Chemicals

**Ladou:**

❖ **Acids**

- **ACUTE EFFECTS:**
  - Irritative dermatitis, skin burn
  - Respiratory irritation, pulmonary edema

- **CHRONIC EFFECTS:**
  - Hydrofluoric acid → osteosclerosis
  - Nitric acid (oxides of nitrogen) → bronchiolitis fibrosa obliterans
  - Chromic acid → nasal ulceration, perforation, skin ulceration
  - Sulfuric acid → laryngeal cancer

- **Metabolism & Mechanism of Action:**
  - Cause direct destruction of body tissue, including mucous membranes and skin.
  - The extent of damage depends on → **concentration, length of exposure, particle size.**

- **Clinical Findings:**
  - **Acute exposure**
    - **Skin** → dehydration and heat release to produce first-, second-, or third-degree burns with pain. Sensitization is rare.
    - **Respiratory effects** → immediate rhinorrhea, throat burning, cough, burning eyes, and conjunctival irritation. High concentrations may cause shortness of breath, chest tightness, pulmonary edema, and death from respiratory failure.
    - Inhalation of acid vapors or mists generally causes immediate symptoms because of high water solubility in mucous membranes, (but respiratory effects may be delayed for several hours).
    - **Asthma** → aluminum potroom workers (*fluorides*, *chloramines*) in indoor swimming pool air.
  - **Chronic exposure**
    - **Dental erosion** → tooth surface loss, **periodontal pockets** (but not oral mucous membrane lesions).
    - **Respiratory effects** → vocal cord dysfunction, hoarseness, loss of voice.
    - **Cancer** → Battery manufacturers and steel workers exposed to mineral acid mists have an increased risk of **upper aerodigestive tract cancer.**
    - **Hydrogen chloride** and **nitric acid** are not cancerogenic.

- **LABORATORY FINDINGS:**
  - Inhalation exposure may cause more extensive mucosal irritation
    - **CXR** → interstitial or alveolar edema
    - **ABG** → hypoxemia
MEDICAL SURVEILLANCE:

- Preplacement and periodic examinations should include medical history of skin and respiratory disease and examination of the skin, teeth, and lungs.

Rx:

- Immediate on-site first aid treatment of acid burns to the eye or skin includes copious flushing with running water with removal of all contaminated clothing.
- First or second-degree burns involving a small area generally can be treated at the on-site medical facility with debridement and application of suitable burn dressings.
- All other acid burns should be treated at a hospital emergency facility.
- For inhalation of acid vapors or mists → removed immediately from the source of exposure and treated on-site with 100% oxygen.
- Bronchospasm → inhaled bronchodilators, intravenous aminophylline and steroids if necessary.

Sulfuric acid:

- Use → manufacture of phosphate and other fertilizers, petroleum refining, ammonium sulfate, iron and steel pickling, explosives and other nitrates, synthetic fiber manufacture, as a chemical intermediate.
- Exposure → electroplaters, jewelers, metal cleaners, picklers, storage-battery makers.
- CMx → laryngeal and nasopharyngeal cancer, Noncardiogenic pulmonary edema.

Phosphoric acid:

- Use → manufacture of fertilizers and agricultural feeds, water treatment, as a component of detergents and cleansers, acid treatment (pickling) of sheet metal, chemical polishing of metals, as a tart flavoring agent for carbonated beverages, as a refractory bonding agent, boiler cleaning, textile dying, lithographic engraving, rubber latex coagulation.
- CMx → sister-chromatid exchanges (phosphate fertilizer factory)

Chromic acid:

- Use → chromium plating, process engraving, cement manufacturing, anodizing, metal cleaning, tanning, ceramic glazes, colored glass, inks, and paints.
- CMx:
  - Ingestion → gastrointestinal hemorrhage, acute renal failure, hepatic injury
  - Direct irritant dermatitis, ulceration of the skin
  - Ulceration and perforation of the nasal septum
  - Lung cancer (hexavalent chromium exposure)

Nitric acid:

- Use → produce ammonium and potassium nitrate, explosives, adipic acid, isocyanates, fertilizers, nitroparaffins, nitrobenzenes.
- Exposure → topical contact with the liquid acid, inhalation of nitrogen oxides when nitric acid reacts with reducing agents (e.g., metals or organic matter), during the combustion of nitrogen-containing materials (e.g., welding, glass blowing, underground blasting, and decomposition of agricultural silage).
- CMx → Bronchiolitis fibrosa obliterans, chronic interstitial lung disease, delayed symptoms 1-24 hours after inhalation, beginning with dyspnea followed by pulmonary edema and cyanosis.
- Rapidly progressive pulmonary edema of delayed onset may follow the inhalation of fumes from accidental nitric acid exposure.

Hydrochloric acid:
- Use → steel pickling, chemical manufacturing, oil- and gas-well acidizing, food processing.
- Hydrochloric acid gas also may evolve from thermal degradation of polyvinyl chloride (PVC), a hazard to firefighters.
- PVC → thermal degradation → Hydrochloric acid gas

Hydrofluoric acid:
- Use → as an intermediate in the production of fluorocarbons, aluminum fluoride, cryolite, as a gasoline alkylation catalyst, an intermediate in the production of uranium hexafluoride, metal cleaning, glass etching, polishing applications.
- CMx:
  - Hydrofluoric acid, one of the most corrosive of the inorganic acids, readily penetrates the skin and travels to deep tissue layers, causing → liquefaction necrosis of soft tissues, decalcification and corrosion of bone, life-threatening systemic hypocalcemia (acute skin exposure), osteosclerotic bone changes (chronic exposure), death (hypocalcemia & hypomagnesemia).
- HF acid solutions of < 50% → burns that may not become apparent for 1-24 hours.
- Stronger solutions of > 50% → immediate pain, rapid tissue destruction, appearing reddened, pasty-white, blistered, macerated, or charred.
- L/D: urine fluoride (post shift urinary biologic monitoring that should be < 7mg/L), analysis of hair for fluoride.
- Rx: definitive treatment is aimed at deactivation of the fluoride ion in tissue with calcium, magnesium, or quaternary ammonium solution.
- If the HF concentration is 20% or more, if exposed to a long delay of a lower concentration, or if a large tissue area has been affected by a lower concentration, then calcium gluconate solution should be used.
- Periungual or ungual tissues involvement → the nail should be split to the base. A burn dressing then is applied along with calcium gluconate 2.5% gel or magnesium sulfate paste.
- Hand involvement → occlusive glove over topical calcium carbonate gel.
- Eye involvement → irrigated copiously and then evaluated by an ophthalmologist. Calcium gluconate 1% in normal saline can be used as an irrigant.
- Systemic effects (Hypocalcemia, QT-interval prolongation) → Calcium gluconate 10% intravenously with adequate hydration.
- Nebulized calcium gluconate 5% solution → inhalational exposure to HF acid.

### Organic acids

- **Chlorine gas** → respiratory mucous membrane irritation, pulmonary edema, obstructive or restrictive pulmonary defects, nonspecific airway reactivity.
- **Formic acid** → textile industry as a dye-exhausting agent, in the leather industry as a deliming agent and neutralizer, as a coagulant for rubber latex, as a component of nickel plating baths.
  - CMx → renal ammoniagenesis, urinary calcium excretion
- **Propionic acid** → as a mold inhibitor, as a food additive.
- **Monocarboxylic acid acrylic acid** → manufacture of resins, plasticizers, and drugs.
- **Aliphatic dicarboxylics maleic, fumaric, adipic acids** → manufacture of synthetic resins, dyes, surface coatings, inks, and plasticizers.
- **Halogenated acetic acids** → glycine, drug, dye, herbicide manufacture.
- **Glycolic acid and lactic acid** → leather, textile, adhesive, and plastics industries, and lactic acid is also used as a food acidulant.
- **Chromate compounds** → can be allergens → pulmonary and skin sensitization

### Alkalis

- **ACUTE EFFECTS:**
  - Skin and eye burns
  - Respiratory irritation
- **CHRONIC EFFECTS:**
  - Corneal opacities of the eye (untreated)
  - Obstructive lung disease
- Metabolism & Mechanism of Action:
  - Inhalation of caustic mists generally is limited by the irritant properties of the compound.
  - Contact the eyes with alkalis → disintegration and sloughing of corneal epithelium, corneal opacification, marked edema, and ulceration.
- The alkalis, whether in solid form or concentrated liquid form, are more destructive to tissue than most acids.
- **CMx:**
  - Acute exposure → In contrast to acids, skin contact with the alkalis may not elicit immediate pain but may start to cause immediate damage with erythema and tissue necrosis within minutes to hours.
  - Rx → copious irrigation with tap water and removal of all contaminated clothing, irrigation with a weak acid such as 5% acetic acid.
  - Eye burns → Topical synthetic metalloproteinase inhibitor, Diphoterine
- Skin burns → Diphtherine
- Intensive topical steroids, antibiotics, and amniotic membrane transplantation may be required.

**Sodium hydroxide:**
- Use → pulp and paper production, water treatment, manufacture of a wide variety of organic and inorganic chemicals, soaps, detergents, textiles, and alumina.
- CMx → Irreversible obstructive lung injury, air trapping.

**Ammonia:**
- Acute exposure → acute tracheobronchitis, respiratory failure, fixed airways obstruction.
- Chronic exposure → pulmonary function decrements, coughing, wheezing, ocular and nasal irritation, corneal opacities, nasopharyngeal carcinoma.

**Sodium carbonate** → glass manufacturing, as a component of cleaning-product formulations, pulp and paper processing, water treatment, as a chemical intermediate.

**Potassium carbonate (potash)** → soap, glass, pottery, shampoo, tanning and finishing leather, photographic chemicals, fire-extinguishing compounds, rubber antioxidant preparations, as an alkalizer, drainpipe cleaner.

**Potassium hydroxide (caustic potash)** → as a chemical intermediate in the manufacture of potassium carbonate, potassium phosphate, soaps, tetrapotassium pyrophosphate, liquid fertilizers, dyestuffs, herbicides.

**Calcium oxide (quicklime)** → in metallurgy as a flux in steel production, for ammonia recovery in the Solvay process for sodium carbonate, construction applications, water purification and softening, beet and sugar cane refining, kraft paper pulp production, sewage treatment.

**Acrylamide**

- **ACUTE EFFECTS** → Dermatitis
- **CHRONIC EFFECTS** → Peripheral neuropathy

- Use → Polyacrylamides are useful as flocculators, for waste and water treatment flocculents, sewage dewatering, water treatment industry, strengtheners for papermaking and retention aids, drilling-mud additives, textile treatment, surface coatings, as a grouting agent in mining and tunnel construction.

- Exposure → papermaking workers, soil-stabilization workers, textile workers, tunnel workers, well drillers, Biomedical laboratory workers, in the manufacture of acrylamide monomer, in the handling of a 10% aqueous solution in a mine, in the production of flocculants, in the use of a resin mixture containing residual monomer, in the production of polymers while manufacturing paper coating materials, elevated temperatures in cooking of carbohydrate-rich foods such as potatoes (e.g., crisps, chips, and fries), cosmetic products.

- Metabolism & Mechanism of Action:
  - The peripheral nerve terminal is a primary site of acrylamide action → inhibition of membrane-fusion processes → impairing neurotransmitter release.
  - Primary metabolite of acrylamide → N-acetyl-S-(3-amino-3-oxypoly) cysteine → excreted in the urine.
CMx:
- Acrylamide polymer → dermatitis
- Acrylamide monomer → Peripheral neuropathy
- N-hexane, methyl-n-butyl ketone, acrylamide → dying-back disorder → distal axonopathy, central neural degeneration.
- Ingestion → encephalopathy, confusion, disorientation, memory disturbances, hallucinations, ataxia, peripheral neuropathy.
- Acrylamide peripheral neuropathy → affects both motor and sensory nerve fibers predominantly in the distal limbs, difficulty in walking, clumsiness of the hand, numbness of the feet and fingers, Distal weakness, loss of tendon reflexes, ↓ vibration sensation, excessive sweating of extremities, redness and exfoliation of the skin.
- In acute CNS involvement → truncal ataxia, lethargy, dysarthria.
- Histologic findings → swelling of axons and/or a decrease in large-diameter axons.
- Increased DNA adducts and chromosomal aberrations

L/D:
- Slight effect on maximal conduction velocity of either motor or sensory fibers.
- ↓ Sensory nerve action potentials (most sensitive electrophysiologic test).
- Biomonitoring:
  - Work place → urinary S-carboxyethyl cysteine metabolite
  - General populations → urinary mercapturic acid metabolite

MEDICAL SURVEILLANCE:
- Preplacement and periodic examinations should exclude symptomatic peripheral neuropathies.
- Hemoglobin adducts → monitor occupational exposure to both acrylamide and acrylonitrile.
- Vibration threshold may be a sensitive indicator of early neurotoxicity caused by acrylamide exposure.

Acrylonitrile
- Acute effects → Respiratory irritation, nausea, dizziness, irritability, Convulsions, coma, death
- Chronic effects → Nausea, dizziness, headache, apprehension, fatigue
- Peach seeds odor
- Its vapors are explosive and flammable and may release hydrogen cyanide on burning.
- Use → acrylic fibers for the apparel, carpeting, and home furnishings industries, Acrylonitrile-containing plastics, particularly the resins acrylonitrile-butadiene-styrene (ABS) and styrene-acrylonitrile (SAN), are used in pipe and pipe fittings, automotive parts, appliances, and building components, make acrylamide.
- Exposure → may occur in monomer-, fiber-, resin-, and rubber-producing plants.
- Metabolism & Mechanism of Action:
  - Acrylonitrile → cyanide (blood) → thiocyanate (blood and urine) [biologic monitoring]
- CMx:
  - Deaths → respiratory distress, lethargy, convulsions, and coma.
Acute poisoning → irritability, respiratory irritation, limb weakness, respiratory distress, dizziness, nausea, cyanosis, collapse, convulsions, and cardiac arrest.

Chronic toxicity → nasal irritation, headache, nausea, apprehension, fatigue, colon and lung cancers.

L/D:
- Chromosomal aberrations, hemoglobin adducts.
- ↑ serum cyanide, ↑ urine thiocyanate levels

DDx → Acute poisoning with acrylonitrile may mimic cyanide intoxication.

MEDICAL SURVEILLANCE:
- Preplacement and annual medical examinations should include special attention to the skin, respiratory tract, gastrointestinal tract, nonspecific symptoms of headache, nausea, dizziness, and weakness that may be associated with chronic exposure.

Rx → N-acetylcysteine + sodium thiosulfate

AROMATIC AMINES
- ANILINE, P,P’-METHYLENE DIANILINE, NAPHTHYLAMINES, BENZIDINE-BASED DYES, O-TOLUIDINE

ACUTE EFFECTS → Dermatitis, Asthma, Cholestatic jaundice, Methemoglobinemia, hemorrhagic cystitis

CHRONIC EFFECTS → Bladder cancer

Use:
- Benzidine → dye manufacture, azo dyes in the leather, textile, and paper industries.
- Aniline → methylene diisocyanate, rubber products, dyes, pesticides, pigments, hydroquinones.
- P,P’-Methylene dianiline → polyurethanes, dyes, polyamide and polyimide resins and fibers, as a laboratory analytic reagent.
- 0-Toluidine → printing textiles, in the preparation of ion-exchange resin, as an antioxidant in rubber manufacture, synthesis of dyestuffs.

Metabolism & Mechanism of Action → The aromatic amines are nearly all lipid-soluble and are absorbed through the skin.

CMx:
- Acute exposure:
  - Dermatitis:
    - P-aminophenol → allergic dermatitis
    - P-phenylenediamine → allergic dermatitis, fur dermatitis and asthma (fur dyers), contact dermatitis (hairdressers).
  - Respiratory effects: Asthma (P-phenylenediamine)
  - Hemorrhagic cystitis: o- and p-toluidine and 5- chloro-o-toluidine.
    - The hematuria is self-limited → no increase in bladder tumors has been noted.
  - Hepatic injury: Cholestatic jaundice, toxic jaundice, Acute liver dysfunction.
- **Methemoglobinemia**: aniline
  - 10-15% → cyanosis
  - 25-30% → headache, weakness, dyspnea, dizziness, malaise
  - 60-70% → coma and death

- **Chronic exposure**: bladder tumors

- **L/D**:
  - Methemoglobin levels
  - Periodic screening of urine for **red blood cells** and evidence of **dysplastic epithelium** may detect early bladder cancer.

- **Differential Diagnosis**:
  - Aliphatic nitrates (e.g., ethylene glycol dinitrate), aliphatic nitrites, inorganic nitrites, chlorates → methemoglobinemia
  - Arsenic, Cigarette smoking → bladder cancer

- **MEDICAL SURVEILLANCE**:
  - Preemployment and periodic measurement of **postshift urinary p-aminophenol** is useful for **biologic monitoring** of aniline exposure.

- **Rx**:
  - Methemoglobinemia → methylene blue
  - Excessive amount of methylene blue may itself provoke the formation of methemoglobin.
  - The ability of methylene blue to reduce methemoglobin can be impaired by hereditary G6PD deficiency and can precipitate frank hemolysis.

**CARBON DISULFIDE (CS2)**

- **ACUTE EFFECTS**: Irritability, manic delirium, hallucinations, paranoia Respiratory irritation
- **CHRONIC EFFECTS**: Coronary artery disease, Neurobehavioral abnormalities, Retinal microaneurysms, Peripheral neuropathy with ascending symmetric paresthesias and weakness.
- **Strong sweetish aroma**
- **Use** → manufacture of rayon, cellophane, carbon tetrachloride, rubber chemicals, grain fumigant.
- **Exposure** → during the opening of sealed spinning machines and during cutting and drying.
- **Metabolism & Mechanism of Action**:
  - Inhalation is the major route of absorption in occupational exposure.
  - Carbon disulfide → metabolized → **dithiocarbamates** → CNS toxicity
  - **Thiourea, mercapturic acids**, glutathione conjugate 2-thiothiazolidine-4-carboxylic acid (**TTCA**) can be detected in **urine**.
  - Carbonyl sulfide → hepatotoxic metabolite
CMx:

- **Acute exposure** → irritability, uncontrolled anger, rapid mood changes (including manic delirium and hallucinations), paranoid ideas, suicidal tendencies, coma and death, irritation of the eyes, nose, and throat.
- Liquid carbon disulfide may cause second- or third-degree burns.
- **Chronic exposure**:
  - **Eye** → eye irritation, *retinal microaneurysms* (delayed flindal peripapillary filling by fluorescein angiography), ↓ *Color vision*.
  - **Ear** → ↑ NIHL, vertigo, nystagmus
  - **Heart** → ↑ blood pressure, ↑ triglyceride, ↓ lipoprotein levels, ↑ heart rate variability, ↑ risk of ischemic electrocardiographic changes
  - **Nervous system** → neurobehavioral changes in psychomotor speed, motor coordination and personality, ↓ peripheral nerve conduction, ↓ slow-fiber-conduction velocity, ↑ prolongation of the refractory period of the peroneal nerve, Impaired motor and sensory nerve conduction, Cerebellar atrophy, extrapyramidal symptoms, *atypical parkinsonism*.
  - **Reproductive effects** → significant effect on libido and potency (but not on fertility or semen quality), menstrual abnormalities, spontaneous abortions, and premature births.

- **L/D**:
  - ↓ peripheral nerve-conduction velocity, abnormalities in psychomotor skills and personality function.
  - **Urinary metabolites**
    - Exposure > **16 ppm** → iodine-azide reaction test +
    - Exposure < **10 ppm** → end-of-shift urinary TTCA +

**MEDICAL SURVEILLANCE**:

- Initial medical examination should include the central and peripheral nervous systems, eyes, and cardiovascular system. Visual acuity and color vision should be measured and a baseline electrocardiogram obtained.
- Neurobehavioral testing, exercise electrocardiography, and nerve-conduction velocity testing may be indicated.
- **Reduced color discrimination** may be a sensitive marker for carbon disulfide neurotoxicity.
- **Biologic monitoring** → *urine TTCA* collected at the end of the work shift following the first workday.
- Presence of preexisting neurologic, psychiatric, or cardiac disease should be considered relative contraindications for individual exposure.

**CHLOROMETHYL ETHERS**

- Bis(chloromethyl) ether (BCME), chloromethylmethyl ether (CMME)
- Exposure → anion-exchange resin production, textile industry
- **ACUTE EFFECTS** → Respiratory irritation, Skin rash
CHRONIC EFFECTS → Lung cancer
- The risk of lung cancer is increased in smokers versus nonsmokers.

L/D:
- CXR may show a mass that should lead to appropriate diagnostic testing.
- Sputum cytology may be abnormal in the presence of a normal chest radiograph and thus may be useful as a screening technique in individual cases.

DDx → asbestos, arsenic, chromium, uranium

MEDICAL SURVEILLANCE:
- Preplacement and annual lung examination.
- Periodic sputum cytology may be of limited value in detecting early lung cancer.

DIBROMOCHLOROPROPANE (DBCP)

- ACUTE EFFECTS → Oligospermia, azoospermia, ↑ FSH, ↑ LH

DIMETHYLAMINOPROPIONITRILE

- Use → flexible polyurethane foams
- CMx → localized autonomic dysfunction without peripheral nervous system damage.
  - Neurogenic bladder dysfunction, urinary retention, hesitancy, dribbling, sensation confined to the lower sacral dermatomes, persistent sexual dysfunction, residual sensorimotor neuropathy.
- LDx : NCV → NL

ETHYLENE OXIDE

- ACUTE EFFECTS → Respiratory tract irritation, Skin rash, Headache, drowsiness, weakness
- CHRONIC EFFECTS → ↑ sister chromatid exchanges in lymphocytes, Possible ↑ risk of cancer
- Flammable gas, ether-like odor
- To reduce the explosive hazard of ethylene oxide it is often mixed with carbon dioxide or haloearbons (15% ethylene oxide and 85% dichlorofluoromethane).
- Use → ethylene glycol (antifreeze, intermediate for polyester fibers, films, bottles), nonionic surfaceactive agents (home laundry detergents, dishwashing formulations), glycol ethers (surface coatings), ethanolamines (soaps, detergents, textile chemicals), pesticide fumigant, sterilant (in hospitals, medical products manufacture, libraries, museums, beekeeping, spice and seasoning fumigation, animal and plant quarantine, transportation vehicle fumigation, and dairy packaging).
- Exposure → health care workers (during the opening of the sterilizer door, in the transfer of freshly sterilized items to the aeration cabinet or central supply area, during tank changes, and at the gas discharge point.
- It is an alkylating agent that binds to DNA and may cause cellular mutation.
CMx:

- **Acute exposure:**
  - 200-400 ppm → upper respiratory tract irritation (irritating to the eyes, respiratory tract and skin, and at high concentrations it can cause respiratory depression).
  - > 1000 ppm → headache, nausea, dyspnea, vomiting, drowsiness, weakness, incoordination.
  - Direct contact of the skin or eyes with liquid ethylene oxide → severe irritation, burns, contact dermatitis.

- **Chronic exposure:**
  - Reproductive effects → spontaneous abortions, preterm birth
  - Carcinogenic effects → chromosomal aberrations, sister chromatid exchange in lymphocytes, micronuclei in bone marrow cells, hemoglobin adducts, lymphatic and hematopoietic cancers.
  - Neurologic toxicity → peripheral neuropathy, neuropsychological abnormalities, lower P300 amplitude.
  - **Occupational asthma**

L/D:

- CXR may show interstitial or frank alveolar edema.
- CBC may be helpful in the diagnosis of leukemia.

DDx:

- Chlorofluorocarbons → upper respiratory symptoms
- Cigarette smoke and other alkylating agents → sister chromatid exchanges, chromosomal aberrations.

Prevention → Self-contained breathing apparatus or airline respirators are the only respirators acceptable for ethylene oxide.

MEDICAL SURVEILLANCE:

- Preplacement and periodic examinations should include attention to the pulmonary, hematologic, neurologic, and reproductive systems.
- The mean absolute numbers of eosinophils and RBC and percentage of hematocrit were significantly elevated among workers with higher cumulative doses of ethylene oxide.
- **Biologic monitoring** → increase in chromosomal aberrations, sister chromatid exchanges, micronuclei, and hemoglobin adducts.

FORMALDEHYDE

- **Acute effects:**
  - Eye irritation causing lacrimation, redness, pain
  - Cough, chest tightness, shortness of breath
  - Skin irritation, contact dermatitis
- **Chronic effects:** Bronchitis, exacerbation of asthma
- **General Considerations:**
  - Colorless flammable gas, pungent irritating odor
Other compounds: formalin (37-50% formaldehyde), methyl aldehyde, methanal (methanol-formaldehyde mixture), methylene glycol, paraform, or paraformaldehyde (a linear copolymer of formaldehyde).

By-product of the incomplete combustion of hydrocarbons.

Found in small amounts in automobile exhaust and cigarette smoke.

- Use → manufacture of urea-formaldehyde, polyacetal, phenolic resins, as an intermediate in the manufacture of ethylenediaminetetraacetic acid, methylene dianiline, hexamethylenetetramine, and nitriloacetic acid, wood industry products, molding compounds, foundry resins, adhesives for insulation, slow release fertilizers, manufacture of permanent-press finishes of cellulose fabrics, and formaldehyde-based textile finishes, for preservation and disinfection.

- Exposure → in the production of formaldehyde resin and plastics, in the manufacture of apparel, plywood particle board, wood furniture, paper, and paperboard, urea-formaldehyde foam insulation dealers and installers, mushroom farmers, embalmers, laboratory workers, hospital autopsy rooms, in gross anatomy, laboratories, Wildland firefighters may be exposed to formaldehyde as a result of vegetation combustion.

- Metabolism & Mechanism of Action:
  - Formaldehyde → formaldehyde dehydrogenase → formic acid
  - Most formaldehyde is converted to CO₂ via formate, and a small fraction is excreted in the urine as formate and other metabolites.
  - Formaldehyde interacts with macromolecules such as DNA, RNA, protein → carcinogenic effect.

- CMx:
  - Acute exposure:
    ✓ Direct irritation (eczematous reaction) (irritant dermatitis)
    ✓ Allergic contact dermatitis (type IV delayed hypersensitivity)
    ✓ Sudden urticarial eczematous reaction of the skin of the eyelids, face, neck, and flexor surfaces of the arms.
    ✓ Direct irritation of the eyes, nose, and throat
    ✓ Irritation of the upper respiratory tract, Shortness of breath, cough, chest tightness, pulmonary edema, pneumonitis, death.
  - Chronic exposure:
    ✓ Cancer → lung, thyroid cancer, myeloid leukemia, nasopharyngeal and hypopharyngeal cancer, sinonasal cancer (particularly adenocarcinoma).
    ✓ Occupational asthma
    ✓ Spontaneous abortions

- L/D → for contact dermatitis → patch testing with appropriate concentrations of formaldehyde.

- Prevention → Protective neoprene clothing, boots and gloves

- MEDICAL SURVEILLANCE:
  - Preplacement history of asthma or allergy should be obtained, along with a baseline FEV1 and forced vital capacity (FVC).
  - Biologic monitoring: cytogenetic changes in epithelial cells of the mouth and in blood lymphocytes.
Pathologic changes in the nasal mucosa → ciliary loss, goblet cell hyperplasia, squamous metaplasia, and mild dysplasia.

NITRATES: NITROGLYCERIN & ETHYLENEGLYCOL DINITRATE

- ACUTE EFFECTS → Headache, Angina, Fall in blood pressure
- CHRONIC EFFECTS → Sudden death, Increased incidence of ischemic heart disease
- General Considerations:
  - Nitroglycerin → oily liquid at room temperature, slightly sweet odor.
    - The sensitivity of nitroglycerin decreases with decreasing temperature, so ethylene glycol dinitrate may be added to nitroglycerin-bearing dynamites to depress the freezing point.
    - Explosions of nitroglycerin may occur when the liquid is heated or when frozen nitroglycerin is thawed.
  - Ethylene glycol dinitrate → oily colorless liquid, more stable and less likely than nitroglycerin to explode when it burns.
- Use → major application of nitroglycerin is in explosives and blasting gels, treatment of angina.
- Exposures → during their manufacture, during the manufacture and handling of explosives, munitions, and pharmaceuticals.
- Metabolism & Mechanism of Action:
  - Skin absorption is more significant.
  - Both act directly on arteriolar and venous smooth muscle → vasodilation → drop in blood pressure, ↑ regional myocardial blood flow, headache (cerebral vessel distension).
  - The tolerance (boat headache and ↓ BP) that develops after 2-4 days of continuous exposure appears to be the result of an increased sympathetic compensatory mechanism.
  - The pathogenesis of sudden death → rebound vasoconstriction → acute hypertension or myocardial ischemia.
  - NIOSH recommends that workplace exposure to nitroglycerin and ethylene glycol dinitrate be controlled so that workers are not exposed at concentrations that will cause vasodilation, as indicated by the development of throbbing headaches or decreases in blood pressure.
- CMx:
  - Acute exposure:
    - loss of consciousness, severe headache (powder headache), difficulty breathing, weak pulse, pallor, depression, restlessness, sleeplessness, acute drop in mean blood pressure of 10 mmHg systolic and 6 mmHg diastolic, irritant and allergic contact dermatitis.
  - Chronic exposure:
    - Angina pectoris and sudden death (In affected workers, the angina usually occurs on the weekend or early in the work shift following periods away from work).
    - Raynaud phenomenon, peripheral neuropathy, methemoglobinemia, ischemic heart disease.
L/D:
- Coronary angiography → normal
- EKG → normal
- Incidence of ectopy is not increased.

DDx:
- Cardiovascular → carbon disulfide
- Sudden cardiac death → carbon monoxide, hydrocarbon solvents.

Prevention → Natural and synthetic rubber gloves accelerate absorption of nitrate esters.
- Only cotton or cotton lined gloves should be worn.

MEDICAL SURVEILLANCE:
- Preplacement and periodic examination should stress a history of cardiovascular disease and physical examination of cardiac abnormalities.
- **Biologic monitoring** → Urinary glycerol dinitrates

Rx → **Sublingual nitroglycerin** should be used immediately for anginal symptoms.

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**NITROSAMINES**

- N-nitrosodimethylamine (NDMA), N-nitrosodiethylamine (NDEA), N-nitrosod Ethanolamine (NDELA), N-nitrosodiphenylamine (NDPhA), N-nitrosomorpholine (NMOR) and N-nitrosopyrrolidine (NPyR).

**ACUTE EFFECTS** → Liver damage

**CHRONIC EFFECTS** → Probable human carcinogen

**Use:**
- NDMA → in the production of dimethylhydrazine (rocket propellant), research chemical, control of nematodes, inhibition of nitrification in soil, as a plasticizer for rubber and acrylonitrile polymers, in the preparation of thiocarbonyl fluoride polymers, as a solvent in the plastics and fiber industry, and as an antioxidant.
- NDELA → cosmetics, lotions, shampoos, certain pesticides, antifreeze, and tobacco.
- NDEA → as a research chemical, a gasoline and lubricant additive, an antioxidant, a stabilizer in plastics, a fiber industry solvent, a copolymer softener, synthesis of 1,1-diethylhydrazine.
- NDPhA → rubber industry as an antiscorching agent or vulcanization retarder.
- Nonoccupational exposure → derived from tobacco products and tobacco smoke (contain NDMA, NDEA, NPyR, and others.
- Low levels of nitrosamines occur in several types of food → **cheese**, **processed meats**, **beer**, **cooked bacon**.
- Nitrate can be reduced to nitrite in vitro and in human saliva in vivo. The reaction of ingested nitrates with amines will yield in vivo nitrosamines in the acidic medium of the stomach.
- Main contributors to gastric nitrite load are **vegetables**, **cured meats**, **baked goods**, **cereals**, **fruits**, and **fruit juices**.
Occupational Exposure:
- NDMA → workroom air of a rubber sealing factory, fish meal producer, manufacturer of surface active agents, rubber footwear plant, and chrome and leather tanneries, cutting-fluid, cutting oils, cigarette smoking, nitrite-preserved meats, pesticides, drinking water.

CMx:
- Acute exposure → hepatic necrosis (headaches, backache, abdominal cramps, nausea, anorexia, weakness, drowsiness, dizziness, ascites, jaundice).
- Chronic exposure → gastric cancer, childhood brain tumors, Liver cirrhosis

MEDICAL SURVEILLANCE:
- NDELA in cutting fluids → Increased single-strand DNA breaks in peripheral mononuclear cells.
- No specific medical surveillance for nitrosamines is recommended.
- There is no treatment for nitrosamine exposure.

PENTACHLOROPHENOL (PCP)

ACUTE EFFECTS → Skin and respiratory tract irritation, Systemic collapse

CHRONIC EFFECTS → Skin rash (chloracne secondary to chlorodibenzodioxin)

Pungent phenolic odor

Use → wood preservative, herbicide, defoliant, fungicide, chemical intermediate in the production of pentachlorophenate, plywood and fiberboard waterproofing, termicide, algicide, disinfectant, as an ingredient in antifouling paint, microbial deterrent.

Exposure → gas, electric service, and wood preservative industries.

- Acute exposure may occur with the opening of pressure-vessel doors or in tank cleaning, solution preparation, and the handling of wood after treatment, Hand application.

Metabolism & Mechanism of Action:
- Inhalation and skin absorption.
- PCP is excreted mainly in urine as free PCP and as a conjugate with glucuronic acid.

CMx:
- Acute exposure:
  ✓ Skin → skin irritation, Chloracne
  ✓ Eye, nose, throat Irritation
  ✓ Acute systemic intoxication → rapid onset of profuse diaphoresis, hyperpyrexia, tachycardia, tachypnea, weakness, nausea, vomiting, abdominal pain, intense thirst, pain in the extremities, muscle contraction, death.
- Chronic exposure → conjunctivitis, sinusitis, bronchitis, Chloracne, non-Hodgkin lymphoma.
  ✓ Chlorophenate → congenital anomalies in offspring, Bone marrow aplasia.
L/D → ↑ blood urea, ↑ creatinine, metabolic acidosis, ↑ anion gap, ↑ serum lactic acid dehydrogenase, ↓ creatinine clearance

DDx:
- Hyperthermia, heat stroke, sepsis
- Chloracne → polychlorinated biphenyls, polychlorinated dibenzodioxins, polychlorinated dibenzofurans.

Gloves of nitrile and polyvinyl chloride provide the best protection.

MEDICAL SURVEILLANCE:
- Preemployment urine analysis for PCP should be performed and repeated at intervals (Samples should be collected prior to the last shift of the work week).
- Routine medical surveillance → attention to skin rash and mucous membrane irritation.
- Hot weather → predisposing factor for PCP intoxication (so exposure to PCP should be minimized during those times).

Biologic monitoring → urine PCP

Rx:
- Acute PCP intoxication → adequate intravenous hydration, maintain normal body temperature
  ✓ Muscular spasms → intubation and resuscitation
  ✓ Careful monitoring of respiratory status is critical.
  ✓ Metabolic acidosis → sodium bicarbonate.
  ✓ Atropine sulfate is contraindicated.

POLYCHLORINATED BIPHENYLS (PCB)

ACUTE EFFECTS → Skin rash (chloracne), Eye irritation, Nausea, vomiting
CHRONIC EFFECTS → Weakness, weight loss, anorexia, Skin rash (chloracne), Numbness and tingling of extremities, ↑ serum TG, ↑ liver enzymes.
Use → fire-resistant nature of PCBs & thermal stability (hydraulic and heat-transfer fluids), waterproofing characteristics of surface coatings, manufacture of carbonless copy paper, printing inks, plasticizers, special adhesives, lubricating additives, vacuum-pump fluids.
Exposure → Leakage, Improper storage, Electrical fires
Metabolism & Mechanism of Action:
- Absorption → respiratory tract, gastrointestinal tract, skin.
- Distribution is into fat.
CMx:
- Acute exposure → mucous membrane irritation, nausea, vomiting, Transient skin irritation, chloracne.
- Chronic exposure → chloracne, endocrine disrupting chemicals (thyroid, steroid, sexual), breast cancer.
- Yusho, or rice oil disease → chloracne, growth retard, dysmorphic physical findings, delayed cognitive development, increased activity levels, nail abnormalities, poorer cognitive abilities, impaired development, endocrine abnormalities.
L/D → ↑ TG, ↑ gamma-glutamyl transpeptidase level

- If exposure to PCB is suspected, serum or fat levels of PCBs maybe measured to document absorption.
- In a steady state, serum is as good a reflection of body burden as is fat.

MEDICAL SURVEILLANCE → baseline skin examination, liver function tests.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

- ACUTE EFFECTS: Dermatitis, conjunctivitis (coal tar pitch volatiles)
- CHRONIC EFFECTS: Excess cancer rates in selected occupations
- They are formed by pyrolysis or incomplete combustion of such organic matter as coke, coal tar and pitch, asphalt, and oil.
- Use: Pure PAHs have no direct use except for naphthalene and anthracene.
  - Anthracene → in the manufacture of dyes, synthetic fibers, plastics, monocrystals, as a component of smoke screens, in scintillation counter crystals, in semiconductor research.
  - Benzo(a)pyrene → as a research chemical
  - Bitumens → road-paving, roofing, asphalt products, road construction when mixed with asphalt, in roofing felt manufacture, in pipe coatings, as binders in briquettes.
  - Carbon black → derived from the partial combustion (pyrolysis) of natural gas or petroleum.
    ✓ As a pigment for rubber tires, paint, plastics, printing inks, pigment in eye cosmetics, carbon paper, typewriter ribbons.
  - Creosote → wood preservative, constituent of fuel oil, lubricant for die molds, pitch for roofing.
  - Coal tar pitch → plastics, solvents, dyes, drugs, waterproofing, paints, pipe coatings, roads, roofing, insulation, sealant, binder, filler in surface coatings, a modifier in epoxy resin coatings, as the binder for aluminum smelting electrodes, pipe-coating enamels, as a binder for briquettes and foundry cores.
  - Naphthalene → as a chemical intermediate in the production of phthalic anhydride, carbamate insecticides, -naphthol, sulfonic acids, surfactants, as a moth repellent, tanning agent.

- Exposure:
  - PAHs → carbon black production workers, wildland firefighters, petroleum tanker deck crews, meat smokehouse workers, printing press room operators.
  ✓ Environmental Exposure to PAHs → coal burning and settle on soil, where they may leach into water, smoked fish and meats, during the broiling and grilling of foods, burning of tobacco.
- The most important source of PAHs in the air of the workplace is coal tar.
- The coke-oven plant is the principal source of coal tar.
- Soot → chimney sweeps, brick masons, heating-unit service personnel.
- Coal tar and pitches → gas and coke works, aluminum reduction plants, iron and steel foundries, coal gasification facilities, during roof and pavement tarring, the application of coal tar paints.
- DIESEL EXHAUST → truck drivers, underground miners, railroad workers.
Metabolism & Mechanism of Action: PAHs are absorbed readily by the skin, lungs, and gastrointestinal tract.

CMx:
- **Acute exposure**:
  - **Naphthalene** → headache, nausea, diaphoresis, vomiting.
    - Accidental ingestion → hemolytic anemia.
    - Skin contact → Erythema, dermatitis
  - **Coal tar** → phototoxicity, skin erythema, burning, itching, eye burning, lacrimation.
- **Chronic exposure**:
  - **PAHs** → genotoxic, increased DNA adducts, micronuclei, chromosomal aberrations, cancers of lung, prostate, bladder, stomach. ↑ liver enzymes, cirrhosis, fatal ischemic heart disease.
  - **Soot** → scrotal cancer (in chimney sweeps)
  - **Carbon black** → reduction in airflow, chronic bronchitis, small opacities on chest radiograph
  - **Creosote** → skin squamous papilloma and carcinoma

L/D:
- **Photopatch testing** → demonstrate photodermatitis in workers with exposure to coal tar pitch and fumes.

MEDICAL SURVEILLANCE:
- Periodic examination of workers exposed to coal tar pitch volatiles should include a history of skin or eye irritation and physical examination with attention to the skin, upper respiratory tract, and lungs.
- **Biologic monitoring** → Urinary 1-hydroxypyrene (1-OHP), Urinary 1-naphthol, Urinary PAHs, PAH-DNA adducts.

**STYRENE (vinyl benzene, phenylethylene)**

- **ACUTE EFFECTS** → Eye, respiratory tract, and skin irritation
- **CHRONIC EFFECTS** → Weakness, headache, fatigue, dizziness, Neuropsychological deficits, color vision loss, sensory nerve conduction slowing.
- Use → synthetic rubber, polystyrenes, acrylonitrile-butadiene-styrene (ABS) resins, styrene-butadiene rubber (SBR), styrene-butadiene copolymer latexes, styrene-acrylonitrile (SAN) resins, glass-reinforced unsaturated polyester resins (construction materials and boats), protective coatings, as a solvent-reactant for unsaturated polyester products that are reinforced with fibrous glass, Reinforced plastics/composites are used in the manufacture of boats, storage tanks, wall panels, tub and shower units, and truck camper tops.
- Exposure → during cleaning, filling, or maintenance of reaction vessels, during transport of liquid styrene, during manual application of resins (hand lamination) or spraying in open molds.
- Metabolism & Mechanism of Action:
  - Occupational exposure occurs mainly via inhalation. Percutaneous absorption is not significant.
Styrene metabolites → styrene oxide → phenylethylene glycol (styrene glycol) → mandelic acid, benzoic acid, hippuric acid.
- Mandelic acid → phenylglyoxylic acid
- Styrene oxide → hydroxyphenylethyl mercapturic acid

**CMx:**

**Acute exposure:**
- 100-200 ppm → eye and upper respiratory tract irritation, skin irritation and dermatitis. Experimental
- Several hundred parts per million → organic solvent anesthetic symptoms, listlessness, drowsiness, impaired balance, difficulty in concentrating, ↓ reaction time, ↑ serum pituitary hormone secretion.

**Chronic exposure** → Weakness, headache, fatigue, poor memory, dizziness, ↓ Mean reaction time, ↓ visuomotor performance, abnormal EEGs, pancreatic cancer, and lymphohematopoietic cancer, leukemia, sensory nerve-conduction slowing, prolonged somatosensory evoked potentials, neuropsychological deficits, **color and contrast vision dysfunction, effect on hearing acuity**, alter the cell-mediated immune, ↑ risk of acute ischemic heart disease mortality.

**L/D:**
- ↑ hepatic transaminase, ↑ direct bilirubin, ↑ alkaline phosphatase concentrations.
- The most reliable indicator of styrene exposure is **Post shift mandelic acid levels in urine.**

**Biologic monitoring** → 1) Post shift mandelic acid levels in urine, 2) monoamine oxidase type B activity in platelets, 3) glycophorin A assay

- **Polyvinyl alcohol** and **polyethylene gloves** and protective clothing give good protection against styrene.

- **MEDICAL SURVEILLANCE** → Initial medical evaluation should include a history of **nervous system disorders** and an examination with particular attention to the **nervous system, respiratory tract, and skin.**

**2,3,7,8-TETRACHLORODIBENZO-PDIOXIN (2,3,7,8 TCDD)**

**ACUTE EFFECTS:**
- Eye and respiratory tract irritation
- Skin rash, chloracne
- Fatigue, nervousness, irritability

**CHRONIC EFFECTS:**
- Chloracne
- Soft-tissue sarcoma, non-Hodgkin lymphoma, Hodgkin disease

- **Use** → **Agent Orange**, used in Vietnam as a **defoliant**
- **Exposure** → during the production and use of 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) and its derivatives, Herbicide sprayers.

- **Metabolism & Mechanism of Action:**
  - It is stored in adipose tissue.
  - The half-life of 2,3,7,8-TCDD in human is 9 years.
Dermal absorption may be important.

CMx:
- **Acute exposure** → acute skin, eye, and respiratory tract irritation, headache, dizziness, nausea. These symptoms subsided within 1-2 weeks and were followed by an **acneiform eruption**, severe muscle pain in the extremities, thorax, shoulders. Fatigue, nervousness, irritability, dyspnea, ↓ libido, intolerance to cold, **severe chloracne**, hepatic enlargement, peripheral neuritis, ↑ PT, ↑ **total serum lipid levels**.
- **Chronic exposure** → **chloracne**, fatigue, weight loss, myalgias, insomnia, irritability, ↑ libido. Liver becomes tender and enlarged, sensory changes, particularly in the lower extremities, inhibits multiple estrogen-induced responses and **antiestrogenic effects**, spina bifida, peripheral neuropathy, heart disease, liver disorders, diabetes or abnormal fasting glucose, soft-tissue sarcoma, lymphohemopoietic neoplasms (non-Hodgkin lymphoma, Hodgkin disease), prostate cancer, breast cancer.

L/D:
- ↑ PT, ↑ TG, ↑ cholesterol, ↑ **Urinary porphyrins**.
- Abnormal nerve conduction tests significantly elevated in subjects with chloracne.
- Concentration of polychlorinated compounds in plasma may be 1000-fold less than in adipose tissue.
- There is a high correlation between adipose and serum 2,3,7,8-TCDD levels.
- **Serum levels are a valid measure of body burden**.
- The correlation between plasma and adipose tissue concentrations of 2,3,7,8-TCDD with signs and symptoms is uncertain.

DDx:
- Acneiform eruption → petroleum cutting oils, coal tar, chlorinated aromatic compounds.

NIOSH recommends that 2,3,7,8-TCDD be considered a potential occupational carcinogen and that exposure in all occupational settings be controlled to the fullest extent possible.

Protective clothing and equipment → made of nonwoven polyethylene fabric.

MEDICAL SURVEILLANCE:
- Baseline and periodic medical examinations → special attention to the skin and nervous system.
- Baseline laboratory testing → liver enzymes, cholesterol, triglycerides.
- Use of serum 2,3,7,8-TCDD levels.

**VINYL CHLORIDE MONOMER (VCM)**

**ACUTE EFFECTS** → Respiratory tract irritation, Lethargy, headache

**CHRONIC EFFECTS** → Acroosteolysis, Raynaud phenomenon, skin thickening, Hepatosplenomegaly, Hepatic angiosarcoma

Highly flammable gas

Use → vast majority of VCM is used for the production of polyvinyl chloride resins (in the production of plastic piping and conduit, floor coverings, home furnishings, electrical applications, recreational products
Exposure → The highest exposures occur in polymerization plants, particularly during reactor-vessel cleaning.

Metabolism & Mechanism of Action:

- Chief route of exposure to VCM → **inhalation** (although dermal absorption may be significant during manual reactor-vessel cleaning).
- Its primary metabolite → **chloroethylene oxide** → hepatic angiosarcoma
- Major urinary metabolite → Thiodiglycolic acid (TdGA)

CMx:

- Acute exposure → respiratory irritation and central nervous system depression (10,000-20,000 ppm).
- Chronic exposure → liver disease, osteolysis, Raynaud phenomenon, vasculitic purpura, mixed connectivetissue disease, scleroderma-like skin lesions.

✓ **Acroosteolysis** → Raynaud phenomenon, osteolysis, thickening or raised nodules on the hands and forearms.

✓ **Vinyl chloride disease** → Raynaud phenomenon, acroosteolysis, joint and muscle pain, ↑ collagen deposition, stiffness of the hands, scleroderma-like skin changes, ↑ circulating immune complex levels, cryoglobulinemia, B-cell proliferation, hyperimmunglobulinemia, complement activation (Susceptibility to this disease has been associated with the HLA-DR5 allele).

✓ **Liver disease** → Hepatic fibrosis, splenomegaly, **thrombocytopenia, portal hypertension, hepatic angiosarcoma, hepatocellular carcinoma**, liver cirrhosis, ↑ chromosomal aberrations, sister chromatid exchanges, and lymphocyte micronuclei, Hemangioendothelioma.

✓ **Pulmonary effects** → pneumoconiosis, ↓ pulmonary function, ↑ incidence of CXR abnormalities, mild obstructive airway disease, small opacities on CXR.

✓ **Reproductive effects** → ↓ androgen levels → impotence, ↓ libido

L/D:

- ↑ liver enzymes, ↑ alkaline phosphatase
- Fasting levels of **serum bile acids** and **urinary coproporphyrins** → clinically useful indicators of early chemical injury in VCM exposed worker populations with asymptomatic liver dysfunction.

DDx:

- Hepatic angiosarcoma → arsenic, thorium dioxide (Thorotrast) ingestion.
- VCM-associated sclerotic changes in skin, with skin nodules, Raynaud phenomenon, osteolysis → idiopathic scleroderma

✓ **Sclerodactyly, calcinosis, and digital pitting scars** are unusual in VCM disease.

MEDICAL SURVEILLANCE:

- Preplacement medical examination should evaluate the presence of **liver disease**.
- Preplacement and periodic measurements of liver enzymes are recommended by NIOSH.
- Concurrent viral hepatitis and alcohol consumption → ↑ the risk of liver disease
• ↑ γ-glutamyl transpeptidase level is associated with vinyl chloride exposure and may offer greater specificity for medical surveillance.

• Fasting levels of serum bile acids or plasma clearance of technetium-labeled iminodiacetate → sensitive measure of liver dysfunction among vinyl chloride-exposed workers.

• Liver ultrasonography is a useful diagnostic test for medical surveillance of vinyl chloride workers → periportal fibrosis among more highly exposed workers.

➢ Acroosteolysis appears to be irreversible after cessation of exposure.

➢ Note:
  ✓ Coronary aretry dx(CAD) → CS2, nitrates
  ✓ ↑ TG → CS2, PCB, 2,3,7,8-TCDD
  ✓ Chloracne →PCP, PCB, PCDD, PCDF
  ✓ Non-Hodgkin lymphoma → PCP, phenoxy acetic acid, 2,3,7,8,-TCDD
  ✓ Proper gloves for special chemicals
    ▪ Styrene → polyethylene, polyvinyl alcohol
    ▪ Formaldehyde → neoprene
    ▪ Nitrates → cotton
    ▪ PCP → nitrile, PVC
    ▪ 2,3,7,8-TCDD → non woven polyethylene fabric