CSP
CHEMICAL SECURITY
ENGAGEMENT PROGRAM

Chemical Safety and Security Officer Training

UAE

September 2011

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company,
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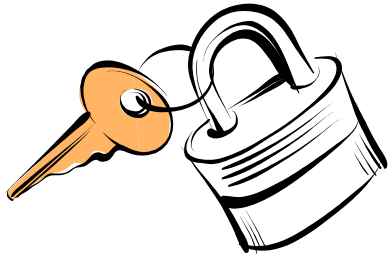
under contract DE-AC04-94AL85000.

Sandia National Laboratories

Lab Inspection (Checklist-See Handout))

Group Discussion

Laboratory Inspection Guidance



- *Access to building*
- *Access to labs*
- *Stockrooms*
  - *Access-security*
  - *Proper arrangement and storage of chemicals*
- *Emergency equipment- Location and condition*
  - *Spill kits, showers, eyewash*
  - *Fire extinguishers, sensors, alarms, sprinklers*
- *Warning signs and labels*
  - *External-internal to room, cabinets, fume hoods*
  - *Emergency contact numbers, evacuation map*

Laboratory Inspection Guidance

- ***Other Hazards***
  - ***Compressed gas bottles***
  - ***Tripping hazards***
  - ***Electrical hazards***
  - ***Flame generating equipment***
- ***Housekeeping***
  - ***Waste- secondary containment***
  - ***Chemical reagents and samples labeled***
  - ***Uncluttered fume hoods***
- ***Personal protective equipment***
  - ***Gloves, goggles, aprons***
- ***SOPs, MSDSs***
- ***Unblocked exits***

Principles of Toxicology

Simplified Physiology

http://sis.nlm.nih.gov/enviro/toxtutor.html

Major Parts of the Cell

All organisms are made up of cells: (eukaryotic, prokaryotic)

- **Cells membrane** – regulate entry
- **Cytoplasm** – liquid atmosphere of cell
- **Mitochondria** – energy production – ATP
- **Nucleus** – DNA – genes, cell division
- **Golgi** – secretory function
- **Lyzosome** – digestive function

In the Body…

- **Cells** combine to form tissues which are specialized – connective, nerve, muscle
- **Tissues** combine to form organs which can perform complex functions
- **Organs** combine to form systems, e.g., respiratory, reproductive, nervous, circulatory system

Routes of Exposure

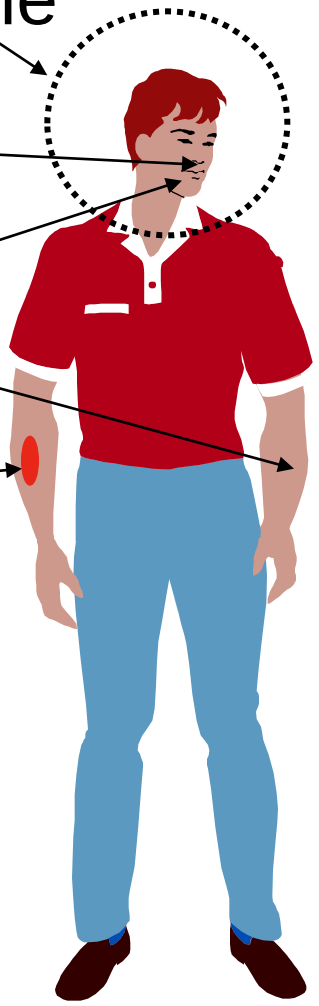
Breathing Zone

Inhalation*

Absorption

Ingestion

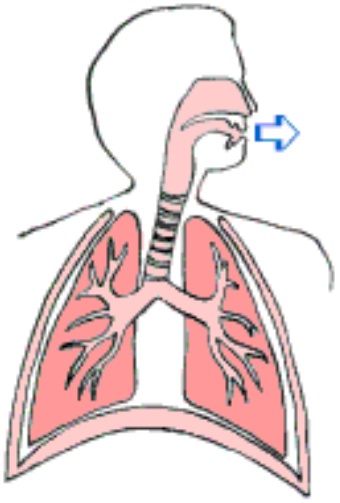
Injection

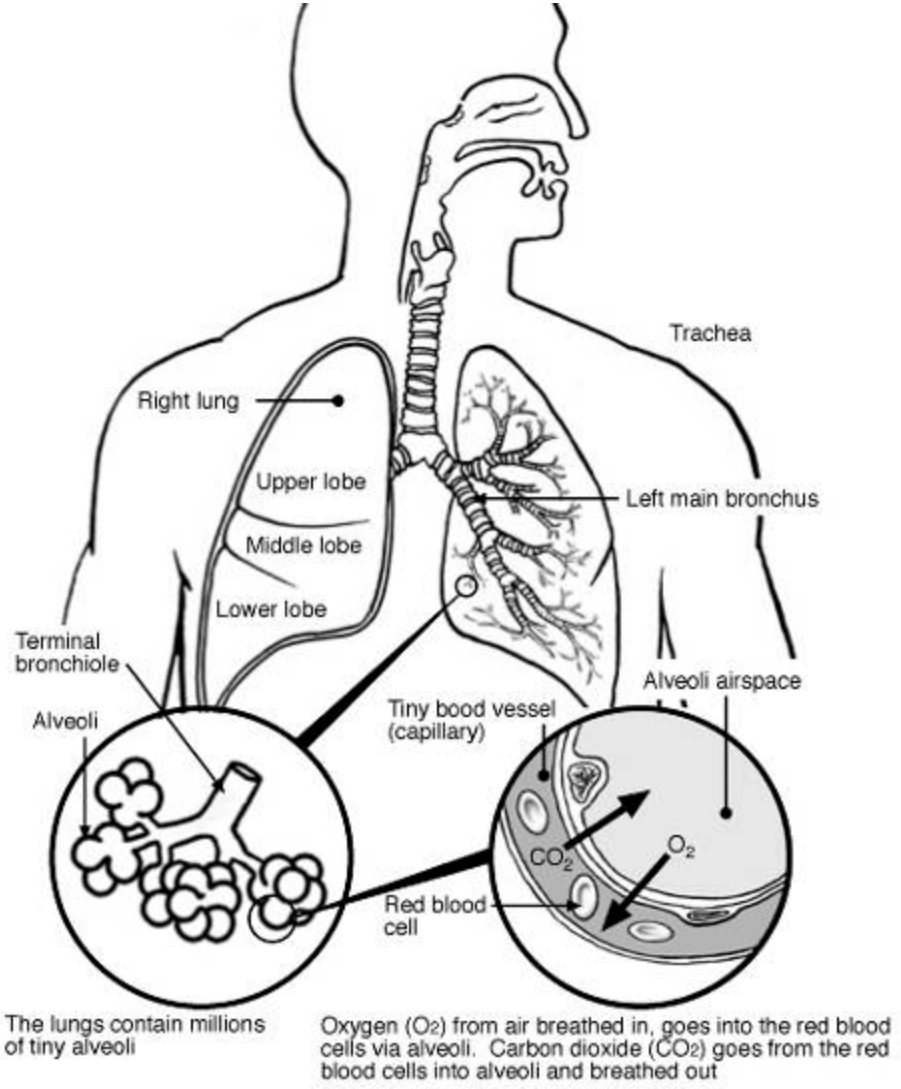


Eyes

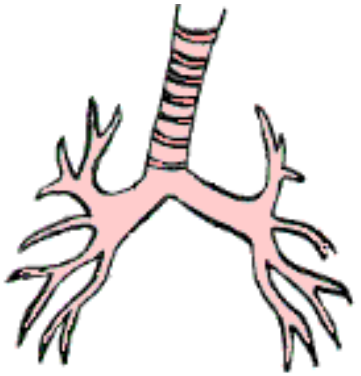
*Most important route of entry

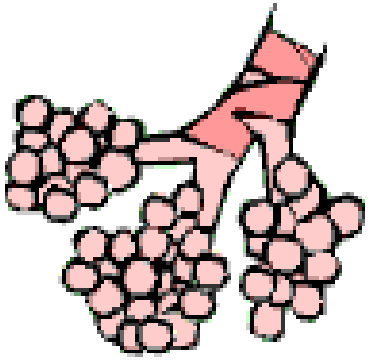
Respiratory System

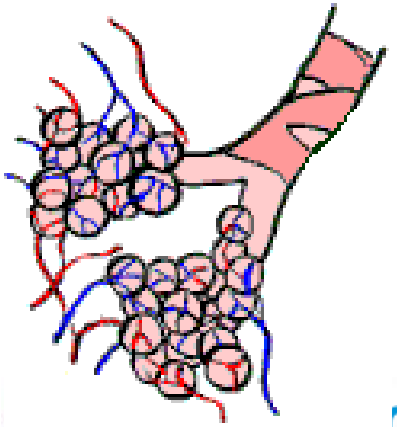




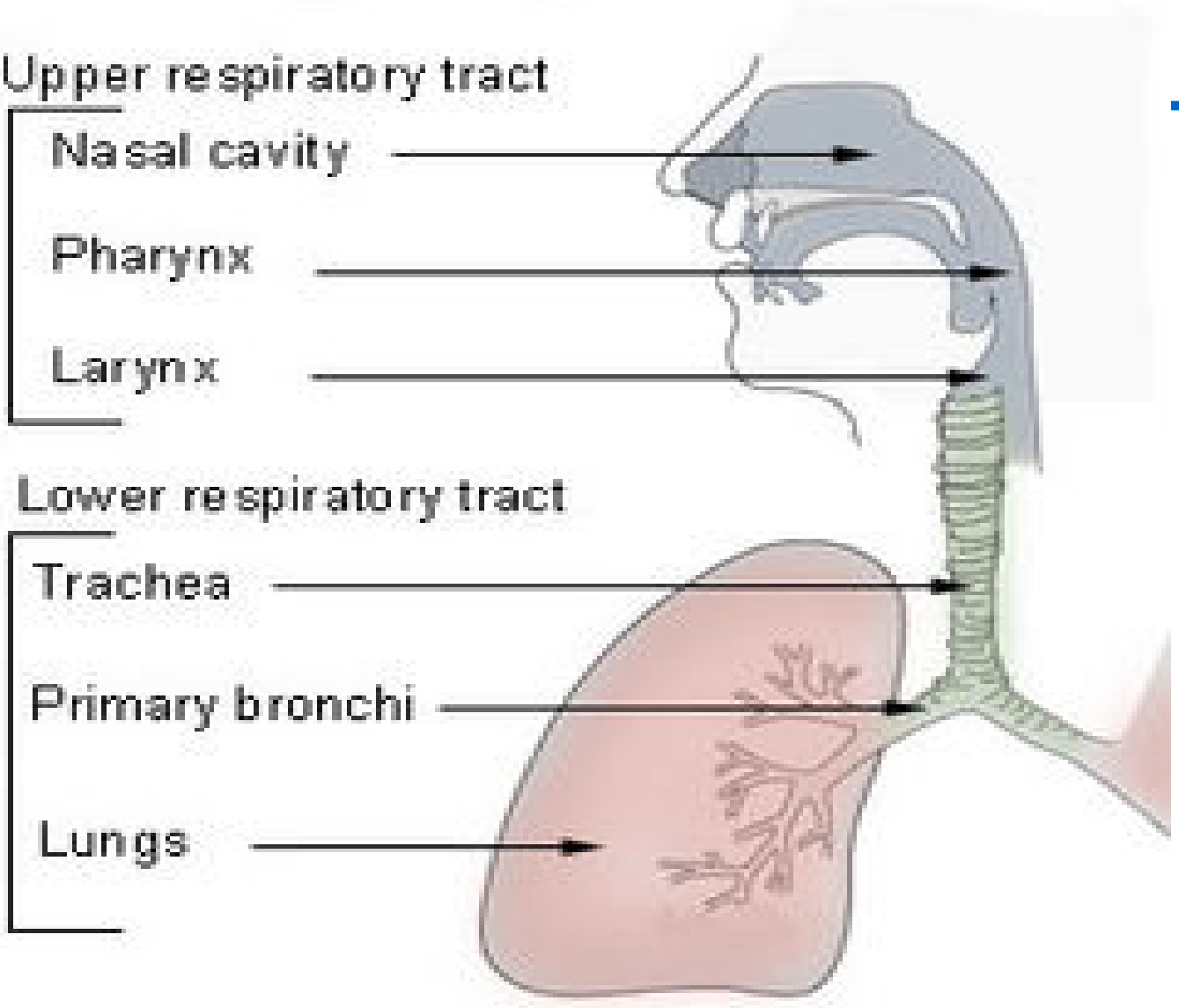
Lung showing alveoli







Conducting Passages

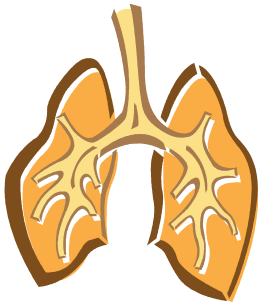


The Lungs
Defense Mechanisms

- **Cilia**
  - Mucus traps dirt and foreign particles.
  - Little hairs (**cilia**) beat back and forth in the airways to move mucus and dirt up where it can be expelled by coughing.
- **Macrophages**
  - Special mobile cells that eat up toxins in the airways and lungs .
- **Requirements:**
  - Regular supply of air with O_2
  - Open, clear airways.

Gas Exchange Region

- About 70 sq meters – the serving area of a tennis court.

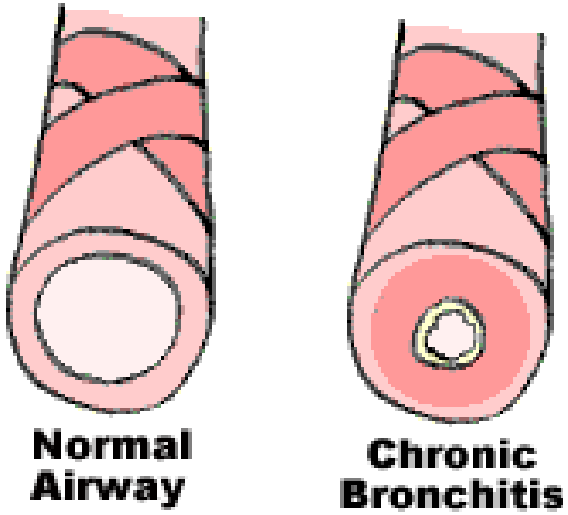


- Consists of alveolar duct and alveoli with surfactant to keep open.

- Close contact with capillaries to exchange O_2 for CO_2 and exhale other gases/vapors.

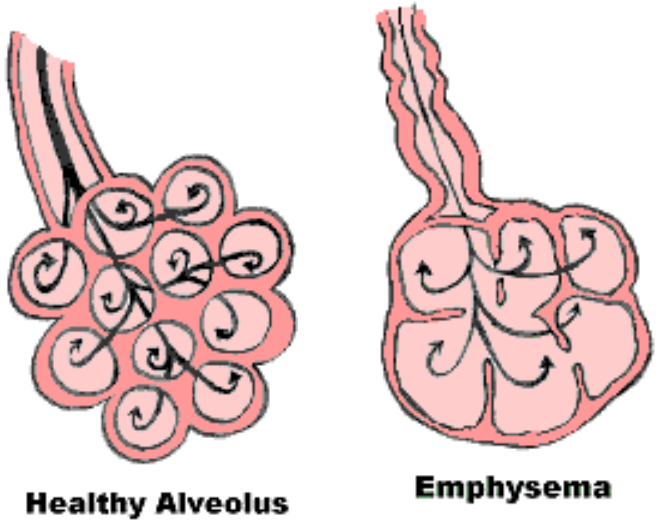
Common Respiratory Issues

Chronic Bronchitis



- Cells inflamed
- Airway narrow and clogged

Emphysema

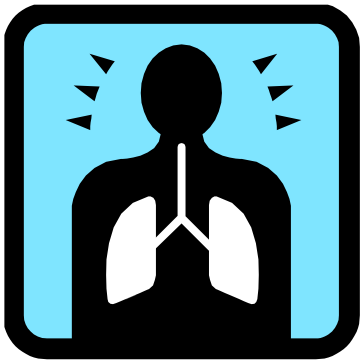


- Normal elasticity destroyed
- Forcefully blow the air out, pressure on the airways
- Excessive coughing

Routes of Exposure

Inhalation (lungs)

- **Most important route if exposed to gases, vapors, mists, aerosols.**
- **Influenced by respiration rate, concentration, duration.**
- **Key factors for gases and vapors:**
  - solubility and reactivity
- **Key factors for aerosols:**
  - particle size and solubility
    - respirable size: 0.1 μm to 10 μm
  - < 5 μm reach alveolar region



Aerosol Penetration into the Lung

Size (micrometers)	% Deposition
> 20	100% in upper airways
10 – 20	80% upper, 0+ alveoli
5.0 – 10	50% upper, 50% alveoli
0.1 – 5.0	0+ upper, 90+ alveoli

Potential Response

- Lung tissue damage
- Transfer point direct to bloodstream
  - transported to target organs - systemic
- Responses:
  - respiratory tract irritation
    - airway constriction
    - infection or fluid build-up (edema)
  - sensitization
    - allergic response, chronic pulmonary disease
  - fibrosis
  - carcinogenesis

Certain Effects of Chemicals on the Lungs

- **Irritations** – acid mists (HCl)
- **Edema** – phosgene ($COCl_2$)
- **Emphysema** – smoke (esp. tobacco)
- **Fibrosis** – silicon dioxide (SiO_2)
- **Cancer** – asbestos (mesothelioma)

Asphyxiates

- **Physical** – dilute oxygen in air to below 10%, non-irritant gases – methane, N_2, CO_2, Freon®

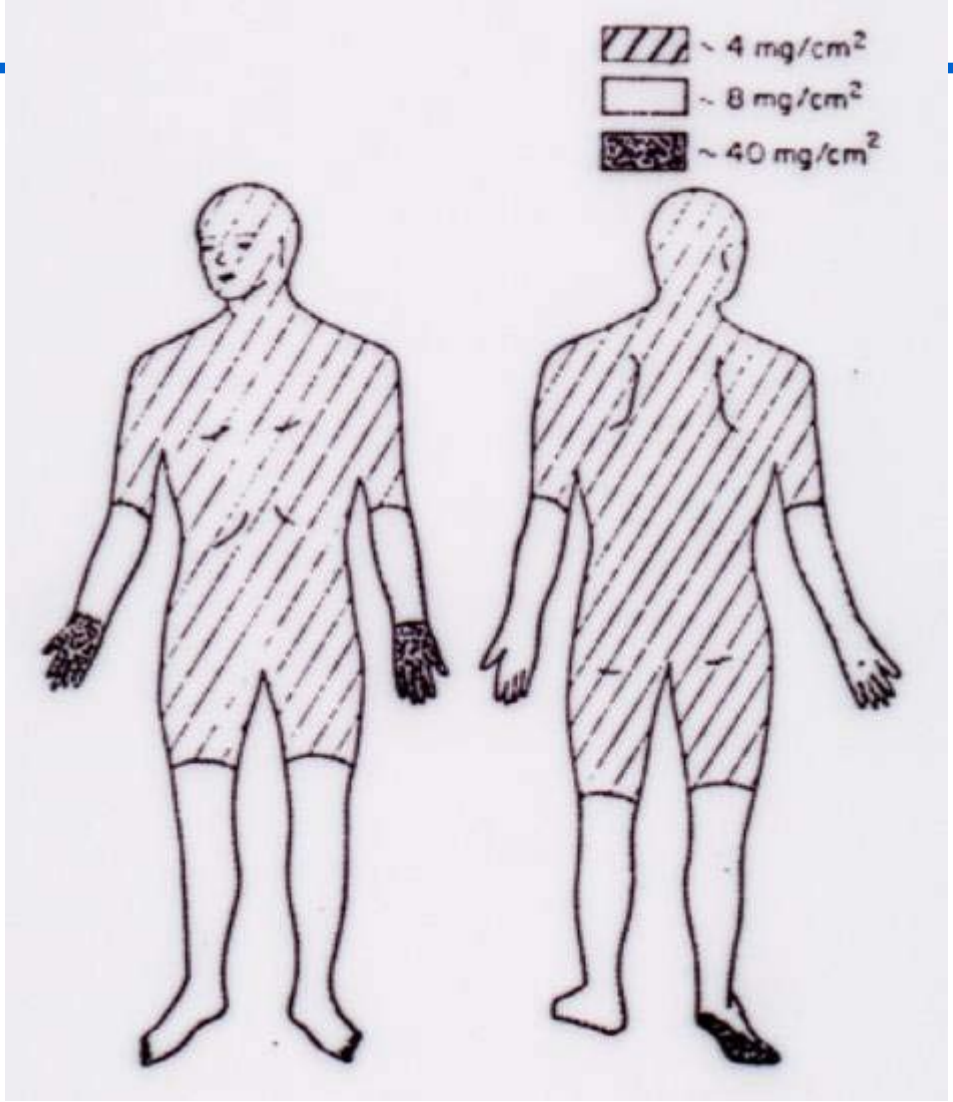
- **Chemical** – displace oxygen on hemoglobin – cyanide, carbon monoxide

Routes of Exposure

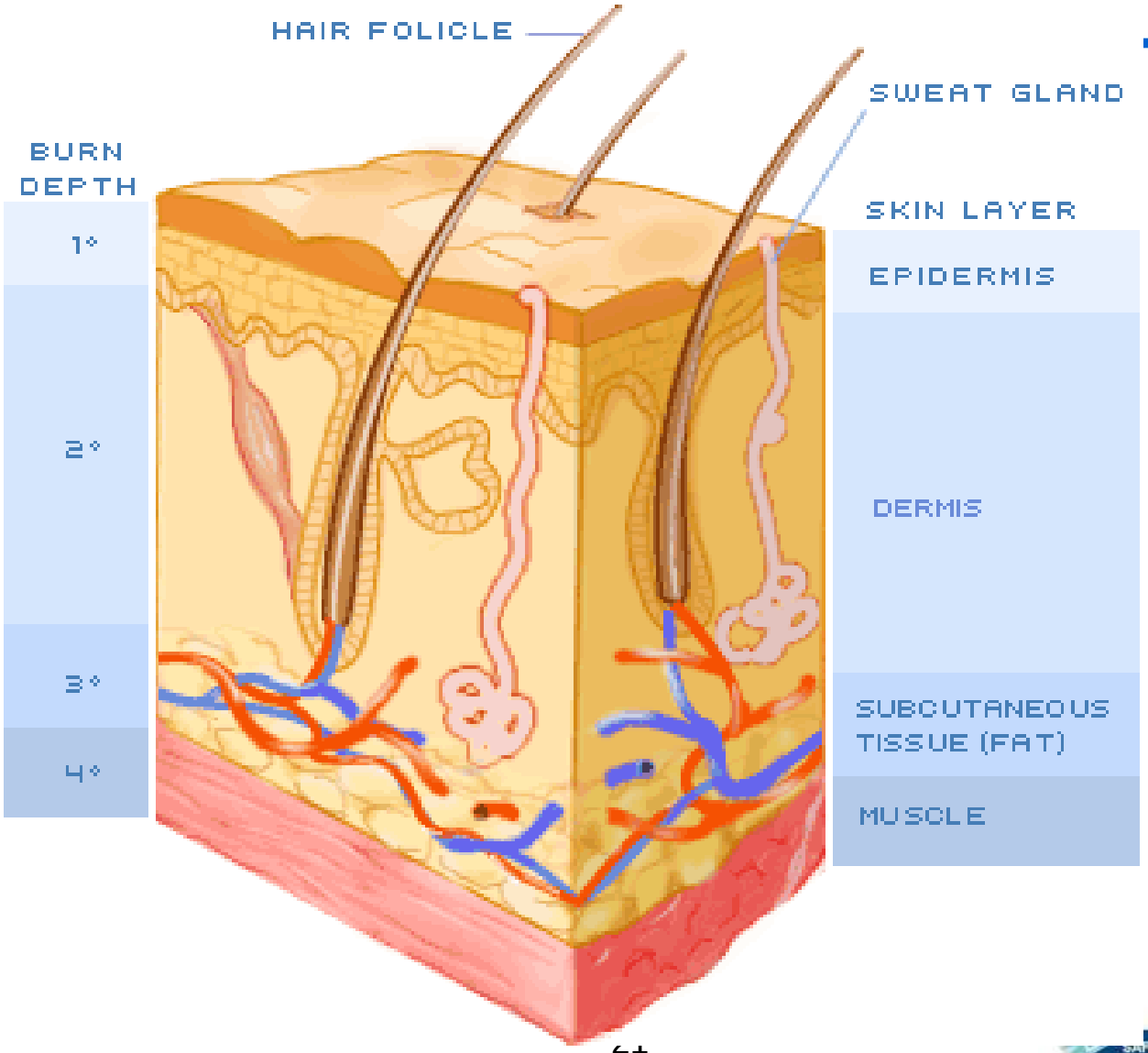
Skin absorption

- **Depends on *site* of contact**
  - temperature (vasodilatation)
  - thickness, blood flow
- **Depends on skin *condition***
  - integrity; pH
- **Time-dependent (*duration*)**
- ***Properties* of the toxin**
  - concentration
  - reactivity
  - solubility (in fat/water)
  - molecular size

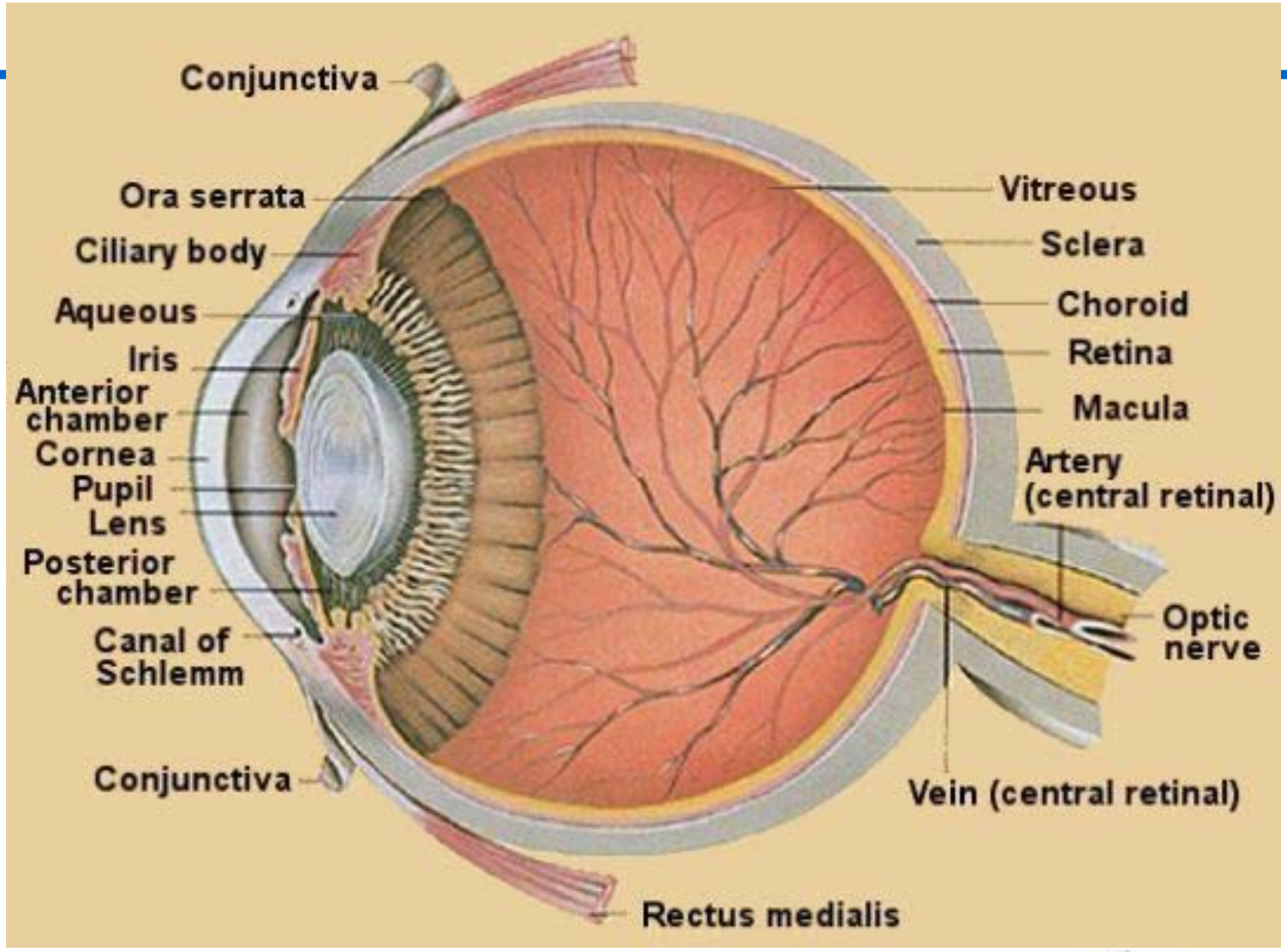
Skin Thickness



Skin


HAIR FOLICLE
SWEAT GLAND
BURN DEPTH
1°
2°
3°
4°
SKIN LAYER
EPIDERMIS
DERMIS
SUBCUTANEOUS TISSUE (FAT)
MUSCLE

The Eyes


Conjunctiva
Ora serrata
Ciliary body
Aqueous
Iris
Anterior chamber
Cornea
Pupil
Lens
Posterior chamber
Canal of Schlemm
Conjunctiva
Rectus medialis
Vitreous
Sclera
Choroid
Retina
Macula
Artery (central retinal)
Optic nerve
Vein (central retinal)

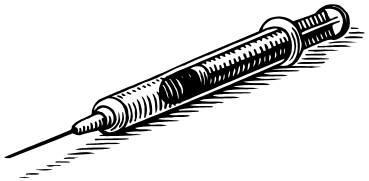
Routes of Exposure

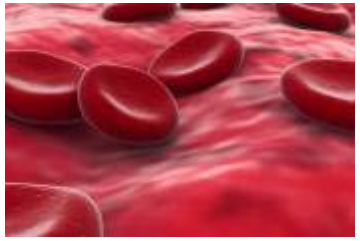
Ingestion (mouth)

- **Rare, but contamination can = intake**
  - mucociliary action of respiratory tract
- **Stomach → GI tract → bloodstream**
- **Absorbed - systemic injury**
- **Liver, kidney; Detoxification process**
  - Inflammation
  - cirrhosis - fibrotic liver disease
  - malignant tumors
- **Factors: physical state, duration**

Routes of Exposure

- **Injection**
  - **Directly into bloodstream**
    - “sharps”, needles, broken glassware
    - skin puncture or injuries
  - **Bypasses protective mechanisms**
  - **Usually rare in workplace**
    - primarily associated with bloodborne pathogens (biomedical facilitates)
    - especially hazardous in health care industry

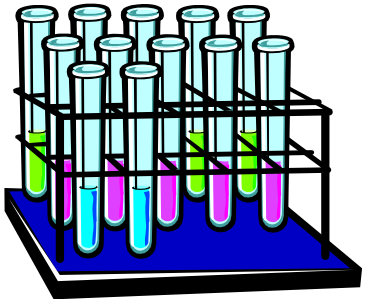




Chemical Toxicology

The World of Chemicals

- **Universe of Chemicals > 5 Million**
- **Industrial Inventories ~ 55,000**
- **Regulated Occupationally ~ 600**



Toxicology

Poisons - *the adverse effects of substances on living systems.*

"All substances are poisons; There is none which is not a poison. The right dose differentiates a poison from a remedy…" ─ Paracelsus (1493-1541)

Chemical Toxicology – *The potential adverse effects and control of chemicals in the workplace.*

Toxicants	• **Substances that produce adverse biological effects of any nature** • **May be chemical or physical in nature** • **Effects may be of various types (*acute, chronic, etc*.)**
Toxins	• **Specific proteins produced by living organisms (*Mushroom toxin or tetanus toxin*)** • **Most exhibit immediate effects**
Poisons	**Toxicants that cause immediate death or illness when experienced in very small amounts**

Basic Concepts

- ***Toxicity*** **– capacity to cause injury**
- ***Hazard*** **– potential harm associated with a specific substance under potential exposure conditions**
- ***Risk*** **– the likelihood or chance that harm will occur under actual conditions**

(Toxicity) X (Exposure) = Risk

Basic Concepts

- All chemicals have the capacity to be toxic
- All chemicals act in the body according to the principles of chemistry, physics and biology
- Natural chemicals are not inherently harmless
- Synthetic chemicals are not inherently hazardous

The Dose Makes the Poison

Chemical	Beneficial Dose	Toxic Dose
Aspirin	300-1000 mg	1000-30,000mg
Vitamin A	500 units/d	50,000 units/d
Oxygen	20% in air	50-100% in air

Lethal Dose

Agent	LD_{50} (mg/kg)
Ethyl Alcohol	7060
Sodium Chloride	3000
Naphthalene	1760
Ferrous Sulfate	1500
Aspirin	1000
Formaldehyde	800
Ammonia	350
Dextromethorphan Hydrobromide	350
Caffeine	192
Phenobarbital	150
Chlorpheniramine Maleate	118
DDT	100
Strychnine Sulfate	2
Nicotine	1
Dioxin	0.0001
Botulinus Toxin	0.00001

There are no harmless substances.

Only harmless ways of *using* substances.

Chemical Toxicology

The study of the effect the chemical has on the body.

Pharmacokinetics

The study of the effect the body has on the chemical.

Toxicity Studies

Determine toxic effect – local effect, target organ, systemic effect, acute, chronic effects.

Determine toxic dose – identify the dose that will produce a given toxic effect.

Factors Influencing Toxicity

- Concentration of toxin
- Duration and frequency of exposure
- Route of exposure
- Environmental factors — temperature, humidity, atmospheric pressure
- Chemical combinations (difficult and expensive to test)

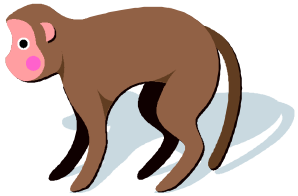
Factors Influencing Toxicity

- Age
- Gender and hormonal status
- Genetic makeup
- State of health—presence of disease or stress
- Nutrition
- Lifestyle

Toxicity Testing Assumptions

- **Effects seen in animals apply to humans**

- **High doses in animals are needed to predict possible hazard to humans**



Routes of Chemical Exposure

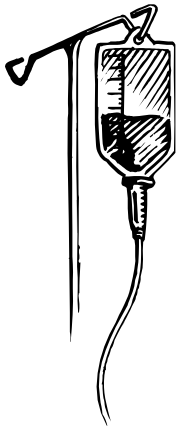
Occupational

- Inhalation
- Dermal/ocular
- Ingestion




Experimental

- Subcutaneous
- Gavage/ip/iv



Duration of Exposure

- **Acute** 1 to 5 days
- **Subchronic** 14 to 90 days
- **Chronic** 6 months to lifetime

Basic Concepts

- **Dose and response can be measured**
- **Response magnitude is related to dose**
- **All toxic interactions follow a dose-response relationship**

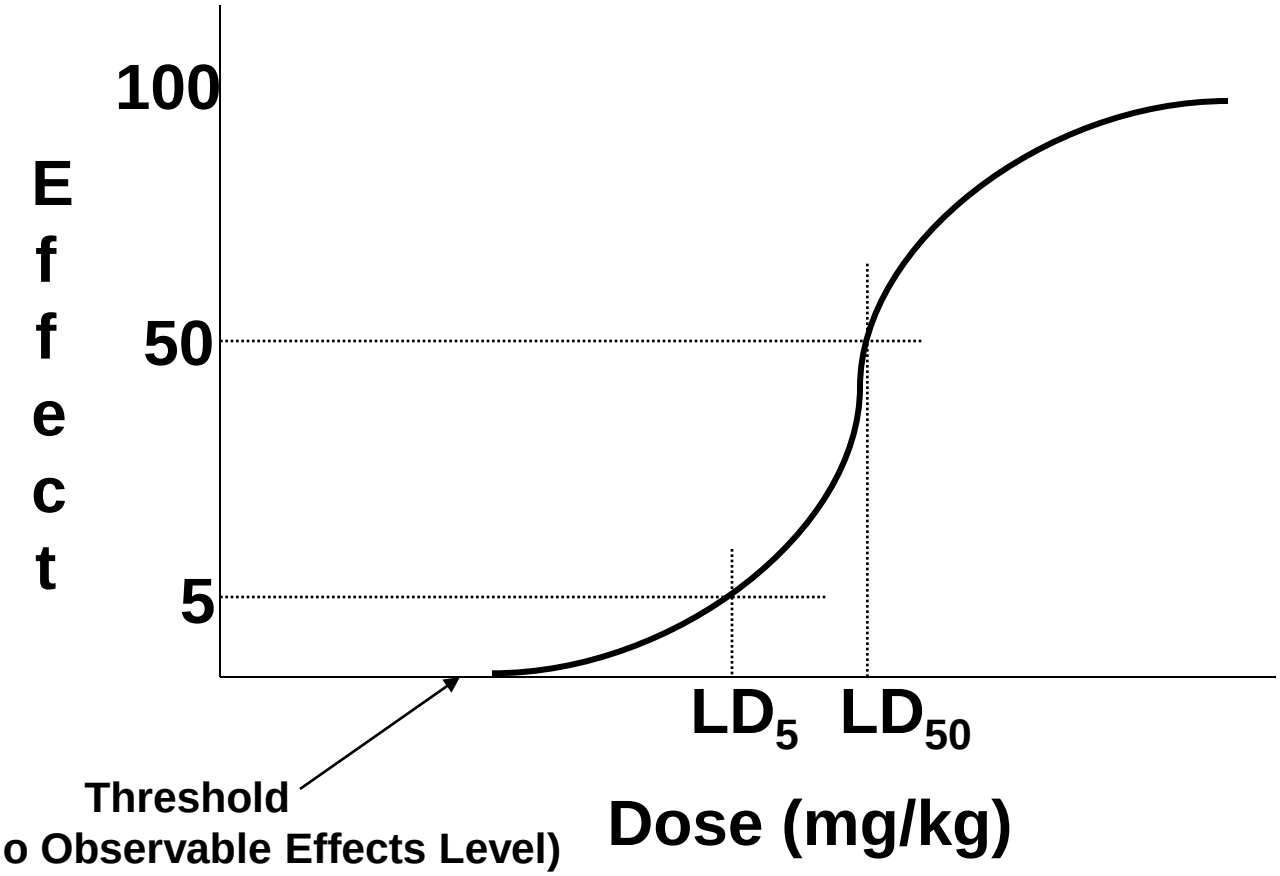
Dose-Response Relationship

- **With increasing dose, there is an increase in the number affected and/or an increase in the intensity of the effect: e.g., mortality; cancer; respiratory depression; liver pathology**

Dose = (Concentration) x (Time)

Dose-Response Relationship

This relationship is unique for each chemical



Dose-Response Relationship

- **Fundamental concept in toxicology**
- **The relationship between the degree of exposure (dose) and the magnitude of the effect (response)**
- **Provides basis for evaluating a chemical's relative toxicity**

Dose and Dosage

- **Dose is *quantity* (mg, mL)**
- **Dosage includes *frequency* (10 mg, 4 times/day)**
- **Exposure dose – quantity administered**
- **Absorbed dose – Actual quantity absorbed**

Dose-Response Terms

- TD_{lo} – Toxic dose low - lowest dose for effect
- LD_{lo} – Lethal dose low - lowest dose that causes death in 10% of the test population
- LD_{50} – Lethal dose 50% - dose that causes death in 50% of the test population
- TC_{lo} – Toxic concentration low - used to express toxic concentration *via* inhalation
- LC_{lo} – Lethal concentration low –*via* inhalation
- LC_{50} – Lethal concentration 50% - concentration that causes death in 50% of the test population *via* inhalation

Concentration Units

Mass per Volume

- mg/m^3 (milligrams per cubic meter)
- μ/m^3 (micrograms per cubic meter)
- ng/m^3 (nanograms per cubic meter)
- **PPM**: Parts of a substance per million parts of air
  - 1 minute in 2 years
- **PPB**: Parts of a substance per billion parts of air
  - 1 second in 32 years
- **PPT**: Parts of a substance per trillion parts of air
  - 1 second in 320 centuries (1 century = 100 years)

Dose Units

Mass per weight or surface area of subject:

- **Quantity per unit mass (mg/kg)**
- **Quantity per unit area of skin surface (mg/m^2)**

Pharmacokinetics

Absorption (uptake) – chemical enters

Distribution (transportation) – spread/storage

Metabolism (biotransformation) – processing

Excretion – elimination

Metabolism

One purpose of metabolism is to make the chemical more water soluble so it can be excreted.

Done by adding oxygen molecules in the form of -OH, =O, -COOH, or by conjugation with glutathione, sulfonate, glycine, etc.

Some chemicals are not directly carcinogenic, but are metabolized to intermediates, e.g, epoxides, which are highly carcinogenic.

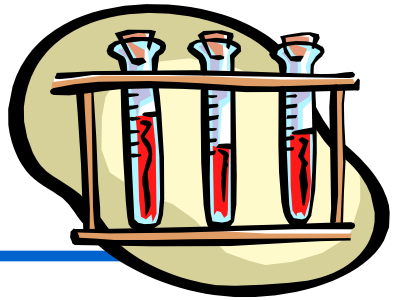
Metabolism, cont'd.

Chemicals not metabolized are stored in the body (e.g.):

- **Lipid soluble materials in fat stores**
- **Metals are bound to proteins (hemosiderin)**
- **Dusts are deposited at surface of lung**

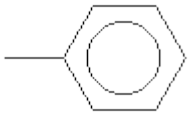
This is why tattoos stay in place!

Metabolites



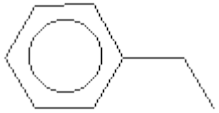
Benzene (C_6H_6)
- carcinogenic
- phenol, S-phenylmercapturic acid in urine

Toluene



- CNS depressant
- hippuric acid in urine

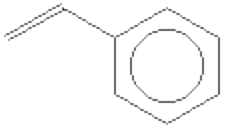
Ethyl benzene)



- irritant, dermatitis
- mandelic acid in urine

Xylene ($C_6H_4(CH_3)_2$)
- CNS, irritant
- methyl hippuric acid in urine

Styrene



- dermatitis
- mandelic acid in urine

Interaction of Chemicals

- **Additive Effect**
  - **Combined effect of 2 chemicals equals sum of each agent alone…(2 + 3 = 5)**
- **Synergistic Effect**
  - **Combined effect of 2 chemicals is greater than sum of each agent alone…(2 + 3 = 20)**

Interaction of Chemicals

- **Potentiation**
  - **One substance does not have toxic effect on certain organ or system, but when added to another chemical, it makes the latter more toxic…(0 + 2 = 10)**

- **Antagonism**
  - **2 chemicals, when given together, interfere with each other's actions or one interferes with the action of the other chemical…(4 + 6 = 8)**

Site of Effects

- **Local**
  - **Effects occurring at site of first contact between biologic system and toxicant**
    - **Ingestion of caustic substances**
    - **Inhalation of irritant materials**
- **Systemic**
  - **Require absorption and distribution of toxicant to a site distant from entry point where effects are produced; most substances produce systemic effects**
    - **CCl_4 effects on the liver**

Target Organs for Chemicals

Systemic toxin - affects entire body or many organs rather than a specific site, e.g., KCN affects virtually every cell and organ in the body by interfering with the cell's ability to utilize oxygen.

Toxicants - may also affect only specific tissues or organs while not producing damage to the body as a whole. These specific sites are known as Target Organs.

Benzene - a specific organ toxicant that it is primarily toxic to the blood-forming tissues.

Lead - has three target organs (central nervous system, kidney, and hematopoietic system).

Comparative Toxicity

Toxicity Rating	Dose for a 70 kg Person (154 lb)
Super Toxic	< 5 mg/kg (a taste, < 7drops)
Extremely Toxic	5-50 mg/kg (7 drops- 1 tsp)
Very Toxic	50-500 mg/kg (1tsp -30g)
Moderately Toxic	0.5-5 g/kg (30g – 500g)
Slightly Toxic	5-15 g/kg (500g-1kg)
Practically Nontoxic	> 15 g/kg (>1kg)

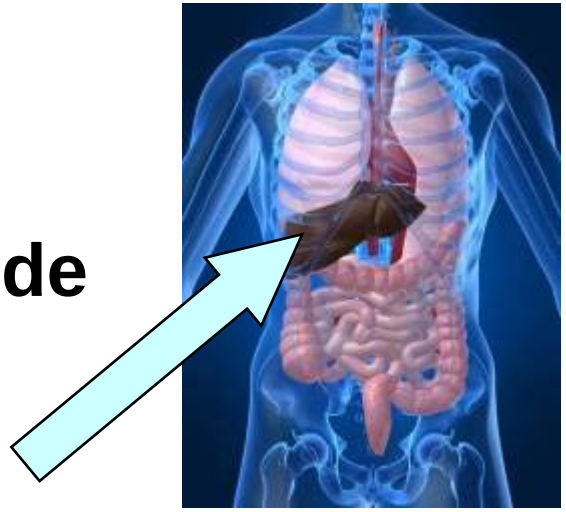
Target Organs

Organs selectively affected by harmful agent:

- Lungs (pneumotoxicity)
- Blood (hematotoxicity)
- Liver (hepatotoxicity)
- Kidneys (nephrotoxicity)
- Nervous system (neurotoxicity)
- Immune system (immunotoxicity)
- Embryos/fetuses (reproductive & developmental toxicity)

Target Organs

Liver Diseases



- **Fatty liver – carbon tetrachloride**
- **Cirrhosis – ethanol**
- **Liver cancer – vinyl chloride and chlorinated solvents/pesticides**

Target Organs

Skin

The protective barrier wrapped around the body (surface area about 2 m^2).

Helps maintain temperature, prevents water soluble materials entry, site of excretion, sensory activities, protective coating.

Target Organs

Sensory Activities

- Heat, touch, and pain receptors
- Irritation/corrosion
- Sensitization/allergy (immune system)
- Phototoxicity (light directly, sun burn)
- Photoallergy (light + chemical)

Target Organs

Skin Diseases

- **Sensitization – chemical allergy**

  TDI – toluene – 2,4-diisocyanate

- **Oil/coal tar acne – chloroacne**

  PCBs-polychlorinatedbiphenyls

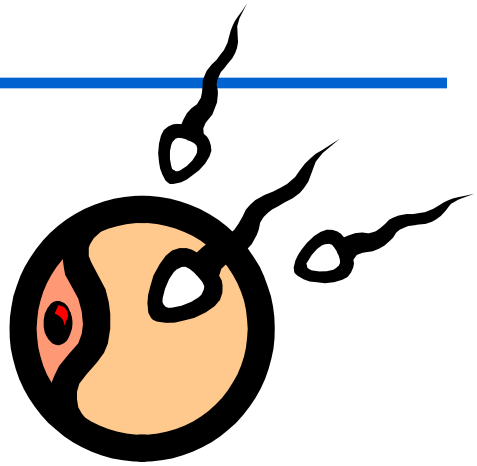
- **Contact dermatitis – fat soluble solvents**
- **Leukoderma (depigmentation) – H_20_2**
- **Allopecia (loss of hair) - thallium**

Target Organs

Reproductive and Developmental Disorders

Concern for spermatogenesis, hormonal status, maternal toxicity, and embryo or fetal toxicity.

Target Organs



Spermatogenesis

- Rarely destroys the testes.
- Usually blocks sperm development.
- EGME (ethylene glycol monoethyl ether)
- Completely reversible after exposure ends.

Target Organs

Developmental Effects:

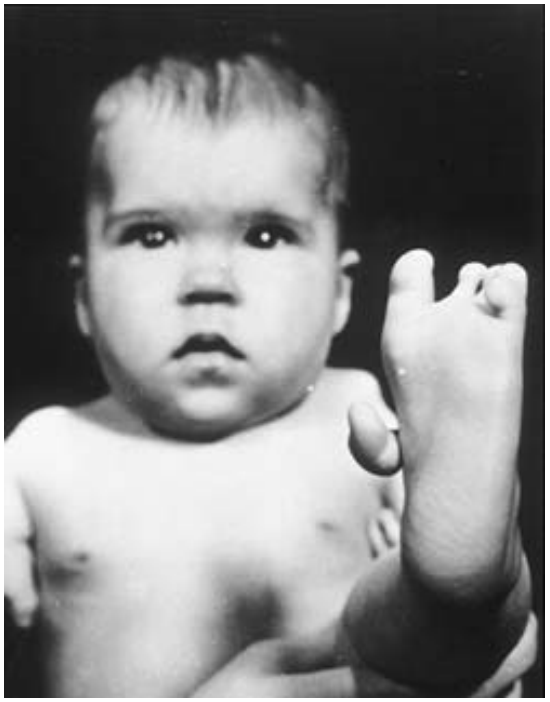
- Lethality – resorptions/stillbirths
- Toxicity – body weight/behavioral effects
- Teratogenicity – malformations (thalidomide)
- Delayed development/structural anomalies/variations

Teratogenicity

A specific type of developmental toxicity

Derived from Greek - monster formation

e.g., thalidomide



http://www.hemonctoday.com/images/hot/200904/aprila_thalidomide.jpg

Target Organs

Maternal Toxicity:

- **Oxygen depletion**
- **Nutrient intake**
- **Lead or other metals**
- **Ovary is more protected than the testes. So, it is not toxicity, but changes in hormonal regulation that is upset.**
- **Endocrine modulation, ovulation, gestation**

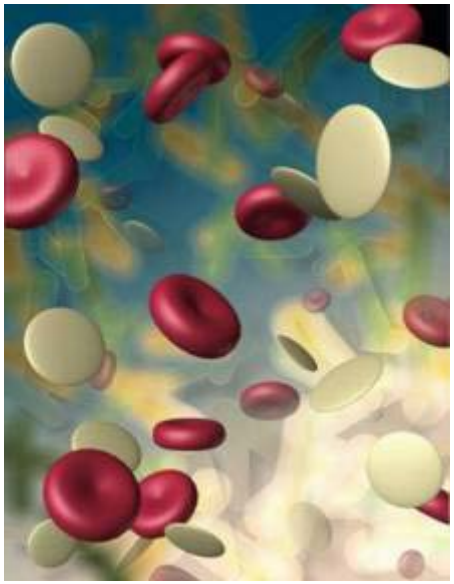
Target Organs

Nervous System:

- **CNS depression – many organic solvents**
- **Cholinesterase inhibition – organophosphorus & carbamate pesticides**
- **Nerve conduction velocity – myelin sheath, peripheral nerve destruction – n–hexane**

Target Organs

Circulatory System:

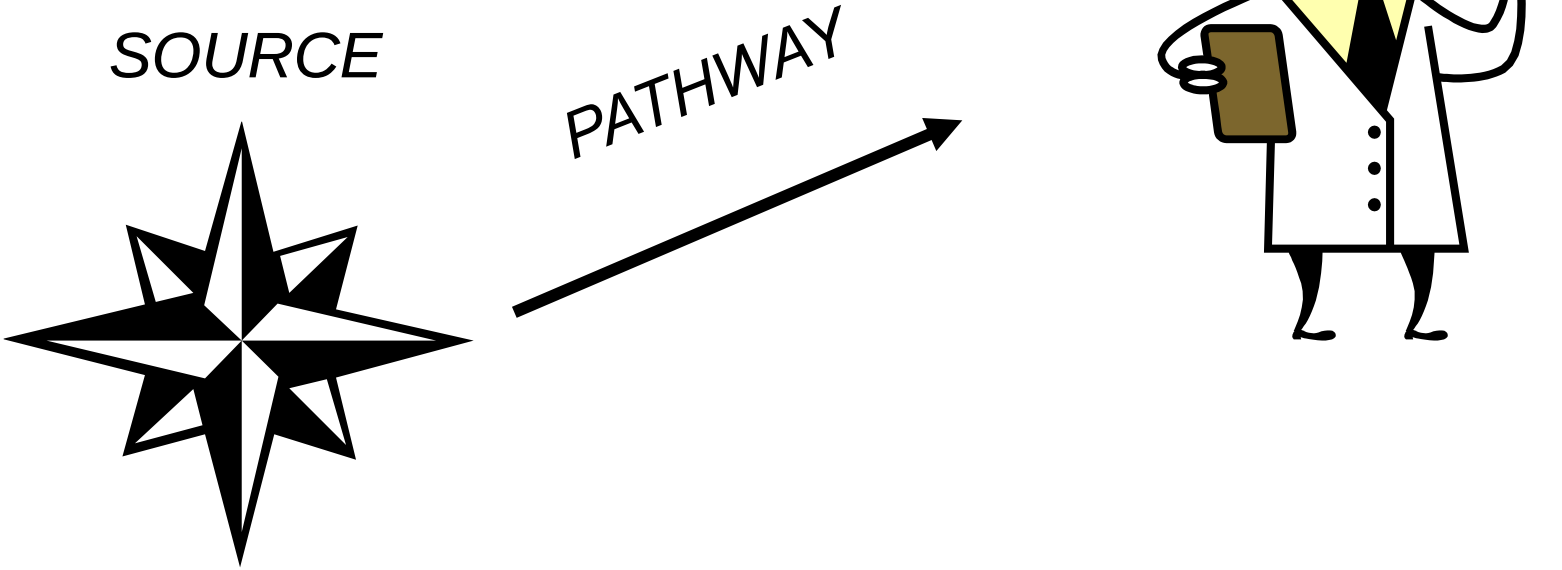


- Hemoglobin – CN and CO
- Red cells – lysis or lead poisoning
- Leukemia – benzene
- Arterial blockage – cholesterol, HDL/LDL

Tea Break

Occupational Exposure Limits Activity

Personal Protective Equipment



Personal Protective Equipment (PPE)

- **Should be a last resort, but may be necessary if:**
  - **engineering controls inadequate or being installed**
  - **administrative controls don't do the job**
  - **emergency response or spill cleanup**
  - **supplement other control techniques if can't achieve required level**
- **Depends upon human behavior**
  - **proper selection, fit and comfort issues**
- **Hazard is still present with PPE …**

Personal Protective Equipment

PPE includes:

eye protection,

gloves,

laboratory coats. etc.,

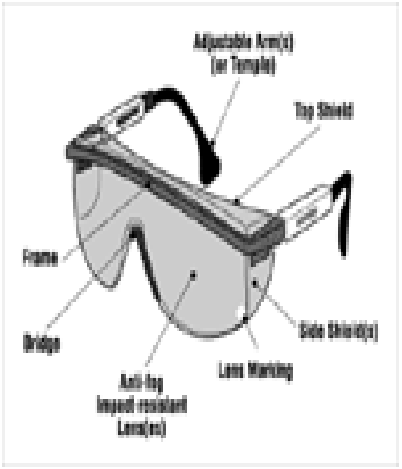
respirators,

appropriate foot protection

Personal Protective Equipment

Eye protection -

specific to the hazard



Personal Protective Equipment

Gloves -

must be chemical specific

Personal Protective Equipment

- Laboratory coats
- Aprons
- Other protective clothing

Personal Protective Equipment
Respiratory Protection

Requires:

training &

fit-testing

Can provide a

false sense of security.

Personal Protective Equipment
Foot Protection

Steel toe-safety shoes are not necessary for laboratory work *unless* there is a serious risk from transporting or handling heavy objects.

However,

open toe shoes

should <u>NOT</u> be worn in labs.

Training and Qualification

Employees should be trained to know:

- **When PPE is necessary?**
- **What PPE is necessary?**
- **How to properly don, doff, adjust and wear PPE.**
- **Limitations of PPE.**
- **Proper care, storage, maintenance, useful life, and disposal of PPE.**

www.free-training.com/osha/ppe/ppemenu.htm

Training and Qualification

Retraining is necessary when there is:

- **Change in the process.**
- **Change in type of PPE used.**
- **Inadequate employee knowledge or use of PPE.**
  - retrain to reinforce understanding or skill

Personal Protective Clothing (PPE)

- *Evaluate task, select appropriate type and train to use it properly*
  - *lab coats, gowns, aprons*
  - *safety glasses (with side shields), goggles, face shields*
  - *gloves*
- *Remove PPE before leaving the lab*

Protective Equipment Works

“It's a hot day, why wear a lab coat?”

An experiment reacted unexpectedly and a flammable solvent from a hood splashed out and landed on the bottom of the lab coat

Eye and Face Protection

- **Thousands are blinded each year from work-related eye injuries.**
- **Nearly *three out of five* workers are injured while failing to wear eye and face protection.**

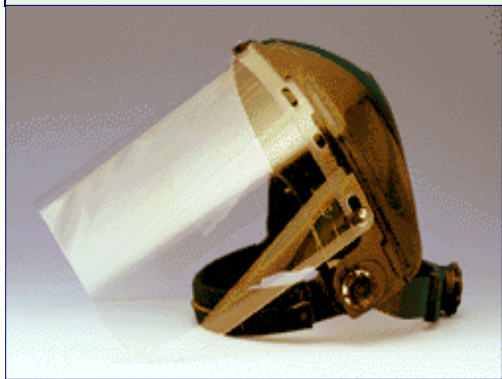
Eye & Face Protection

- Safety glasses
- Goggles
- Face shield

Eye and Face Protection

Eye protection shields eyes by:

- **Primary protection:**
  - **Safety glasses with side shields protect from flying objects.**
  - **Goggles prevent objects from entering under or around the eyewear.**
- **Secondary protection:**
  - **Face shields**
    - **Combine with safety glasses or goggles**
    - **Do not protect from impact hazards**



Biohazards

Use caution anytime you are working with blood or other bodily fluids.

Contaminated blood or bodily fluids may result in transmission through the eyes.

Eye and Face Protection

Optical Hazards

- *Welding helmets are secondary protection to shield from UV, heat, and impact.*
- *Exposure to laser beams requires suitable laser safety goggles with protection for the specific wavelength.*

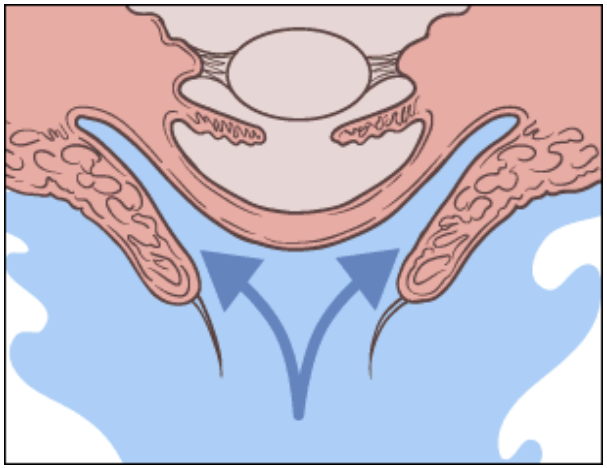
Additional Considerations

- Provide adequate protection against the specific hazards.
- Safe design and construction for the work to be performed.
- Comfortable.
- Don’t interfere with the wearer’s movements.
- Durable!
- Capable of being disinfected.
- Easily cleaned.
- Distinctly marked to indicate they are approved eye protection.
- Worker satisfaction.
    - – Include workers in the selection process.

Eyewash and Showers

- US regulations
  - 29 CFR 1910.151(c)
  - ANSI Z358.1-2004
- Types
  - eyewash
  - shower
  - drench hose
- Concerns
  - drainage
  - freezing
  - contaminated water

Eyewash Standards



- Eye wash stations
  - Minimum 0.4 to 3.5 gal/min (1.4 – 13.2 l/min.)
  - Flush for 15 minutes
- Provide flow for both eyes
  - Hold eyes open
  - Tepid, pH match eye (preferred)
- Easily accessible locations
  - 33 to 45 in. (84-114 cm) from floor
  - 6 in. (15cm) from wall
- Test weekly
  - Portable: clean/refill (6 mo – 2 yrs)
- Various types

ANSI Z358.1
NC DOL Guide:
www.nclabor.com/osha/etta/indguide/ig28.pdf

Hand Protection

- **Glove considerations**
  - **Type glove**
    - **Dexterity required**
    - **Chemical & physical**
      - **material**
      - **strength**
    - **Exposure time**
      - **breakthrough time**
    - **Size, comfort, reusable/disposable**
  - **Manufacturer selection charts**

Glove Selection

- **Considerations:**
  - **Chemicals (splashes vs immersion)**
  - **Thermal (extreme heat/cold)**
  - **Abrasion; cuts; snags; splinters; punctures**
  - **Grip: oily, wet, dry**
  - **Comfort, fit, size**
  - **Ergonomics**

Chemical Protective Gloves/ Clothing

- **Permeation (“silent killer”)**
  - **Substances pass through intact material on a molecular level.**
- **Penetration**
  - **Substances pass through seams, zippers, stitches, pinholes, or damaged material.**
- **Degradation**
  - **Substance damages material making it less resist or resulting in physical breakdown.**
- **Contamination**
  - **Substances transferred inside material (improper doffing or decontamination).**

Permeation Rate (PR)	Permeation Breakthrough (PB)	Permeation Degradation rate (DR)
E- Excellent; permeation rate of less than 0.9 mg/cm^2/min	>Greater than (time - minutes)	E - Excellent; fluid has very little degrading effect.
VG - Very Good; permeation rate of less than 9 mg/cm^2/min	< Less than (time - minutes)	G - Good; fluid has minor degrading effect.
G - Good; permeation rate of less than 90 mg/cm^2/min		F - Fair; fluid has moderate degrading effect.
F - Fair; permeation rate of less than 900 mg/cm^2/min		P - Poor; fluid has pronounced degrading effect.
P - Poor; permeation rate of less than 9000 mg/cm^2/min		NR - Fluid is not recommended with this material.
NR - Not recommended; permeation rate greater than 9000 mg/cm^2/min		† Not tested, but breakthrough time > 480 min DR expected to be Good to Excellent
		†† Not tested, but expected to be Good to Excellent based on similar tested materials

Gloves

- *It's important to have the right glove for the job and know how long it will last.*

- *Glove Chart Examples:*
  - *Consider several glove manufactures data before final selection.*
  - *www.bestglove.com/site/chemrest/*

The first square in each column for each glove type is color coded. This is an easy-to-read indication of how we rate this type of glove in relation to its applicability for each chemical listed. The color represents an overall rating for both degradation and permeation. The letter in each square is for Degradation alone…

- GREEN: The glove is very well suited for application with that chemical.
- YELLOW: The glove is suitable for that application under careful control of its use.
- RED: Avoid use of the glove with this chemical.







CHEMICAL	LAMINATE FILM BARRIER			NITRILE SOL-VEX			UNSUPPORTED NEOPRENE 29-865			SUPPORTED POLYVINYL ALCOHOL PVA			POLYVINYL CHLORIDE (Vinyl) SNORKEL			NATURAL RUBBER CANNERS AND HANDLERS*			NEOPRENE/ NATURAL RUBBER BLEND CHEMI-PRO*		
	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate	Degradation Rating	Permeation: Breakthrough	Permeation: Rate
1. Acetaldehyde	■	380	E	P	—	—	E	10	F	NR	—	—	NR	—	—	E	7	F	E	10	F
2. Acetic Acid	■	150	—	G	270	—	E	60	—	NR	—	—	F	180	—	E	110	—	E	260	—
3. Acetone	▲	>480	E	NR	—	—	E	10	F	P	—	—	NR	—	—	E	10	F	G	10	G
4. Acetonitrile	▲	>480	E	F	30	F	E	20	G	■	150	G	NR	—	—	E	4	VG	E	10	VG
5. Acrylic Acid	—	—	—	G	120	—	E	390	—	NR	—	—	NR	—	—	E	80	—	E	65	—
6. Acrylonitrile	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
7. Allyl Alcohol	▲	>480	E	F	140	F	E	140	VG	P	—	—	P	60	G	E	>10	VG	E	20	VG
8. Ammonia Gas	■	19	E	▲	>480	—	▲	>480	—	—	—	—	■	6	VG	—	—	—	■	27	VG
9. Ammonium Fluoride, 40%	—	—	—	E	>360	—	E	>480	—	NR	—	—	E	>360	—	E	>360	—	E	>360	—
10. Ammonium Hydroxide	E	30	—	E	>360	—	E	250	—	NR	—	—	E	240	—	E	90	—	E	240	—
11. Amyl Acetate	▲	>480	E	E	60	G	NR	—	—	G	>360	E	P	—	—	NR	—	—	P	—	—
12. Amyl Alcohol	—	—	—	E	30	E	E	290	VG	G	180	G	G	12	E	E	25	VG	E	45	VG
13. Aniline	▲	>480	E	NR	—	—	E	100	P	F	>360	E	F	180	VG	E	25	VG	E	50	G
14. Aqua Regia	—	—	—	F	>360	—	G	>480	—	NR	—	—	G	120	—	NR	—	—	G	180	—
15. Benzaldehyde	▲	>480	E	NR	—	—	NR	—	—	G	>360	E	NR	—	—	G	10	VG	G	25	F
16. Benzene, Benzol	▲	>480	E	P	—	—	NR	—	—	E	>360	E	NR	—	—	NR	—	—	NR	—	—
17. Benzotrichloride	—	—	—	E	>480	E	NR	—	—	—	—	—	—	—	—	NR	—	—	NR	—	—
18. Benzotrifluoride	—	—	—	E	170	G	F	—	—	E	—	—	G	<10	F	P	50	G	—	—	—
19. Bromine Water	—	—	—	E	>480	E	E	>480	E	—	—	—	—	—	—	—	—	—	—	—	—
20. 1-Bromopropane	▲	>480	E	■	23	F	■	<10	P	▲	>480	E	■	<10	F	■	<10	P	■	<10	P

Types of Gloves

Polyethylene/Ethylene-vinyl Alcohol {“Silver Shield®”}

- *Resists permeation and breakthrough with chemicals.*
- *Uses: aromatics, esters, ketones, and chlorines.*

Butyl

- *Highest permeation resistance to gas or water vapors.*
- *Uses: ketones (MEK, acetone) and esters (amyl acetate, ethyl acetate).*

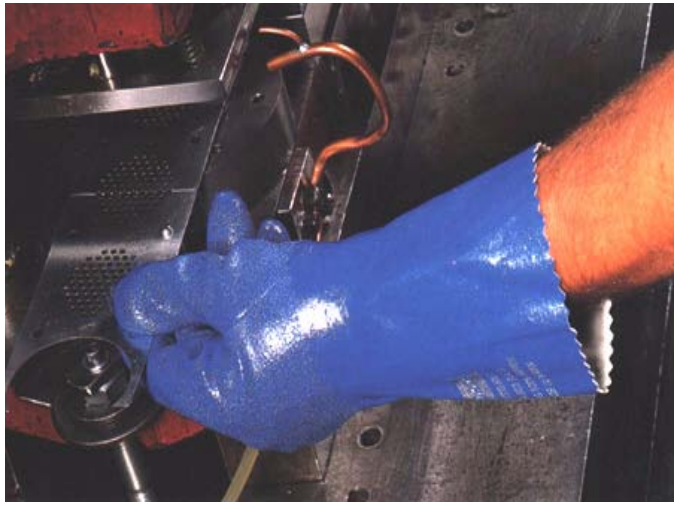
Types of Gloves

Viton®

- *Highly resistant to permeation by chlorinated and aromatic solvents*
- *Can be used with water/water based solvents*

Nitrile *(acrylonitrile-butadiene rubber)*

- *Good replacement for latex*
- *Protects against acids, bases, oils, aliphatic hydrocarbon solvents and esters, grease, fats*
- *Resists cuts, snags, punctures and abrasions*



Types of Gloves

Neoprene

- *Protects against acids, caustics, DMSO.*
- *Resists amines, alcohols, glycols.*
- *Limited use for aldehydes and ketones.*

Poly vinyl chloride (PVC)

- *Protects against acids, caustics.*
- *Resists alcohols, glycols.*
- *Not useful for aromatics, aldehydes and ketones.*

Latex Allergies

- **Symptoms may occur within minutes of exposure or may take several hours depending on the individual.**
  - **Skin Redness**
  - **Hives**
  - **Itching**
  - **Respiratory Symptoms**
    - **Runny Nose**
    - **Itchy Eyes**
    - **Scratchy Throat**
    - **Asthma**

Latex Allergy

Proper Steps for Removing Gloves

1

2

3

4

5

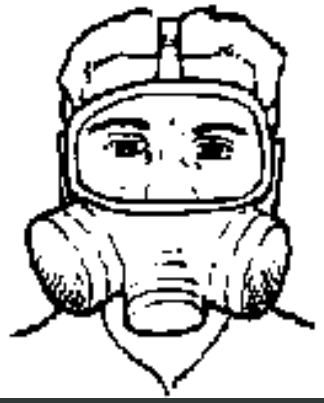
6

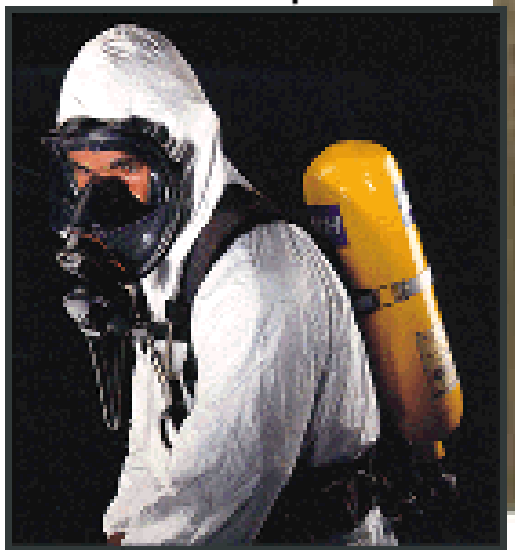
Respiratory Protection Program

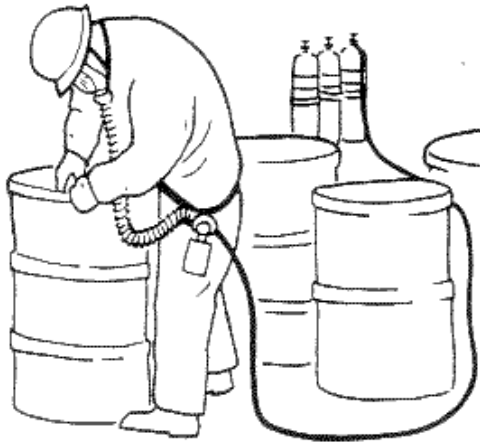
- *Written program*
- *Administered by Safety Office*
- *Medical clearance*
  - *Respiratory Protection Questionnaire*
  - *No beards*
- *Fit testing*
- *Respirator selection*
  - *Air monitoring*
- *Training (annual refresher)*

Types of Respirators

- **Air purifying (APR)**
  - **Half Face**
  - **Full Face**
  - **PAPR**
- **Air supply**
  - **Air line**
  - **SCBA**





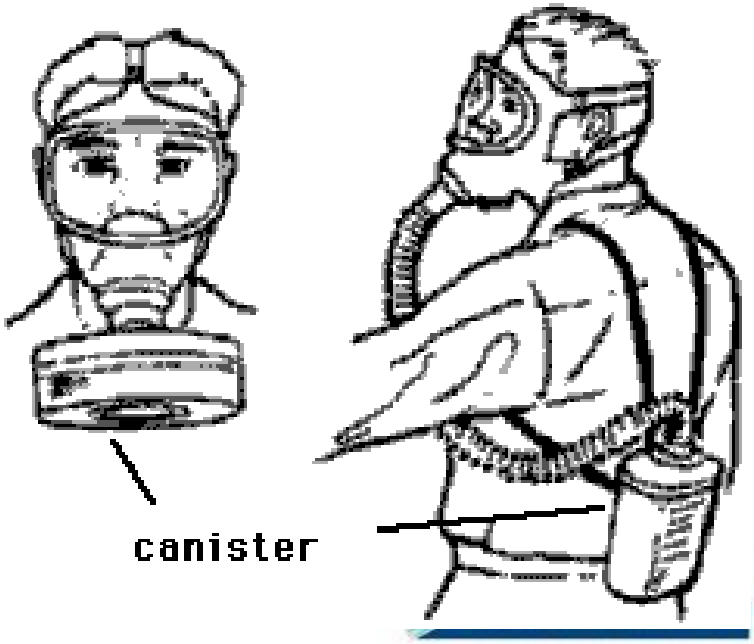


Air Purifying Respirators

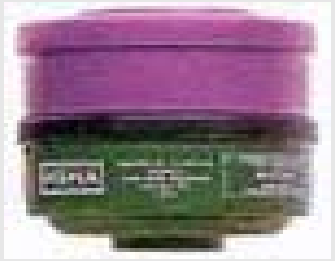
- ***Must have at least 19.5% oxygen.***
  - Never use in O_2 deficient atmospheres
- ***Only filters the air.***
  - **Particulate filters**
    - **Removes aerosols**
  - **Chemical cartridges or canisters**
    - **Remove gases and vapors**
- ***Concentrations must not exceed limitations of filter/cartridge.***
- **PAPR (Powered Air Purifying Respirator)**
  - **Uses a blower to force air through an air purifying element**

APR Chemical Cartridge Selection

- Specific gases or vapors
- NIOSH or MSHA approval
- Adequate warning properties
- End of service life
- Mechanisms
  - adsorption
  - absorption
  - chemical reaction
- Breakthrough times
- *Proper maintenance and storage*



Cartridge Selection

Cartridge	Description
	Organic Vapor
	Organic Vapor and acid gases
	Ammonia, methylamine and P100 any particulates filter 99.97% minimum filter efficiency

End of Service Life Indicators (ESLI)

There are very few NIOSH-approved ESLI's:

- ammonia
- carbon monoxide
- ethylene oxide
- hydrogen chloride
- hydrogen fluoride
- hydrogen sulfide
- mercury
- sulfur dioxide
- toluene-2,4-diisocyanate
- vinyl chloride

Fit Testing

- **Qualitative**
  - **Irritant smoke (stannic chloride)**
  - **Isoamyl acetate (banana oil)**
  - **Saccharin**
  - **Bitrex (bitter taste)**
  - *Employees should perform a user seal check each time they put on a tight-fitting respirator*
- **Quantitative**
  - **Portacount**

Dust Masks *vs.* Hospital Masks

High Efficiency Particulate Air Filter (HEPA) Respirator

Lunch