INDUSTRIAL HYGIENE
in Construction

Welcome

- **Troy Corbin, CIH/CSP**
- Certified Industrial Hygienist / Marine Chemist
- AMEC Earth & Environmental

INDUSTRIAL HYGIENE
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- **What is Industrial Hygiene?**
- **What does an IH do ?**
- **Learn to use Worker Exposure Indices (TLV – PEL – REL – IDLH)**
- **Review / Understand OSHA Z Table & Expanded Health Standards**

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- **Routes of Exposure**
- **Types of Toxins**
- **Review specific Construction Health Hazards & Controls**
- **Respirators & PPE**

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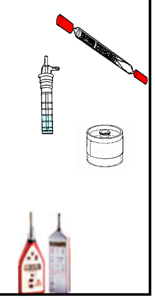
Specific Construction Health Hazards

- **Dusts**
  Silica, Asbestos, Other
- **Solvents, Cleaners, Paints**
- **Welding Hazards**
- **Heavy metals**
  Lead, Cadmium, Chromium
- **Noise**



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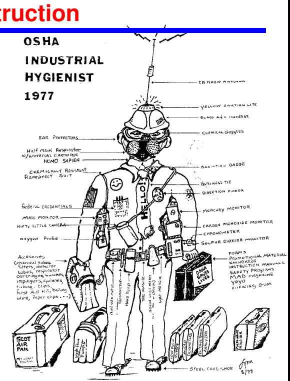
What is an industrial hygienist?

I didn't know what one was........

&

now I is one!!



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OSHA: Industrial hygiene is the science of **anticipating, recognizing, evaluating, and controlling** workplace conditions that may cause workers' injury or illness.

Industrial hygienists use environmental monitoring and analytical methods to detect the extent of worker exposure and employ **engineering, work practice controls,** and other methods to control potential health hazards.

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NIOSH: Industrial hygiene

A science devoted to the protection and improvement of the health and well-being of workers exposed to chemical and physical agents in their work environment.

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ABIH
american board of industrial hygiene

"Industrial Hygiene is that science and art devoted to the recognition, evaluation, and control of those environmental factors or stresses, arising in or from the work place, which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among the citizens of the community."

INDUSTRIAL HYGIENE
History

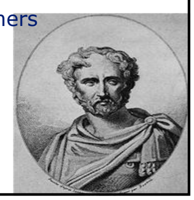
400 BC Hippocrates

Noted health effects from Lead exposure in mining

INDUSTRIAL HYGIENE
History

1st Century AD: Pliny the Elder, Roman scholar

- Noted health hazards from working with zinc and sulfur in the mines
- First recorded use of a respirator
- Goat's bladder respirator for miners



INDUSTRIAL HYGIENE
History

2nd Century AD, Greek physician, Galen

- Described the pathology of lead poisoning
- Recognized the hazardous exposures of copper miners to acid mists.

INDUSTRIAL HYGIENE
History

1473 Ulrich Ellenbog

- Publication on occupational illness in gold miners
- Wrote about the toxicity of
  - carbon monoxide,
  - mercury,
  - lead, and
  - nitric acid.

INDUSTRIAL HYGIENE
History

1556: German scholar, Georgius Agricola

De Re Metallica

- Diseases of miners
- Mine ventilation
- Worker protection
- Discussed mining accidents
- Described diseases associated with mining occupations such as silicosis.

INDUSTRIAL HYGIENE
History

1567 PARACELSUS

- Laid the foundation for the study of modern toxicology
- Established the **DOSE-RESPONSE RELATIONSHIP**

INDUSTRIAL HYGIENE
History

"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."

INDUSTRIAL HYGIENE
History

1700 Bernardo Ramazzini

"Father of Industrial Hygiene"

INDUSTRIAL HYGIENE
History

1700 Bernardo Ramazzini

- PAINTERS, ".SEIZED FIRST WITH PALSY..SPASMS PAIN IN THE STOMACH .. (HE) WAS IN THE HABIT OF SQUEEZING THE COLOR FROM HIS BRUSH WITH HIS FINGERS .. AND .. SUCK(ING) IT."
- POTTERS, "... PALSIED HANDS, 'CADAVEROUS' FACE WITH THE COLOR OF LEAD ... CARRIES NUMBNESS INTO THEIR BLOOD ... AND CRUCIFIES THEIR HANDS.."

INDUSTRIAL HYGIENE
History

1775 PERCIVAL POTT

- British Parliament passed the *Chimney-Sweepers Act of 1788.*

INDUSTRIAL HYGIENE
History

1775 PERCIVAL POTT

- Linked Scrotal Cancer to Chimney Sweeps exposed to Soot
- This work in 1775 is **one of the earliest accounts of a cause and effect linkage being established for an occupational carcinogen,** and as such, represents the beginning of the study of occupational cancer.

CTPV – same materials in coal tar products used today

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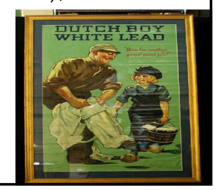
History

LEAD

In early times, Lead was a key component in face powders, rouges, and mascaras; the pigment in many paints ("crazy as a painter" was an ancient catch phrase rooted in the demented behavior of lead-poisoned painters);



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History

- FEDERAL EMPLOYEE HEALTH SERVICES, 1933
- 1946 ACGIH develops first list of Workplace Exposure Standards
  - MAC – Maximum Allowable Concentrations
  - Now TLVs

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Science dedicated to the

- **RECOGNITION**
- **EVALUATION** and
- **CONTROL** of health hazards in the work place.

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Worker Exposure Indices

- What are they?
- Airborne levels of substances which are believed to be safe for worker exposures over a working lift time.
- Typically a 5-day, 8-hour/day work week.

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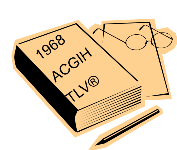
Worker Exposure Indices

- **OSHA - PELs**
  Legal - Often Outdated
  Based on 1968 TLVs
- **ACGIH - TLVs**
  Recommended
- Annual Updates
- **NIOSH - RELs**
  Similar to PELs & TLVs
- **IDLH**
  Immediately Dangerous to Life or Health



Worker Exposure Levels
PELs - TLVs - RELs

ACGIH-TLVs and BEIs®.

- 1946 1st TLVs (MACs)

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ACGIH-TLVs and BEIs®.

Threshold Limit Values **(TLVs®) and Biological Exposure Indices (BEIs®) are developed as guidelines** to assist in the control of health hazards.

These **recommendations** or **guidelines** are intended for use in the practice of industrial hygiene, to be interpreted and applied only by a person trained in this discipline.

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Worker Exposure Indices

The TLVs® and BEIs® represent conditions under which ACGIH® believes that nearly all workers may be repeatedly exposed without adverse health effects.

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Worker Exposure Indices

OSHA PELs.

OSHA sets permissible exposure limits (PELs) to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. They may also contain a skin designation. PELs are enforceable.

OSHA PELs are based on an 8-hour time weighted average (TWA) exposure. OSHA's PELs are based on 1968 TLVs.

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Worker Exposure Indices

NIOSH REL.

NIOSH develops recommended exposure limits (RELs) for hazardous substances. To formulate these recommendations, NIOSH evaluates all known available medical, biological and engineering, chemical trade, and other information relevant to the hazard.

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Worker Exposure Indices

TLVs or PELs

- **Exposure Concentrations**
  - ppm or mg/m³?

- Gases – Vapors: **ppm**
- Dust, Mists, Fumes: **mg/m³**
- Fibers (asbestos): **f/cc**

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Worker Exposure Indices
- TLVs , RELs, or PELs

- TWA - STEL – Ceiling
  - TWA = Full Shift
  - STEL = 15 minutes
  - Ceiling = Real Time

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1910.1000(a)(1) ***Substances with limits preceded by "C" - Ceiling Values.***

An employee's exposure to any substance in Table Z-1, the exposure limit of which is preceded by a "C", shall at no time exceed the exposure limit given for that substance.

If instantaneous monitoring is not feasible, then the ceiling shall be assessed as a 15-minute time weighted average exposure which shall not be exceeded at any time during the working day.

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1910.1000(a)(2) ***Other substances – 8-hour Time Weighted Averages.***

An employee's exposure to any substance in Table Z-1, the exposure limit of which is not preceded by a "C", shall not exceed the 8-hour Time Weighted Average given for that substance any 8-hour work shift of a 40-hour work week

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1910.1000(e) To achieve compliance…, administrative or engineering controls must first be determined and implemented whenever feasible.

When such controls are not feasible to achieve full compliance, protective equipment or any other protective measures shall be used to keep the exposure of employees to air contaminants within the limits prescribed in this section.

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1910.1000(e) To achieve compliance…,

Any equipment and/or technical measures used for this purpose must be approved for each particular use by a competent industrial hygienist or other technically qualified person.

Whenever respirators are used, their use shall comply with 1910.134.

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1910.1000(d) *Computation formulae*. 1910.1000(d) To illustrate the formula.... assume that Substance A has an 8-hour time weighted average limit of **100 ppm** noted in Table Z-1.

Assume that an employee is subject to the following exposure:

Two hours exposure at 150 ppm
Two hours exposure at 75 ppm
Four hours exposure at 50 ppm

Substituting this information in the formula, we have

$$(2\times150 + 2\times75 + 4\times50)\div8 = 81.25 \text{ ppm}$$

Since 81.25 ppm is less than 100 ppm, the 8-hour time weighted average limit, the exposure is acceptable.

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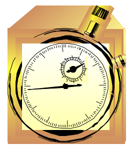
Worker Exposure Indices



- **TWA** - 8 hour exposure
  - Acetone = 1000 ppm TWA
  - Benzene = 1 ppm TWA
- **STEL** - 15 minute exposure
  - Benzene = 5 ppm STEL
- **Ceiling** - Never Exceeded
  - HCL = 5 ppm Ceiling

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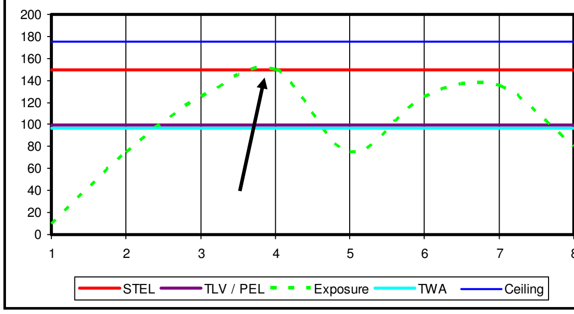
Worker Exposure Indices



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Worker Exposure Indices

Chemical	OSHA* PEL	ACGIH TLV
CO	50 ppm	25 ppm
Ammonia	50 ppm / 25 ppm OR	25 ppm
Acetone	1000 ppm	500 ppm
Manganese	Ceiling 5 mg/m³	0.2 mg/m³
Silica*	OR OSHA 0.1 mg/m³	0.025 mg/m³
Toluene*	100 / 300 ppm C	20 ppm
Benzene	1 / 5 ppm STEL	0.5/2.5 ppm
Port. Cement	15 mg/m³	10 mg/m³ *1
TDI	0.02 ppm C - 0.005 / 0.2 C	(0.001 / 0.003 STEL)
H_2S	20 C / 50 Peak	10 ppm *1

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How much is 1 ppm?

- 1¢ in $10,000.00
- 1 inch in 15.8 miles
- 1 ounce of vermouth in 7812.5 gallons of gin = World's Driest Martini

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Subpart Z Toxic & Hazardous Substances

1910.1000 Air Contaminants

- **Expanded Standards**
  - Lead
  - Arsenic
  - Formaldehyde
  - Benzene
  - Methylene Chloride
  - Asbestos
  - Chromium

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OSHA Expanded Standards

PEL
Action Limit

Mandatory Monitoring
Based on levels detected

PPE
•Respirator Selection
•Protective Clothing

Hygiene Facilities & Practices
Change Rooms/Showers

Medical Surveillance
•Physical Exams
•Mandatory Removal

Engineering Controls

Training

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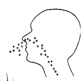
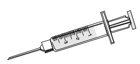
Routes of Exposure



- **Inhalation**

- **Skin Contact**
  Skin Absorption

- **Ingestion**



- **Injection**

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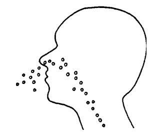
Inhalation



- **Primary Route**
- Dusts - Fumes - Gases - Vapors – Fibers
  - Silica – Asbestos
  - Solvents – Adhesives
  - Heavy metals – Welding Fume

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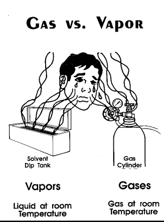
Inhalation - *Gas vs. Vapor*

Gases are gases at room temperatures

- Welding and internal combustion engines
  NOx, CO, Chlorine, Ammonia

Vapors are gases formed when liquid evaporates

- Solvents – Paints - Cleaners
- Fuels (gasoline)



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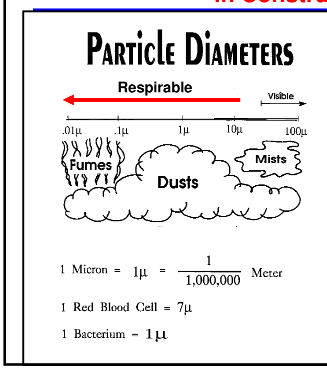

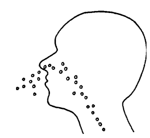

DUSTS

MISTS

FUMES

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DUSTS

MISTS

FUMES

Inhalation – Total Dust

In the ***nasopharyngeal* region**, larger dust particles larger than **10 microns** are filtered out.

Some gases can also be filtered out in this region. The efficiency with which gases are removed here depends on how easily the gas dissolves in water

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DUSTS

MISTS

FUMES

Inhalation

The ***tracheobronchial* region** (windpipe and branches) has additional defense mechanisms. The main one is the ***mucociliary*** apparatus. - **Mucociliary elevator**

Particulates are collected in the mucous layer which covers the trachea and moved up and out of the region by the upward beating of the cilia, tiny hair-like projections which propel the particles toward the mouth.

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DUSTS
MISTS
FUMES

Inhalation – Respirable Dust

In the ***bronchiolar*** region, the defenses are more limited and less effective. There is little mucous covering and no cilia.

Particulates which penetrate this far, generally those of 1-3 microns, stay in this region for weeks, as opposed to the tracheobronchial region where residence time is measured in hours or days.

Welding Fume – Asbestos Fibers
< 5 microns

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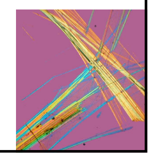
DUSTS
MISTS
FUMES

Inhalation – Fibers

Solid particles with a slender, elongated shape

Found in construction, mining, friction products and insulation materials.

Examples include **asbestos, fiberglass, ceramic fibers,** and **fibrous talc**.



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DUSTS
MISTS
FUMES

Inhalation – Fumes

Volatilized solids that condense in air
Very small, solid, respirable particles created when hot vapor reacts with the air to form an oxide – **Welding Fume**

< 1.0 µm in diameter

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Inhalation – Most important route

Almost 100% of vapors and fumes inhaled go directly into the blood stream

- **Lead**
- **Cadmium**
- **Chrome**
- **Solvents**

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Inhalation

An adult breathes about 22,000 liters of air per day

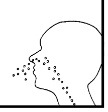
Heavy work loads increase this number

Resting ~ 6 L / minute

Heavy Work up to 75 L / minute

8500 to 10,000 L / 8 hour work day

1 L = 1000 milliliters or cc^3



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Inhalation

10,000 L / 8 hour work day = 10,000,000 ml or cc^3

OSHA PEL for Asbestos is 0.1 f/cc

0.1 f/cc X 10,000,000 cc =

1,000,000 asbestos fibers per 8-hour work shift!!!

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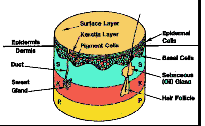
- Skin Contact
- Direct Damage or Absorption

The skin is made up of alternating fatty and watery layers. A compound that dissolves readily in fats is more likely to pass through the skin.



INDUSTRIAL HYGIENE
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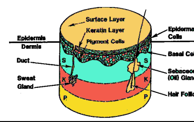
- **Skin Contact**
  - Corrosives – Solvents
  - Sensitizers - Epoxies
- **Absorption**
  - Some solvents, Toluene, Benzene, Methanol – Hydrofluoric Acid – Pesticides



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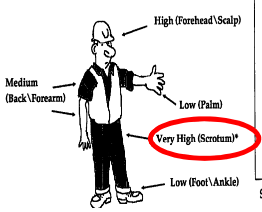
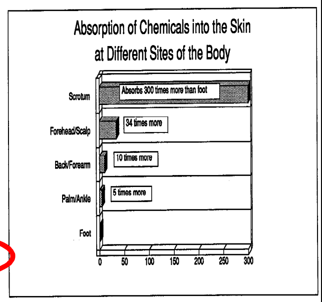
Skin Absorption





Source: E. Hodgson and P.E. Levi, *A Textbook of Modern Toxicology* (Elsevier: New York, 1987), p. 34-35.

* For men (Studies of female workers yet to be done.)

INDUSTRIAL HYGIENE
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Skin Absorption

Karen E. Wetterhahn was a professor of chemistry at Dartmouth College and the founding director of Dartmouth's Toxic Metals Research Program.

An expert in the mechanisms of metal toxicity, Professor Wetterhahn was best known for her research on chromium.

She became ill and died in **1997**, at the age of 48, as a result of a tragic laboratory accident involving a highly toxic mercury compound.

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Skin Absorption

Wetterhahn's research work involved understanding how elevated levels of heavy metals interfere with such processes as cell metabolism and the transfer of genetic information. That work was the direct cause of her death.

"Karen was the acknowledged international expert in chromium carcinogenicity," noted John S. Winn, chairman of the Dartmouth chemistry department. She began a sabbatical at Harvard in the fall of '95. The work involved doing some model compound studies involving mercury chemistry wit a group at MIT.

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Skin Absorption

That work led to mercury NMR characterization of the model compounds with the use of dimethylmercury as this element's NMR standard. Winn relates that while preparing the mercury NMR standard in a fume hood on August 14, 1996,

Dr. Wetterhahn spilled one to a few drops of dimethylmercury onto her latex glove near her thumb.

Knowing that dimethylmercury was very toxic, she quickly cleaned it up.

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Skin Absorption

What she did not know was that **dimethylemercury** was so soluble that it permeated the glove instantly and penetrated her skin and was absorbed into the blood-stream.

It took five months until her gait began to falter and her words slur. By the time Dr. Wetterhahn connected that laboratory spill with the damage spreading in her brain, nothing could help her.

Tests showed that her body contained more than 80 times the lethal dose of mercury. Her vision narrowed to a pencil's thinness and winked out. She lost her hearing and speech and she faded into a long coma.

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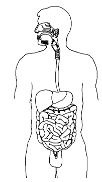
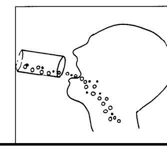
- **Ingestion**
- Failure to Decon
- Poor Hygiene
- **Lead, Arsenic**





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Toxicology – The Dose Makes the Poison

Dose ... The amount of the toxin that enters the body.

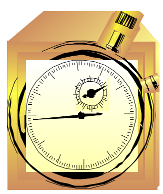
Total Dose depends on:

Number of doses

Concentration of the toxin;

Frequency

Time period exposed to it.



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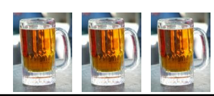
For example:

- 8 beers in 8 hours
- 8 beers in 6 hours
- 8 beers in 4 hours
- 8 beers in 2 hours



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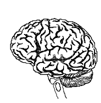
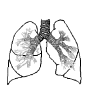
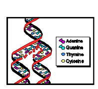
Types of Toxins

- **Irritants - Primary & Secondary**
- **Sensitizers**
- **Anesthetics**
- **Asphyxiants - Simple & Chemical**
- **Carcinogens**
- **Mutagens**
- **Reproductive Hazards**







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Irritants - Primary & Secondary

Irritant Substances. A substance is an irritant if it causes inflammation of the skin, eye irritation, serious eye effects or irritation to the respiratory system.

Primary Irritants are very water soluble
Chlorine, Ammonia, Muriatic, Sulfuric Acid

Secondary Irritants are not very water soluble
Phosgene – Cadmium Fume – Welding Gases NOx

INDUSTRIAL HYGIENE
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Corrosive Substances. A corrosive substance causes destruction of, or damage to, materials or living tissue on contact. Corrosives are also irritants.

Acids, Bases/Alkaline materials
Lye, Muriatic Acid, Concrete, Cleaners

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Sensitizers. A sensitizer is a substance which causes sensitization, i.e., to become sensitive/allergic to the effects of minute quantities of a substance.

Can be life threatening!!!

- **Isocyanates in paints, glues, foams**
- **Epoxies - Adhesives**
- **CTPV** (Coal Tar) - **Formaldehyde**

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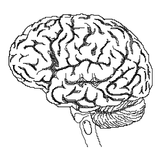
Anesthetics, substances that act on the CNS

Anesthetics make you drunk

- Organic solvents
  - Paints, Cleaners
- Alcohols
  - IPA, Methanol, etc.



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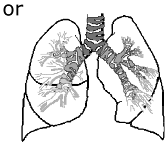
Asphyxiants

Simple & Chemical substances that prevent the body from obtaining or using oxygen.



- Simple Asphyxiants include nitrogen, helium argon, etc. Problems in confined spaces
- Chemical Asphyxiants include carbon monoxide, H_2S

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Carcinogenic Substances. A carcinogenic substance is one which is capable of causing cancer.

- **Benzene** – (gasoline & solvents) – leukemia, aplastic anemia
- **Asbestos** – Lung Cancer, Mesothelioma
- **Silica** – Lung Cancer?
- **Chrome VI** – Lung Cancer – Welding fume

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A **reproductive toxin** interferes with reproductive or sexual functioning of the adult from puberty to adulthood, for example, depressed libido, impotence, irregular menstrual cycles and infertility.

- **Some chemicals – Herbicides/Pesticides**
- **Glycol ethers**
- **Toluene**

A **developmental toxin** produces an effect in the offspring from conception to puberty

- **Lead**

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Mutagenic Substances are agents capable of producing a mutation. A mutation is a permanent change in the genetic material of cells.

A mutation in the germ cells in sexually reproducing organisms may be transmitted to the offspring.

- **Radiation can cause mutagenic changes**
- **Some Chemicals**
  - Methyl chloride
  - Glutaraldehyde
  - Acetaldehyde

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Teratogenic Substances. A teratogenic substance is one which is capable of causing abnormalities in a developing fetus, that is, causing birth defects.

- **Thalidomide -** Morning Sickness drug
- **Lead**