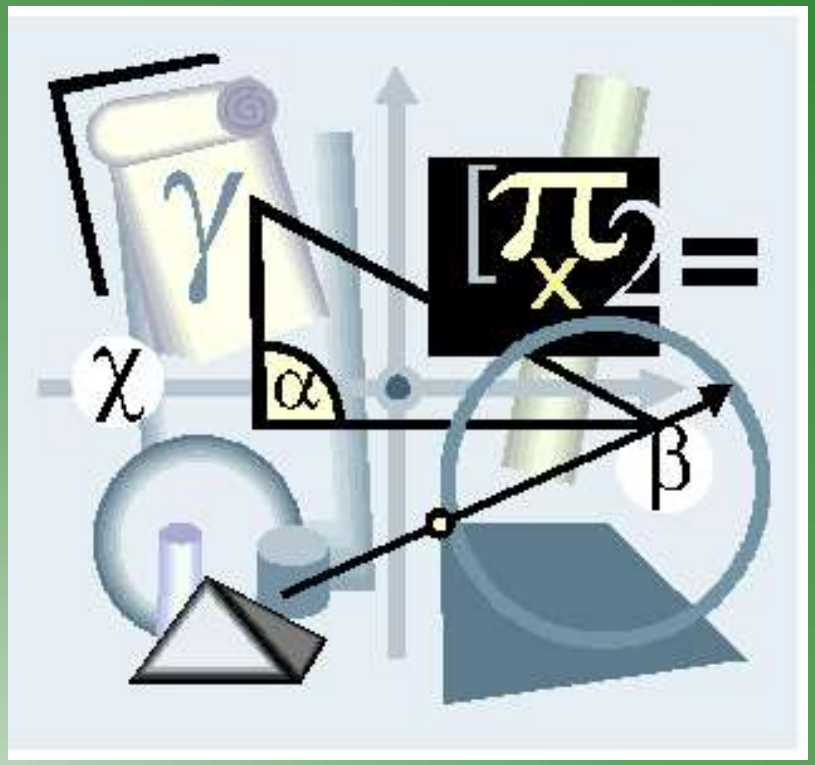
Introduction
Basic Toxicology & Occupational Health

- Toxicology, for the purpose of this module, is the study of the effects of chemicals on living organisms. It is a broad science because of the variety of potential effects and the diversity of chemicals.
- Toxicity is an inherent characteristic of all chemicals and a certain dose of any substance may cause illness, injury or death. As Paracelsus, the father of toxicology, said: "All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."

Learning objectives

- At the end of this module you will be able to:
  - Define basic toxicology fundamentals
  - Understand how you may be exposed to hazardous chemicals and substances
  - Recognize the effect various chemicals may have on your body
  - Explain current occupational exposure guidelines (PELs, TLVs. Etc.).

Does-Response Relationship

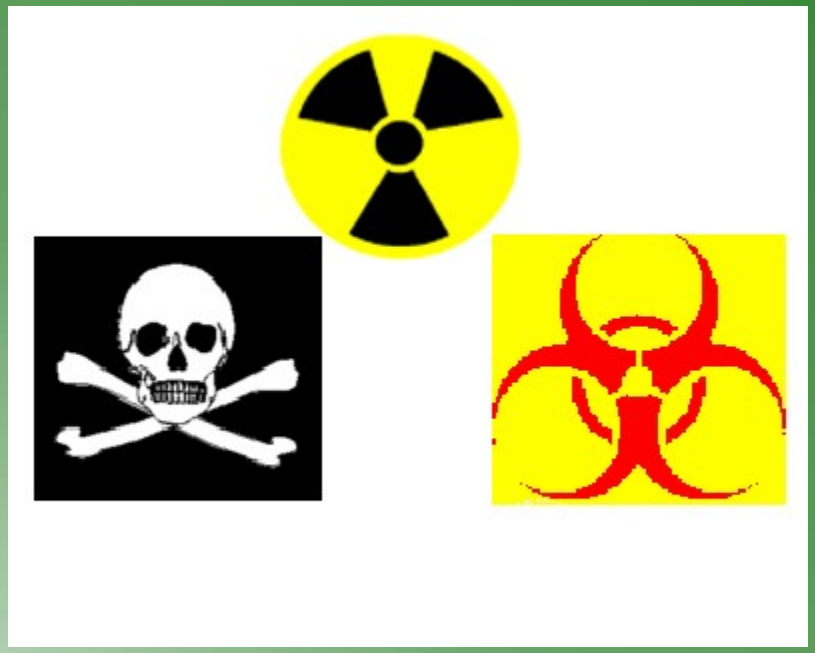


- The characteristics of exposure and the spectrum of effects come together in a correlative relationship. In general, a given amount of a toxic agent will elicit a given type and intensity of response.
- However, each person's tolerance level or response to a toxic agent is based on genetic make-up, work habits, age, gender, body weight, physical health, and medication being taken. This does-response relationship is the basis for measurement of the relative harmfulness of a chemical.

Dose

- In toxicological studies, the dose given to a test organism is a function of the concentration and the duration of exposure.

Response/Effects



- Before a dose-response relationship can be evaluated, the type of effect or endpoint that is being measured must be identified and defined.
- The toxic effects seen following chemical exposure can be categorized as follows:
  - Local effects
  - Systemic effects
  - Immediate vs. delayed effects
  - Reversible vs. irreversible effects.

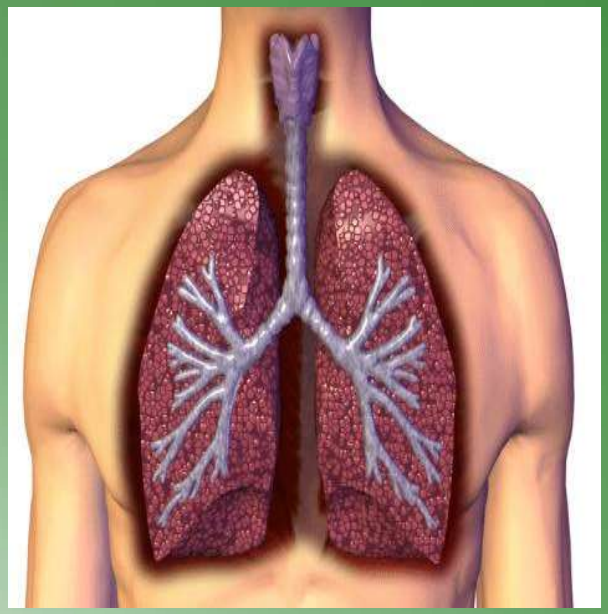
Test your knowledge

- The lethal dose or lethal concentration at which 50% of the population is killed is expressed as:
  - TD50/TC50
  - NOEL
  - LD50/LC50
  - Ldlo/LClo

Routes of Exposure

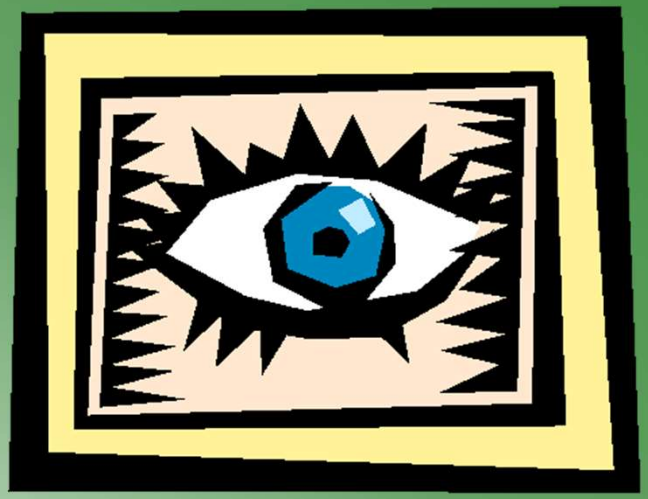
- In order for a chemical to exert its toxic effect, it must get into the body and reach its target.
- There are four major routes for chemicals to enter the bloodstream:
  - **Inhalation**
  - **Skin or eye adsorption**
  - **Injection**
  - **Ingestion**
- The following screens describe these routes.

Inhalation



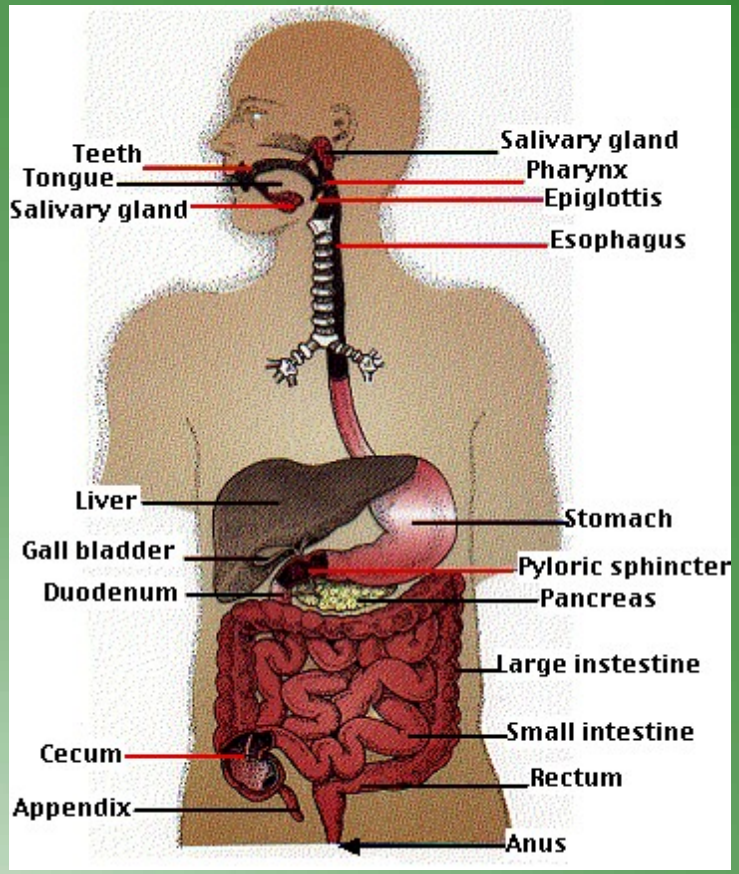
- Inhalation is the primary route of exposure and most rapid and efficient route of entry for chemical vapors, gases, mists or particulates.
- Inhalation of a chemical can cause local effects of irritation when the chemical reaches the nose, throat, and upper respiratory tract. The chemical action can cause damage to tissues of the throat and bronchi.
- Systemic effects occur when the chemical reaches the alveoli where gas is exchanged. Once the chemical reaches this point, it can enter the bloodstream and cause adverse effects in target organ systems.
- Inhalation is a main source of industrial exposure.

Skin/Eye Contact and Absorption



- Exposure can occur from a spill or splash and from hand-to-eye contact.
- Local effects occur when the chemical causes irritation, burns or dermatitis.
- Systemic effects occur when the chemical is absorbed through the skin into the bloodstream and distributed to other parts of the body. Broken skin can increase the absorption rate. Skin contact is a main source of industrial exposure.
- Examples of chemicals that can be absorbed into the skin include:
  - Benzene
  - Carbon disulfide
  - Carbon tetrachloride
  - Toluene.

Ingestion



- Ingestion is usually less of a concern in the field because it is a less common route for chemicals to enter the bloodstream.
- Accidental ingestion occurs from contaminated food and drink and poor personal hygiene. For example, washing your hands can help prevent accidental ingestion.
- Exposure can be local(nausea, vomiting) or systemic (affecting target organ system).

Injection

- The skin must be penetrated or punctured by contaminated objects for injection to occur.
- Situations that can lead to accidental injection include:
  - Misuse of contaminated tools
  - Misuse of improper disposal of contaminated needles/sharps
  - Improper handling or disposal of contaminated glass/metal objects
  - Accidentally stepping on nails or other sharp, rusty objects
  - Cuts from contaminated tools or equipment.

Test your knowledge

- Mark four chemicals that can be absorbed through the skin.
  - Ozone
  - Carbon monoxide
  - Toluene
  - Isopropyl alcohol
  - Carbon disulfide
  - Benzene
  - Carbon tetrachloride

Toxicokinetics

- Toxicokinetics, or pharmacokinetics, is an approach used to gain an understanding of how the body handles any given substance over time. Mathematical functions are used to qualify where a chemical goes once it enters the bloodstream and how much is absorbed, distributed, excreted, or metabolized.

Test your knowledge

- Match each description with the correct toxicokinetic term.

  - A Resulting compound may be more toxic than the original chemical.
  - B After entering the bloodstream, the chemical is available for translocution throughout the body.
  - C Process in which a toxic agent crosses body membranes and enters the bloodstream.
  - D Elimination of substances from the body.

  - 1 Metabolizing
  - 2 Absorption
  - 3 Excretion
  - 4 Distribution

Toxic Hazards

- Toxic hazards include a wide range of categories, or classes of substances which are based on the type of effects produced from acute and chronic exposure. The following are considered hazard classes:
  - Irritants
  - Sensitizers
  - Systemic poisons
  - Carcinogens/Mutagen/Teratogens
  - Asphyxiants

Irritants

- Irritants are materials that cause inflammation of tissue membranes, usually following acute exposure to high concentrations of a substance.

Sensitizers

- Sensitizers are materials that trigger an immune response in the body. Unlike the other classes of toxic hazards, these chemicals are not dose dependent, and they usually require an initial or preconditioning exposure.

Systemic Poisons

- Systemic poisons are chemical agents that exert their toxic effect on specific organs or organ systems following exposure to any of the four major routes of exposure.
- These toxic hazards can be grouped in categories based on the organ or organ system targeted or on the effect produced, such as:
  - Central nervous system depressants
  - Neurotoxins
  - Hepatotoxins
  - Hemolytic agents
  - Nephrotoxins
  - Reproductive systems toxins
  - convulsants

Carcinogens/Mutagens/Teratogens

- Some examples of physical or chemical agents that may be harmful are carcinogens, mutagens, and teratogens.

Asphyxiants

- Asphyxiants are materials that deprive the body of oxygen. Click on the buttons below for more information about the two general types of asphyxiants
  - Simple asphyxiants
  - Chemical asphyxiants

Test your knowledge

- Materials that cause inflammation of tissue membranes usually following acute exposure to high concentration are:
  - Asphyxiants
  - Sensitzers
  - Irritants
  - Neurotoxins

Factors influencing toxicity

- Many factors affect the reaction of an organism to a toxic chemical. The specific response that is elicited by a given dose varies depending on the species being tested and variations that occur among individuals of the same species.

- The following affect the reaction of an organism to a toxic chemical:
  - Factors related to the toxic agent
  - Factors related to the exposure situation
  - Factors related to the individual
  - Factors related to the environment
  - Effects of interactions of chemicals.

Factors Related to the Toxic Agent

- Listed below are some examples of factors related to the toxic agent.
  - Chemical characteristics
  - Physical properties
  - Presence of impurities
  - Carrier substance or vehicle

Factors Related to the Exposure Situation

- Listed below are some examples of factors related to the exposure situation.
  - Dose
  - Rate of administration
  - Route of entry

Factors Related to the Individual

- Listed below are some examples of factors related to the individual.
  - Heredity
  - Age
  - Previous exposure
  - Sex
  - Nutrition
  - Presence of disease
  - hormones

Factors related to the Environment

- Listed below are some examples of factors related to the environment.
  - Carrier
  - Additional chemicals present
  - Temperature
  - Air pressure
  - Light/radiation

Effects of Interaction of Chemicals

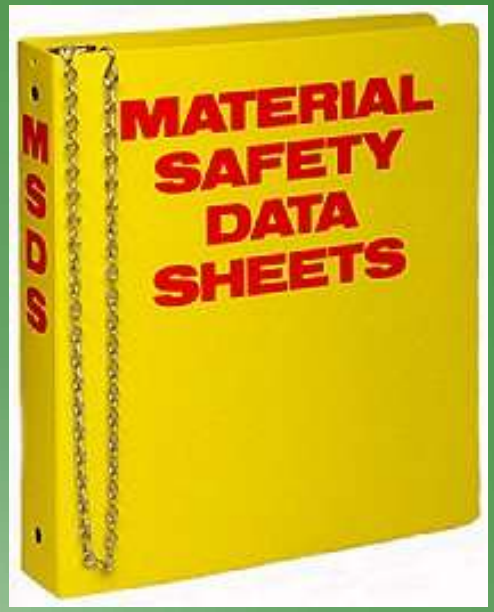
- Listed below are some interactions of chemicals.
  - Additive
  - Synergism
  - Potentiation
  - Antagonism

Test your knowledge

- When two chemicals are combined, they produce an effect that is greater than the sum of the effect of each agent given alone. This is called:

  - Antagonism
  - Synergism
  - Potentiation
  - Additive

Evaluating Health Hazards



- It is important to try to obtain specific information on the chemical health hazards you may be exposed to in the field activities so you can decide what protective measures will be necessary. One source of general toxicological information is the material safety data sheet (MSDS).

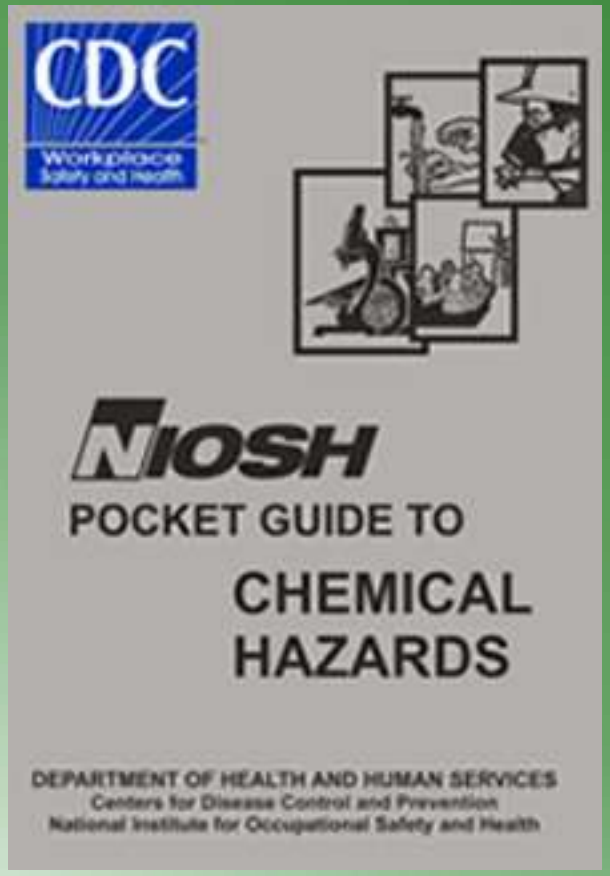
Evaluating Health Hazards

- Knowledge of specific hazards of chemicals can help you to determine:
  - Whether a hazard exists and the degree of the hazard
  - Whether air monitoring is needed and whether techniques exist for monitoring exposures present before or during field activities.
  - Whether possible exposures should be documented by medical monitoring
  - Needs for specific protective equipment and clothing and establish the basis for selecting and using such equipment and clothing.

Evaluating Health Hazards

- The following sections outline some information that will assist in evaluating the toxicity of a chemical:
  - Exposures limits/airborne concentrations
  - Toxicological data
  - Signs and symptoms of overexposure.

Exposure Limits/Airborne Concentrations



- One of the first considerations in controlling exposures to hazardous chemicals in knowing whether acceptable exposure concentrations have been established for the chemicals in question.
- There are three major sources of exposure limits:
  - The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs)
  - The Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs)
  - National Institute of Occupational Safety and Health (NIOSH) Recommended Exposure Limits (RELs)

Exposure Limits/Airborne Concentration

- The categories of exposure limits are based on time and exposure and concentration and include:
  - Time-weighted average (TWA) concentration for an 8-hour work day
  - Short-term exposure limit (STEL), meaning the 15-minute TWA exposure which shall not be exceeded at any time during a work day even if the 8-hour TWA is within established limits. Exposures above the TWA up to the STEL should not be longer than 15 minutes, should not occur more than 4 times per day, and should b at least 60 minutes between successive exposures in this range
  - Ceiling (C) , meaning the concentration that should not be exceeded during any part of the working day.
- In addition to the previously mentioned limits, the National Institute for Occupational Safety and Health (NIOSH) and OSHA have developed immediately Dangerous to Life and Health (IDLH) concentrations for use in the decision-making process for respiratory selection. IDLH represents a maximum concentration from which on could escape within 30 minutes without any impairing symptoms or irreversible health effects.

Toxicological Data

- Information on the toxic properties of chemical compounds and the dose=response relationship can be obtained from:
  - Animal Data that include all descriptive animal toxicity testing; effects produced by the compound in laboratory animals are often applicable to humans
  - Epidemiological Studies based upon the results observed/measured in a given population exposed to a chemical when compared to an appropriate, non-exposed group
  - Clinical Studies that involve individual reports of chemical exposure.

Toxicological Data

- The extrapolation of human data from animal studies is complex, and these values should only be considered as an approximation for the potency of the compound and used in conjunction with additional data.
- For example, when comparing chemicals, if an LD50 is greater in one chemical than another, the chemical with the higher LD50 is said to be less potent than the other, since it would take more of the other chemical to produce the same effect. Those chemicals which will produce death in microgram doses are considered extremely toxic.
- Information about the toxicological effects of a chemical can be obtained from the labels and the MSDSs. These sources contain data on acute and chronic health effects, including skin and eye irritation, systemic toxicity, and carcinogenicity.

Signs and Systems of Overexposure

- During field activities, you must always be aware of the potential for unexpected exposure to toxic chemicals and be able to identify any signs and symptoms of overexposure.

Signs and Symptoms of Overexposure

- Some signs and symptoms may include the following:
  - Sneezing and coughing
  - Changes in breathing rate
  - Headache, dizziness
  - Nausea
  - Irritation of the eyes and throat
  - Redness and swelling of the skin
  - Itchiness of the skin
  - Changes in behavior.
- Anyone who develops signs and symptoms of chemical exposure should seek medical attention immediately.

Test your knowledge

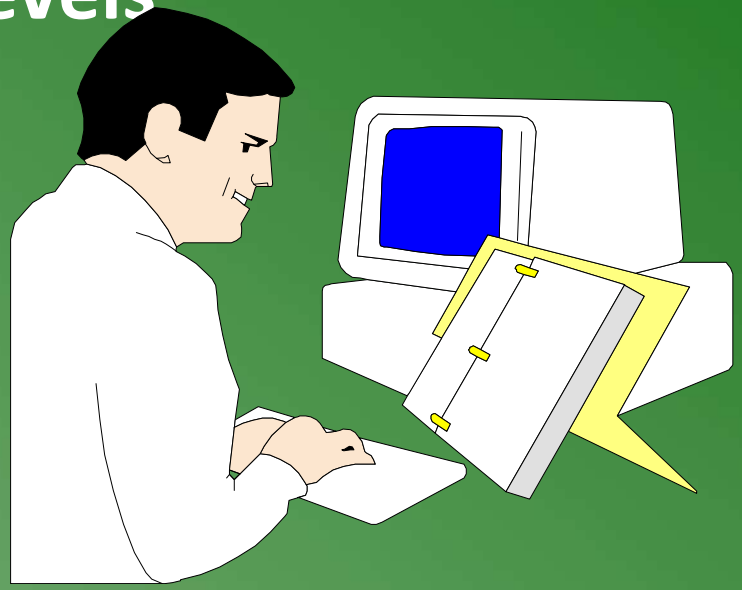
- Extrapolation of human data from animal studies is complex, and these values should be considered as the exact potency of the compound.

  - True
  - False

Medical Surveillance Program

Applies to employees exposed or potentially exposed to hazardous substances or health hazards at or above published exposure levels

- injuries
- illnesses
- overexposure



Medical Surveillance Program

- Primary purpose
  - assess and monitor worker's health before and during employment
  - emergency and non-emergency medical treatment
  - record keeping

Site-Specific Medical Program

- Written for each site
- Directed by a qualified physician
- Consider
  - site conditions
  - monitoring needs of each worker
  - routine job tasks

Site-Specific Medical Program

- Identify toxic substances
- Recognize the limitations of occupational medical tests
- Low level and high level exposure both possible
- Risk can vary for individuals

Site-Specific Medical Program

Components include:

- Surveillance
- Treatment
- Record Keeping
- Program Review

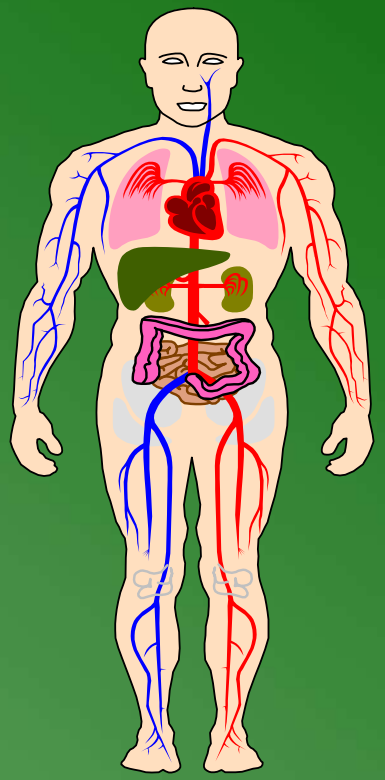
Surveillance

- Pre-employment screening
  - fitness for duty
  - baseline
- Occupational & Medical History
  - prior exposure to chemical & physical hazards
  - personal habits

Surveillance

Physical Examination

- pulmonary
- cardiovascular
- musculoskeletal
- hearing
- hernia
- skin
- blood test
- meets requirements of 1910.134



Surveillance

- Physician's written opinion
  - given to the employer and employee
  - recommendations based on worker's assigned tasks
  - written assessment of respirator capability
- Periodic Medical Examinations
  - frequency and content may vary
  - recommended at least yearly
- Termination Examination

Emergency Medical Treatment

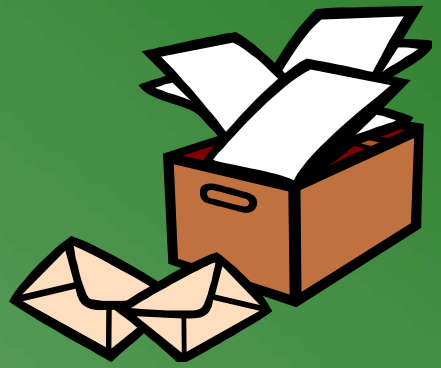
- location for monitoring vitals and heat stress, general first aid, stabilization, emergency decon
- on-site medical supplies, eye wash, fire blanket, and restocking procedure
- train a team of site personnel in emergency first aid and emergency decon
- establish communication for emergency use and make sure phone numbers are posted
- review emergency procedures at safety meetings

Treatment

- Medical Support
  - on call
  - emergency transport
  - coordination with hospital
  - medical history provided if needed
  - non-emergency medical care

Record Keeping

- Maintain and preserve for 30 years post employment (1910.20)
- Make available to worker, their authorized rep., and OSHA (1910.20)
- Maintain Occupational Injury and Illness Log (1904)



Program Review

- Accidents and injuries promptly investigated and changes made
- Efficiency of specific medical testing
- Add or delete medical tests if needed
- Update emergency procedures
- Review management commitment to worker health and safety

Summary

- Measures you can take to minimize the risks associated with chemical exposure include:
  - Understand the basic principles of toxicology and how they relate to exposures you may encounter during field activities.
  - Practice applying this knowledge.
  - For example, pick a common hazardous material you are exposed to in the field (for which you know the approximate concentration), look up the TLV or PEL, estimate your daily exposure duration, and try to calculate your dose. Compare you calculated dose to the established values.
  - Know the primary routes of exposure for chemicals you commonly encounter in the field.
  - Be aware of the different effects toxins can have on your body (e.g., chronic, acute, local, systemic, immediate, delayed, reversible).

Summary

- Additional measure you can take to minimize the risks associated with chemical exposure include:
  - Recognize that toxins present a wide range of hazards (e.g., irritants, sensitizers poisons, carcinogens, mutagens, teratogens, asphyxiants).
  - Identify any relevant factors that may influence your reaction to toxins (e.g., heredity, previous exposure, nutrition, hormones, age, sex, presence of disease).
  - Obtain specific information about the chemical health hazards you may be exposed to during field activities so you can decide what protective measure may be needed.
  - During field activities, be aware of the potential for unexpected exposures. Signs and symptoms may include sneezing and coughing, changes in breathing rate, headache, dizziness, nausea, etc.
  - Seek medical attention immediately upon development of signs/symptoms of chemical exposure.

- You have completed the module:
- Basic Toxicology & Occupational Health