when struck, vibrated, dropped, heated, or otherwise agitated. Some chemicals become increasingly shock-sensitive with age. Of great concern in the laboratory is the inadvertent formation of shock-sensitive explosives such as peroxides in solvents.

Bretherick's Handbook of Reactive Chemical Hazards is highly recommended.

The following materials can be shock-sensitive explosives:

- azide salts of ammonium, copper I and II, calcium, silver, mercury I, and lead II
- carbides and acetylides of copper and silver
- nitrides of sulfur, selenium, and mercury
- polynitro aromatics (e.g., trinitrotoluene, picric acid)
- nitrate esters of organic alcohols and polyols (e.g., nitroglycerine)
- nitrate and nitrite amides (e.g., N-nitroso-N-methyl urea)
- nitrate, chlorate, bromate, iodate, vanadate chromate, and permanganate salts of hydrazine, transition metal amine complexes, ammonia, guanidine, etc.

- hydroxyl ammonium salts of iodine and phosphate
- halogen acetylides and azides (e.g., chlorine azide, 1-bromo-1-propyne)
- the following salts of transition metals (especially copper, silver, gold, mercury and lead):

azides	Acetylides
picrates	Fulminates
oxalates (especially silver)	Cyanates
carbides	nitrides

- the following salts of organics and hydrazines, guanidines, etc.: nitrates, perchlorates and chromates
- lead tetrachloride
- lead and silver chlorite
- mercury tartrate

This list is not inclusive. If you are in doubt as to the reactive or explosive potential of your chemical procedures, consult an authoritative reference such as Bretherick's Handbook of Reactive Chemical Hazards. Similar on-line resources are available. Suggested sources include, but are not limited to the American Chemical Society, Chemical and Engineering News or through a general web search for reactive chemicals.

Compressed Gas Cylinders

Cylinders that are handled incorrectly can be lethal in the laboratory. A broken cylinder valve can cause a cylinder to act like a rocket. Some gases, such as hydrogen sulfide, are potentially lethal if the cylinder leaks.

Cryogenic Liquids

Cryogenic liquids are hazardous because of the physical and chemical characteristics of their super-cooled state. Cryogenic liquids can cause fires (e.g., liquid oxygen) or explosions, embrittlement of structural materials, asphyxiation, and tissue destruction.

HEALTH HAZARDS OF CHEMICALS

Chemicals that are health hazards can cause health effects in a wide variety of ways. Toxic chemicals used in laboratories can be of many types: allergens and sensitizers, irritants, corrosives, asphyxiants, anesthetics, hepatotoxic agents, nephrotoxic agents, neurotoxic agents, agents that affect the hematopoietic system, fibrosis-producing dusts, carcinogens, mutagens, and teratogens.

Toxic chemicals may also have other adverse physical hazards (reactivity, flammability, etc.). Many chemicals have multiple toxic and/or hazardous characteristics.

Prior to working with a chemical, you need to ask many questions. Is the chemical toxic? How toxic is it? Are you exposed to it? Does that exposure represent a risk to your health? What kind of risk? Find out all the information that you can concerning the health risks of the chemicals that you work with. Read the Safety Data Sheets and research the characteristics of the chemicals you plan to use. This part of the Guide will help you ask the right questions, and help you to understand some of the jargon of toxicology. With this information, and the guidance in Part D of this Guide, you can take appropriate steps to reduce your exposure to those chemicals that represent a risk to your health.

Read and understand the Safety Data Sheets for the chemicals you use.

You may have difficulty obtaining health hazard information on the chemicals you use. The American Chemical Society's Chemical Abstracts service lists over ten million known chemicals. The National Institute of Occupational Safety and Health's (NIOSH's) Registry of Toxic Effects of Chemical Substances, which is a compendium of all toxicity tests, lists less than 200,000 chemicals. This leaves millions of chemicals that have not been tested for toxicity. Further, most toxicity tests have been for acute toxicity. Most toxicity information is from animal studies, and we have learned that species react differently and often unpredictably to various chemicals. Some information is not directly applicable to humans. Therefore, we have much to learn about the toxicity of chemicals.

There is a paucity of chemical toxicity information.

Fortunately, Safety Data Sheets contain safety information for most commonly used chemicals. Research laboratories, however, more frequently encounter the exotic, rare, and newly synthesized chemicals for which toxicity data is sparse or non-existent. This emphasizes the importance of handling all laboratory chemicals with the utmost care. Whenever you handle laboratory chemicals, minimize your exposure by using fume hoods, personal protective equipment (e.g., gloves), and applying safety procedures described in Part D of this Guide.

Handle all laboratory chemicals with care.

Allergens and Sensitizers

Allergenic and/or sensitizing chemicals include a wide variety of substances that can produce skin and lung hypersensitivity. Common examples include nickel, chromates, formaldehyde, isocyanates, and certain phenols. Once sensitized, repeat exposures to minute levels of sensitizers can result in life-threatening allergic reactions.

A sensitizer causes a substantial portion of people to develop an allergic reaction in normal tissue after repeated exposure to it. The reaction may be as mild as a rash (contact dermatitis) or as serious as anaphylactic shock. Examples include:

epoxides	nickel compounds
poison ivy	toluene diisocyanate
chlorinated hydrocarbons	chromium compounds
formaldehyde	amines

Primary Anesthetics

Primary anesthetics have a depressant effect upon the central nervous system, particularly the brain. Examples include:

diethyl ether	alcohols
halogenated hydrocarbons (chloroform, trichloroethylene, carbon tetrachloride)	

Simple Asphyxiants

Asphyxiants have the ability to deprive tissue of oxygen. Simple asphyxiants are inert gases that displace oxygen. Examples include:

nitrogen	carbon dioxide
helium	nitrous oxide
argon	

Chemical Asphyxiants

Chemical asphyxiants have as their specific toxic action the ability to render the body incapable of utilizing an adequate oxygen supply. They are active at very low concentrations (a few ppm in air). Examples include carbon monoxide, hydrogen sulfide and cyanides.

Agents Toxic to the Blood

Some toxic agents act on the blood or hematopoietic system. Blood cells can be directly affected or bone marrow can be damaged. Examples include:

nitrites	toluidine
benzene	aniline
nitrobenzene	

Carcinogens

A carcinogen commonly describes any substance that contains an agent that can initiate or speed the development of malignant or potentially malignant neoplastic proliferations of cells. Appendix D provides source lists for chemicals that are considered carcinogens.

Corrosives

Corrosives are chemicals that can cause visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact. Corrosives also can react with metals causing deterioration of the metal surface. Acids and bases are corrosives. Aqueous solutions of acids with a pH less than 2, and bases with a pH greater than 12 are especially dangerous, and require special precautions. Examples include:

sulfuric acid	chromic acid
potassium hydroxide	sodium hydroxide

Environmental Toxins

Some chemicals have been shown to be very toxic to wildlife, or can otherwise harm ecosystems, but pose less of a risk to humans. Other factors that contribute to environmental toxicity are persistency (resistance to degradation) and bioaccumulation as the chemical moves up the food chain. With some known environmental toxins, the degree of human toxicity is uncertain or controversial. DDT and polychlorinated biphenyls (PCBs) are examples of chemicals that have been shown to cause reproductive failure in certain species, but appear to be less hazardous to humans. Despite these species differences, careful use and disposal of environmental toxins is warranted.

Hepatotoxic Agents

Hepatotoxic agents cause damage to the liver. Examples include carbon tetrachloride, nitrosamines, and tetrachloroethylene.

Irritants

Irritants are materials that cause inflammation of mucous membranes. Inflammation of tissue results from concentrations far below those needed to cause corrosion. Long term exposure to irritants can result in increased mucous secretions and chronic bronchitis. Examples include:

ammonia	hydrogen chloride
halogens (Fl_2, Cl_2 I_2)	phosgene
nitrogen dioxide	arsenic trichloride
hydrogen fluoride	ozone
diethyl/dimethyl sulfate	phosphorus chlorides
alkaline dusts (hydroxides)	

Irritants can also cause changes in the mechanics of respiration and lung function. Examples include:

sulfur dioxide	formaldehyde
sulfuric acid	iodine
acetic acid	formic acid
Acrolein	

Agents that Damage the Lungs

Some toxic agents cause damage to the pulmonary tissue (lungs) but not by immediate irritant action. Fibrotic changes can be caused by free crystalline silica and asbestos. Other dusts can cause a restrictive disease called pneumoconiosis. Examples include coal dust, cotton dust, wood dust and talc.

Nephrotoxic Agents

Nephrotoxic agents damage the kidneys. Examples include halogenated hydrocarbons and uranium compounds.

Neurotoxic Agents

Neurotoxic agents damage the nervous system. The nervous system is especially sensitive to organometallic compounds and certain sulfide compounds. Examples include:

trialkyl tin compounds	methyl mercury
tetraethyl lead	carbon disulfide
Thallium	manganese
organo-phosphorus insecticides (malathion, parathion, vapona)	

What is Worst for You?

A personal risk analysis may help you to understand your risk when working with hazardous chemicals. First, review the Safety Data Sheets (SDSs) for each of the chemicals you use to determine the consequences of an accident or exposure. Are the chemicals you use corrosives or carcinogens? Second, consider the likelihood of an accident or exposure. This depends on the quantities of the chemicals used, the manner in which they are used, and the properties of the chemicals. Do you use five-gallon cans of a flammable solvent? What is its flash point? Are toxic powders and volatile chemicals used in a fume hood? How much is used? What is the degree of their toxicity?

Another indicator of risk is accident history. Ask your principal investigator and other researchers who do similar work about accidents and exposure incidents that have occurred with chemicals you use.

This analysis will not precisely rank your chemical risks, but it can help you assess the relative risks of the chemicals you use. Most importantly, you will know which chemicals require extra care, and where you should focus your safety efforts.

Reproductive Health Hazards

Some chemicals can cause damage to the reproductive function of both men and women. Reproductive impairment can include infertility, impotence, menstrual irregularities, spontaneous abortion, and damage to offspring.

Teratogens

Teratogenic chemicals (embryotoxic or fetotoxic agents) are those that cause fetal malformation from maternal exposure during pregnancy. Teratogens are agents that interfere with normal embryonic and fetal development without damage to the mother. These effects are not hereditary.

Embryotoxins are substances that act during pregnancy to cause adverse effects on the fetus. These effects include embryolethality (death of the fertilized egg, the embryo, or the fetus) and teratology (malformation, retarded growth, and postnatal functional deficits). Examples of embryotoxins include organomercurials, lead compounds, and formamide.

Mutagens

A mutagen affects the genetic material of exposed cells. The effect is hereditary and becomes part of the genetic pool passed on to future generations. Ethidium bromide is a mutagen commonly found in biomedical research laboratories.

Known Reproductive Health Hazards

No recognized comprehensive list of known human reproductive toxins exists. The Occupational Safety and Health Administration (OSHA) only regulates four agents based on their reproductive toxicity: dibromochloropropane (DBCP), lead, ionizing radiation, and ethylene oxide. Appendix D provides a source for various lists of those substances considered reproductive toxins.

As noted previously, there is a paucity of toxicological data for a large number of chemicals. This is especially true for data on the human reproductive health effects of chemicals. Most commercial chemicals and physical factors have not been thoroughly evaluated for their possible toxic effects on reproduction and development. Much of the information on suspected reproductive health hazards is derived from animal studies, which present problems of interpretation in extrapolating to effects in humans. Individuals also vary widely in susceptibility and extent of exposure to reproductive hazards. This again stresses the importance of handling all laboratory chemicals with caution, as described in Part D of this Guide.

TOXICOLOGY OVERVIEW

The previous section described the various toxicological properties of chemicals. This section explains routes of exposure, sites of action, and acute and chronic toxicity. These concepts are important to understanding toxicity information on Safety Data Sheets (SDS's) and for assessing chemical exposure, which is discussed in the next section.

Routes of Exposure to Chemicals

The mere presence or use of a hazardous chemical in your laboratory is not sufficient for it to present a risk to your health. In order for a hazard to exist, the chemical must contact or enter the body to reach the site where the chemical exerts its effect. These ways into the body are called routes of entry. Inhalation, skin absorption, ingestion, and injection are all routes of entry for toxic chemicals into the human body. A chemical may be severely toxic by inhalation but pose only moderate danger by other routes of entry. Therefore, it is extremely important to know the chemical's toxicity by each route of entry.

On SDS's, toxicity by route of entry may be indicated by these abbreviations for routes of administration in toxicity studies:

SKN: Applied to the skin, to test for irritation or for systemic toxicity through dermal absorption.

ORL: Oral route, intragastric administration, or mixed with food or water.

IPR: Administration into the peritoneal cavity.

SCU: Subcutaneous administration of the chemical.

IVN: Intravenous administration of the chemical.

IHL: Administration of the chemical through inhalation.

In many cases, inhalation into the lung is the most critical route of exposure. This is because the surface area for absorption of the inside lining of the lungs is as large as a football field; it transfers chemicals directly into the bloodstream, and because of the large volumes of air that we breathe.

Sites of Action

The effects of chemicals on the body are classified according to their sites of action. For a chemical to express its intrinsic toxic characteristics, it must come in contact with a target organ. If the effect is produced at the point of surface contact directly without first being absorbed into the circulatory system, the lesions produced are considered local effects. Areas commonly damaged by local effects include the eyes, skin, lung, and intestinal tract surfaces.

If the effects are produced in these tissues because of absorption and dissemination through the circulatory system, or are produced in tissues or organs away from the site of original contact, the lesions or effects are considered systemic effects. Chemicals can produce both of these types of effects.

Acute Toxicity

All chemicals are toxic under some condition of exposure. Therefore, it is necessary to define these conditions as well as the quantity involved in the exposure in order to compare the toxicity characteristics of chemicals. Acute toxicity is defined as the toxic effects produced by a single or multiple exposure to a substance by any route for a short period (e.g., less than one day). Acute toxicity information is dominated by lethality data, levels of airborne exposure (LC_{50}) or ingestion dose (LD_{50}) estimated to kill 50 percent of a specific population of animals under controlled conditions and dose-response (mortality) relationships.

On SDS's, the degree of acute toxicity is usually expressed by these acronyms for types of toxicological studies:

LDLo: The lowest dose of a material introduced by any route, other than inhalation, over any given period in one or more divided portions and reported to have caused death in humans or animals.

LCLo: The lowest concentration of a material in air, which has been reported to cause death in humans or animals.

$LD_{50}O$: Lethal Dose to 50 percent of a population (of lab animals). Amount of dose, in mg/kg of body weight, to kill one-half of the animals to which it is administered. Widely used as an index of toxicity. The lower the LD, the more toxic the substance is.

LC_{50}: Lethal Concentration to 50 percent of a population (of lab animals). Refers to an airborne concentration of a contaminant that will kill one-half of the population of study organisms. Used as an index of toxicity. The lower the LC_{50}, the more toxic the substance is.

Toxicologists have developed categories of acute lethal toxicity. An example of such a classification is given in the following table.

Classes of Acute Toxicity

Toxicity Class	Dose (amount of substance per kg of body weight)	**Probable Oral Lethal Dose** (for a 70 kg Adult Human)	Examples in Toxicity Class	Rat Oral LD50 of Example
Practically Non-toxic	>15 g/kg	More than 1 quart	Sucrose	29.7 g/kg
Slightly Toxic	5-15 g/kg	Between a pint and a quart	Ethanol	14 g/kg
Moderately Toxic	0.5-5 g/kg	Between an ounce and a pint	Sodium Chloride	3 g/kg
Very Toxic	50-500 mg/kg	Between a teaspoonful and an ounce	Caffeine	192 mg/kg
Extremely Toxic	5-50 mg/kg	Between 7 drops and a teaspoon	Sodium Cyanide	6.4 mg/kg
Super toxic	<5 mg/kg	A taste (less than 7 drops)	Strychnine	2.5 mg/kg

In addition to the above criteria, if any of these three criteria are satisfied for a particular chemical, then it is considered extremely toxic:

1. A chemical that has a median lethal dose (LD_{50}) of 50 mg or less per kilogram of body weight when administered orally to rats.

2. A chemical that has a median lethal dose (LD_{50}) of 200 mg or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of rabbits.

3. A chemical that has a median lethal concentration (LC_{50}) in air of 200 ppm by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to rats.

If any of these three criteria are satisfied for a particular chemical, then it is considered very toxic:

1. A chemical that has a median lethal dose (LD_{50}) of more than 50 mg per kilogram, but not more than 500 mg per kilogram of body weight when administered orally to rats.

2. A chemical that has a median lethal dose (LD_{50}) of more than 200 mg per kilogram but not more than 1,000 mg per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of rabbits.

3. A chemical that has a median lethal concentration (LC_{50}) in air of more than 200 ppm but not more than 2,000 ppm by volume or less of gas or vapor, or more than 2 mg per liter but not more than 20 mg per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to rats.

Chronic Toxicity

Latent effects, such as carcinogenicity or mutagenicity, are examples of long term or chronic effects. The damage done from one large or multiple low-level exposures to a carcinogen are often latent, that is, the cancer often does not show up until 10 to 20 years later. Likewise, the effect of exposure to a mutagen will not manifest itself until the birth of offspring with malformations resulting from the mutation.

Chronic toxicity is the toxic effect resulting from repeated, low-level daily doses over a persons or animals lifetime. These chronic effects can result from cumulative damage to tissues sustained from each small dose, or they can result from accumulation of the toxic chemical in the body over a long period of low-level exposure.

CHEMICAL EXPOSURE AND OVER-EXPOSURE

"All substances are toxic. There is no substance without toxicity. It is solely the dose which determines toxicity."
-Paracelcus, 16th century alchemist

This assertion is the foundation of toxicology. It is very important to find out your degree of exposure to a toxicant, not merely that a particular chemical is present in the laboratory.

Understanding Your Exposure to Chemicals

While higher exposures are generally more worrisome than lower ones, for a specific agent there may be a threshold exposure below which toxic effects do not occur. Determining this threshold, however, is often difficult. We know, for instance, that heavy alcohol consumption by a pregnant female can result in Fetal Alcohol Syndrome in her child, but have no idea whether there is some lesser amount of alcohol consumption that poses no risk to the fetus. For other agents there may be no safe dose; ingestion of as little as a single 50 mg capsule of thalidomide by a pregnant female can cause malformations in her child.

Individual biology also makes a difference. Each person has a different degree of susceptibility or sensitivity to the effects of exposure to chemicals. Another complication is that most people are exposed to more than one, usually many chemicals at once. Data is available on the toxic effects of individual chemicals, but exposure to multiple chemicals at once can result in complex interactions that we do not even begin to understand.

There is no such thing as zero exposure to a chemical. If the chemical is present in the laboratory, and you are working with it, then you are probably exposed to it at some level. The American Conference of Governmental Industrial Hygienists (ACGIH) and the Occupational Safety and Health Administration (OSHA) have established acceptable limits for workplace exposures. The ACGIH's Threshold Limit Values (TLVs) are guidelines for use by professional industrial hygienists. The Permissible Exposure Limits (PELs) established by OSHA, however, are more than just guidelines; they have the force of law. Employers are responsible for assuring that their employees are not exposed to levels above the PEL. TLVs and PEL's represent a level of exposure that an average healthy worker can be exposed to on an 8-hour per day, 40 hours per week lifetime exposure without suffering significant adverse effects.

Individuals respond differently when exposed to chemicals.

On Safety Data Sheets, you will typically see these acronyms for standards and regulations governing workplace chemical exposures:

IDLH: Immediately Dangerous to Life or Health: An atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere.

ACGIH: American Conference of Governmental Industrial Hygienists

TLV: Threshold Limit Value: refers to airborne concentrations of substances to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Established by the ACGIH as guidelines for use by professional industrial hygienists.

SKIN: A notation on some of the TLV's that indicates that the substance may be absorbed by the skin, mucous membranes and eyes, either by air or direct contact, and that this additional exposure must be considered part of the total exposure to avoid exceeding the TLV for that substance.

TLV-TWA: Time-Weighted Average: An average airborne concentration over an eight-hour work shift. Excursions above the TLV are permitted, if they are compensated by equivalent excursions below the TLV.

TLV-STEL: Short-term Exposure Limit: a 15-minute time-weighted average that should not be exceeded at any time during the workday, even if the 8-hour TWA is within the TLV-TWA. Limits established to avoid: 1) irritation, 2) chronic or irreversible tissue damage, or 3) narcosis of sufficient degree to increase the likelihood of accidental injury.

TLV-C: The Ceiling exposure limit; the concentration that should not be exceeded even instantaneously.

PEL: Permissible Exposure Limit: Similar to a TLV, but established by OSHA as the legal limit for employee exposure. Employers have the legal responsibility to ensure that their employee's exposures do not exceed the PELs.

OSHA: Occupational Safety and Health Administration: Federal Government agency, part of the Department of Labor, charged with ensuring the health and safety of private sector workplaces in the United States establishes and enforces safety and health regulations.

NIOSH: National Institute for Occupational Safety and Health: Part of the Centers for Disease Control of the Public Health Service of the U.S. Department of Health and Human Services. It conducts research and development in Occupational Safety and Health and advises OSHA in rulemaking and standard setting.

REL: Recommended Exposure Limit: Similar to a TLV, but established by NIOSH.

Several sets of exposure limits have been established.

As noted above, the lung is usually the most critical route of entry. Exposures via other routes, such as ingestion, and skin absorption, must also be taken into account to determine if an excessive exposure is present.

In some cases, the Environmental Health and Safety (EHS) Office can measure your workplace air concentrations of chemicals. Contact EHS if you are concerned about your exposure or would like advice on controlling chemical exposure. Read the guidelines in Part D of this Guide on controlling chemical hazards in the laboratory.

Overexposure is a possibility when:

- Volatile or airborne chemicals are used outside of a laboratory exhaust hood or some other containment.
- An aerosol results in direct contact with skin or eyes.
- There is an accidental ingestion.
- You are near an accidental spill or gaseous release.

If you are concerned about effects to your health from exposure to a chemical, see a physician. Students may receive medical care from the University Health Center. Call EHS for additional guidance in seeking medical assistance for chemical exposures.

Information on the signs and symptoms of an overexposure can be obtained from a physician, an SDS, and the American Association of Poison Control Centers (1-800-222-1222).

If you feel that you may have had a harmful exposure, see a physician immediately. For emergency care, go to a hospital emergency room. If an exposure may be life threatening dial 911 for emergency transport. If the exposure is not life threatening, yet you desire to seek medical care, contact University Police at 9-9999.

If you are concerned about effects to your health from exposure to a chemical, see a physician.

REVIEW QUESTIONS

1. A certain chemical is known to cause cancer in humans. This chemical would be called:
   a) a carcinogen.
   b) toxic.
   c) corrosive.
   d) nephrotoxic.
   e) a and b.

2. A flammable liquid will emit enough vapors to be ignited by a spark source at temperatures:
   a) above absolute zero.
   b) above its flash point.
   c) above its ignition temperature.
   d) above its freezing point.

3. What material will burst into flames upon contact with air?
   a) explosives.
   b) peroxide-former.
   c) teratogenic.
   d) pyrophoric.

4. Nephrotoxic agents damage the:
   a) Liver.
   b) Nervous System.
   c) Spleen.
   d) Pancreas.
   e) Kidney.

5. A teratogen can cause birth defects if the person exposed to it is:
   a) Anybody.
   b) A pregnant woman.
   c) A postmenopausal woman.
   d) A male.

6. A chemical is described as having a local effect. The damage to the body caused by it is:
   a) widespread.
   b) only where the chemical makes contact with the body.
   c) inflicted upon everyone in the immediate vicinity of the chemical.
   d) not inflicted on foreigners and tourists.

7. The lower the LD_{50}, the chemical is:
   a) less toxic.
   b) more corrosive.
   c) more toxic.
   d) more flammable.

8. The routes of entry of toxic chemicals into your body include:
   a) Inhalation into your lungs.
   b) Ingestion into your stomach.
   c) Absorption through your skin.
   d) Injection into your bloodstream through a wound.
   e) All of the above.

9. The oral rat LD_{50} is a commonly used index of:
   a) flammability.
   b) corrosivity.
   c) carcinogenicity.
   d) acute toxicity.

ANSWERS

1. e) a and b.

2. e) b and c.

3. d) pyrophoric.

4. e) Kidney.

5. b) A pregnant woman.

6. b) only where the chemical makes contact with the body.

7. c) more toxic.

8. e) All of the above.

9. d) acute toxicity.