

Industrial-occupational toxicology



Unit -5

CUTM1648: Concepts of Toxicology

By: Dr. R. C. Jhamtani

INTRODUCTION

- ▶ **Toxicology**: is the study of the nature and action of chemical substances on living systems.
- ▶ It is the science and study of harmful chemical interactions on living tissue.
- ▶ **Toxicity** is the ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or on the body. The ability of a substance to cause harm or adversely affect an organism.

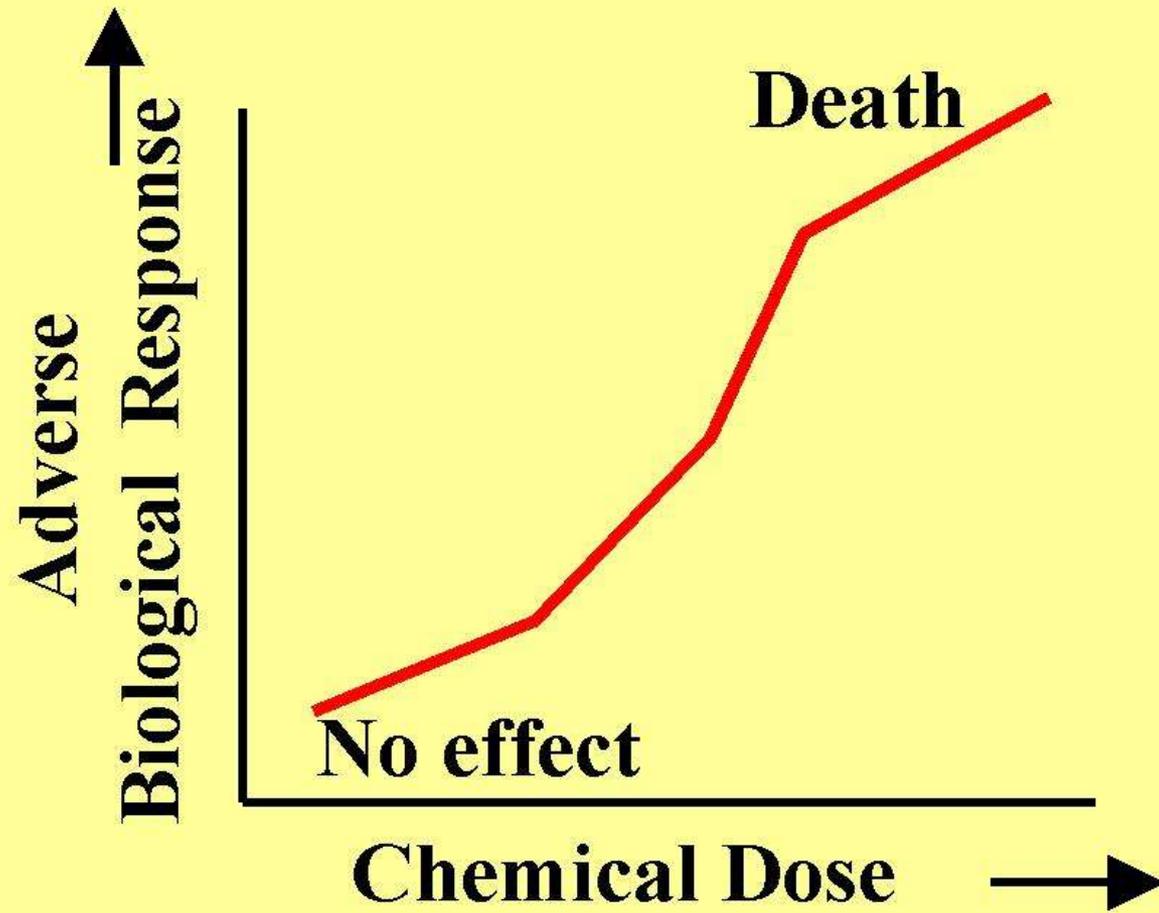
What is industrial toxicology ...?

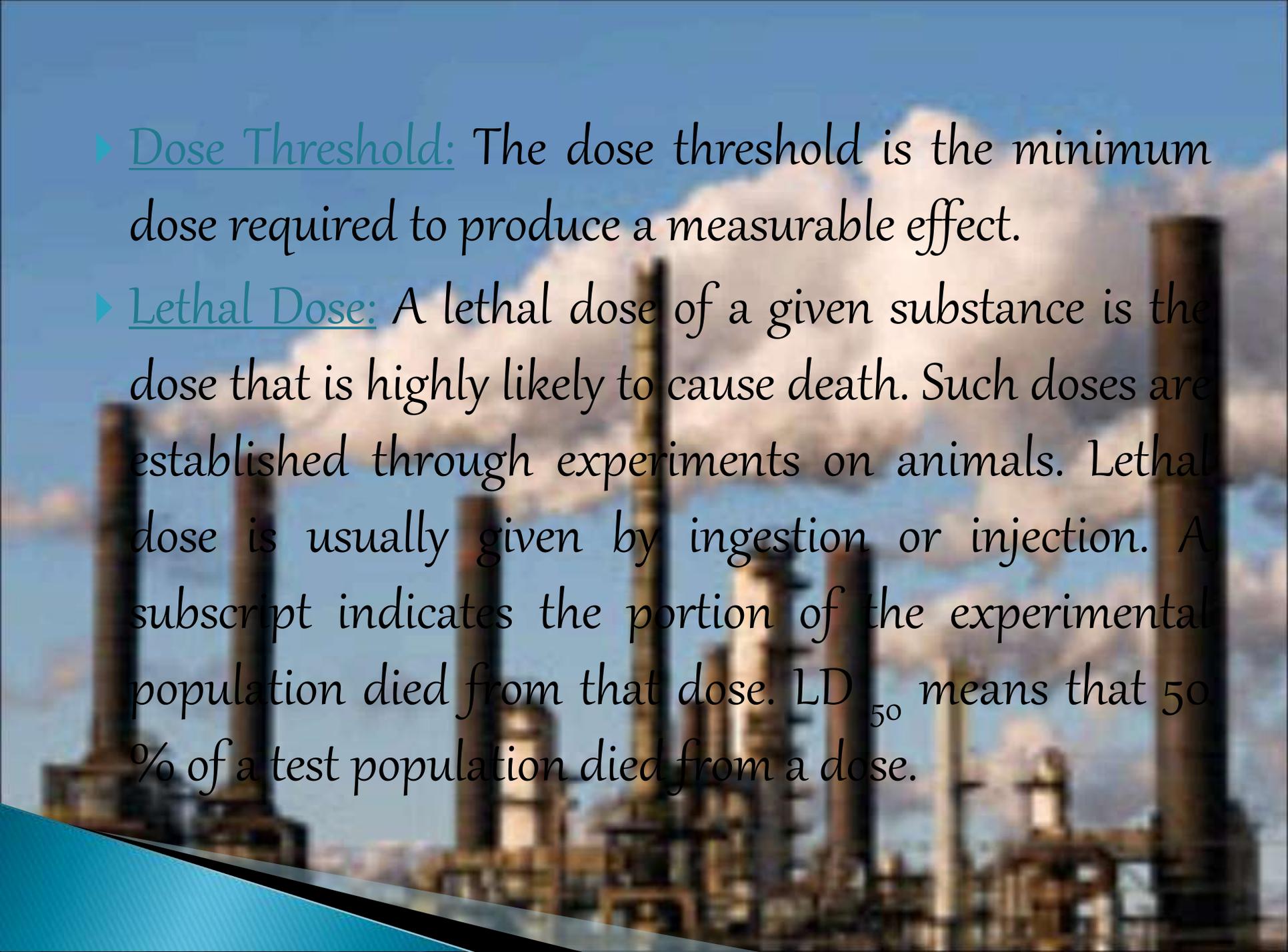
- It is very close related to environment toxicology.
- It deals with nature and type of chemicals released by the industries in ambient air and in water.



Dose-Response Relationships

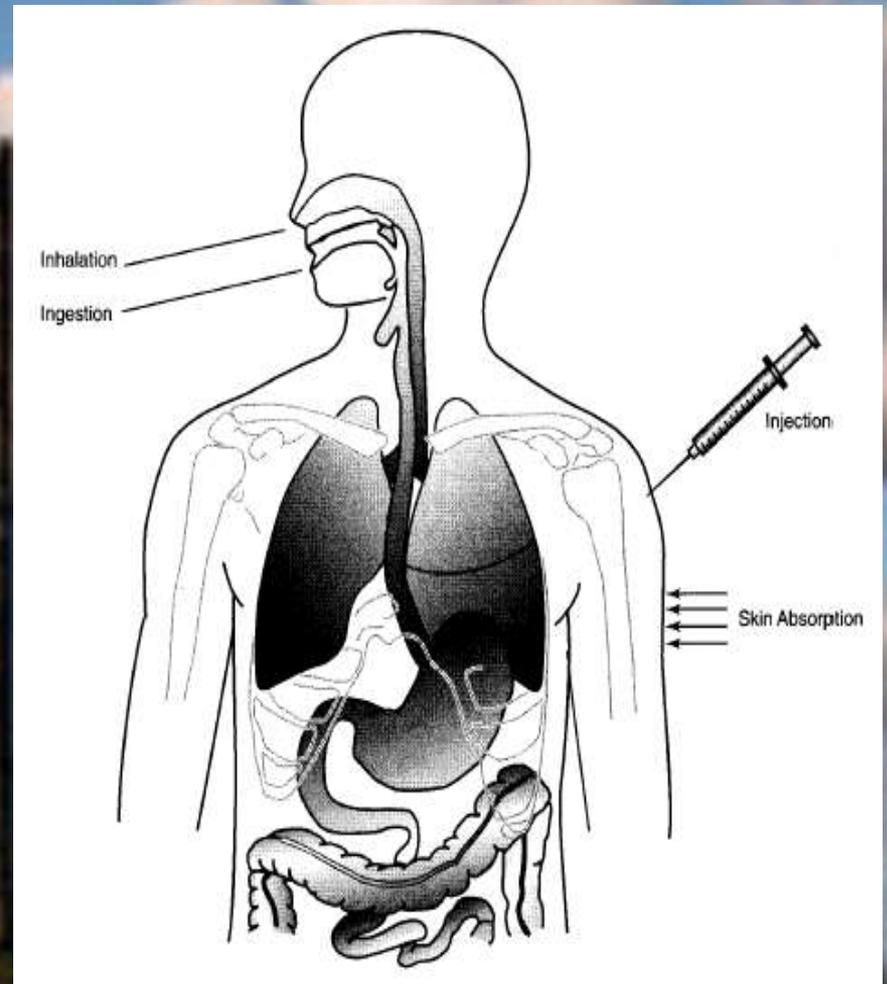
- ▶ The potential toxicity (harmful action) inherent in a substance is manifest only when that substance comes in contact with a susceptible living biological system. A chemical normally thought of as "harmless" will evoke a toxic response if added to a biological system in sufficient amount. The toxic potency of a chemical is defined by the relationship between the dose (the amount) of the chemical and the response that is produced in a biological system.



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- ▶ Dose Threshold: The dose threshold is the minimum dose required to produce a measurable effect.
 - ▶ Lethal Dose: A lethal dose of a given substance is the dose that is highly likely to cause death. Such doses are established through experiments on animals. Lethal dose is usually given by ingestion or injection. A subscript indicates the portion of the experimental population died from that dose. LD_{50} means that 50% of a test population died from a dose.

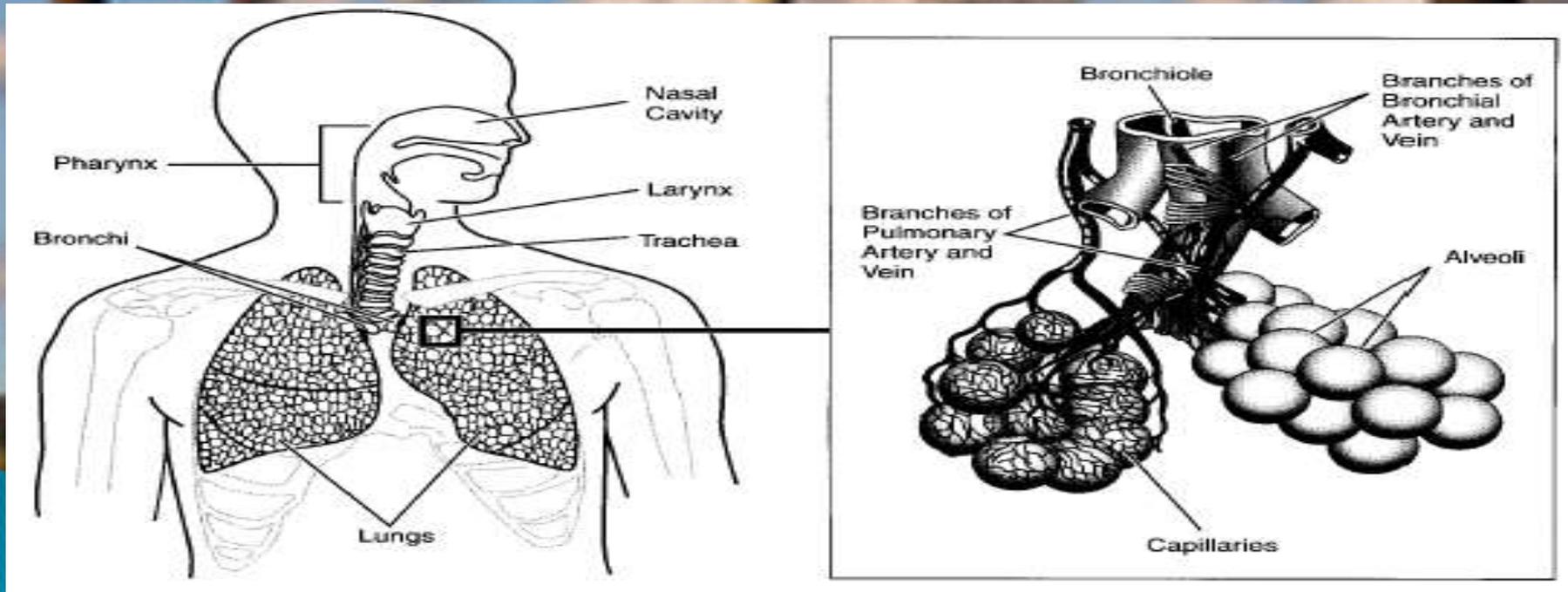
Routes of Entry into the Body

- ▶ Inhalation
- ▶ Ingestion
- ▶ Absorption through the skin
- ▶ Less common
 - Injection
 - Absorption through eyes and ear canals



Inhalation

- ▶ Most common route of entry into body
- ▶ Therefore our area of highest concern
- ▶ Lungs are designed for efficient gas exchange between the air and bloodstream





Skin Absorption (2nd most important route)

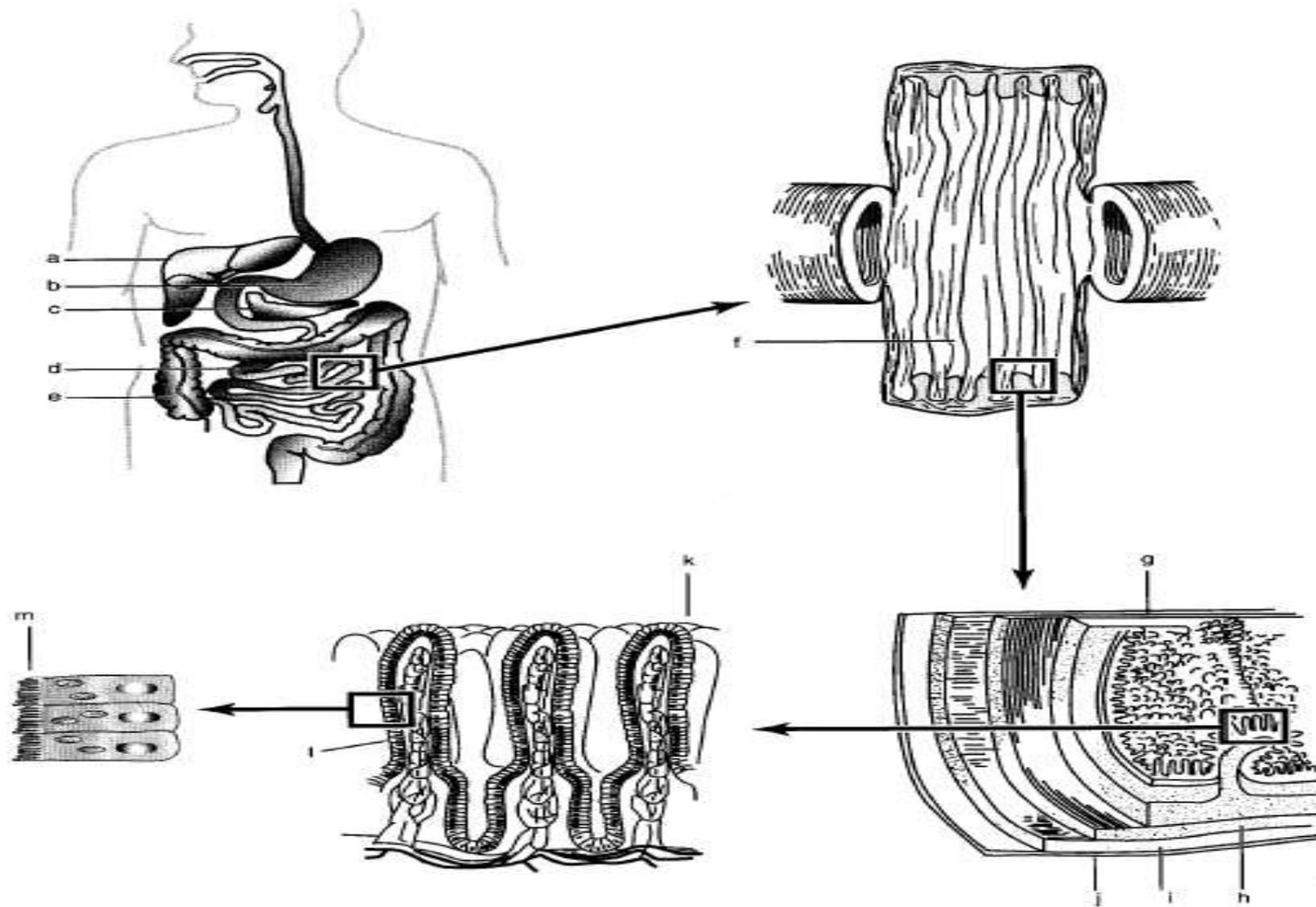
- ▶ Skin surface area is about 20 square feet (4.5 ft by 4.5 ft)
 - Compare to 1000 sq ft for lungs
- ▶ Materials can be absorbed into blood stream just below the skin surface or toxins can be stored in fat deposits
- ▶ Obviously workers can easily expose their hands into solvents, oils, chemicals, etc., plus these materials can be sprayed or rubbed on other parts of the body
- ▶ Many chemicals are either soluble in water or in oil (fat, lipid)
 - The skin easily absorbs lipid-soluble materials
 - Solvents
 - Water-soluble materials are not easily absorbed
 - Lipid layer on skin provides a barrier

Ingestion (3rd most important route)

- ▶ Ingestion is not usually intentional
- ▶ Unintentional ingestion
 - Failure to wash hands and face before meals
 - Eating/drinking in areas where airborne hazards exist
 - Lighting cigarettes with dirty hands
 - Application of cosmetics
 - Use of chewing tobacco or gum in contaminated areas

Ingestion

- ▶ The digestive tract is moist and designed for efficient absorption
- ▶ Surface area of intestines is greatly increased by small projections (villi)
 - Thin surfaces, highly vascularized
 - Materials easily transferred to bloodstream



- a Liver
- b Stomach
- c Duodenum
- d Ileum
- e Colon

f Longitudinal section of the ileum showing folding that increases surface area

- g Detail of fold showing villi with circular and longitudinal muscles
- h and i, Circular muscles bounded by the serosal membrane
- j Serosal membrane
- k Detail of villi
- m Microvilli

Injection

- ▶ Less common
- ▶ Possible hazards
 - Outdoor work, construction sites, hazardous waste sites, plants, animals, reptiles, insects, abrasions, puncture wounds, cuts, needle sticks

Absorption into eyes and ears

- ▶ Much less common but possible
- ▶ Moist surfaces

Example of Toxicity Classification

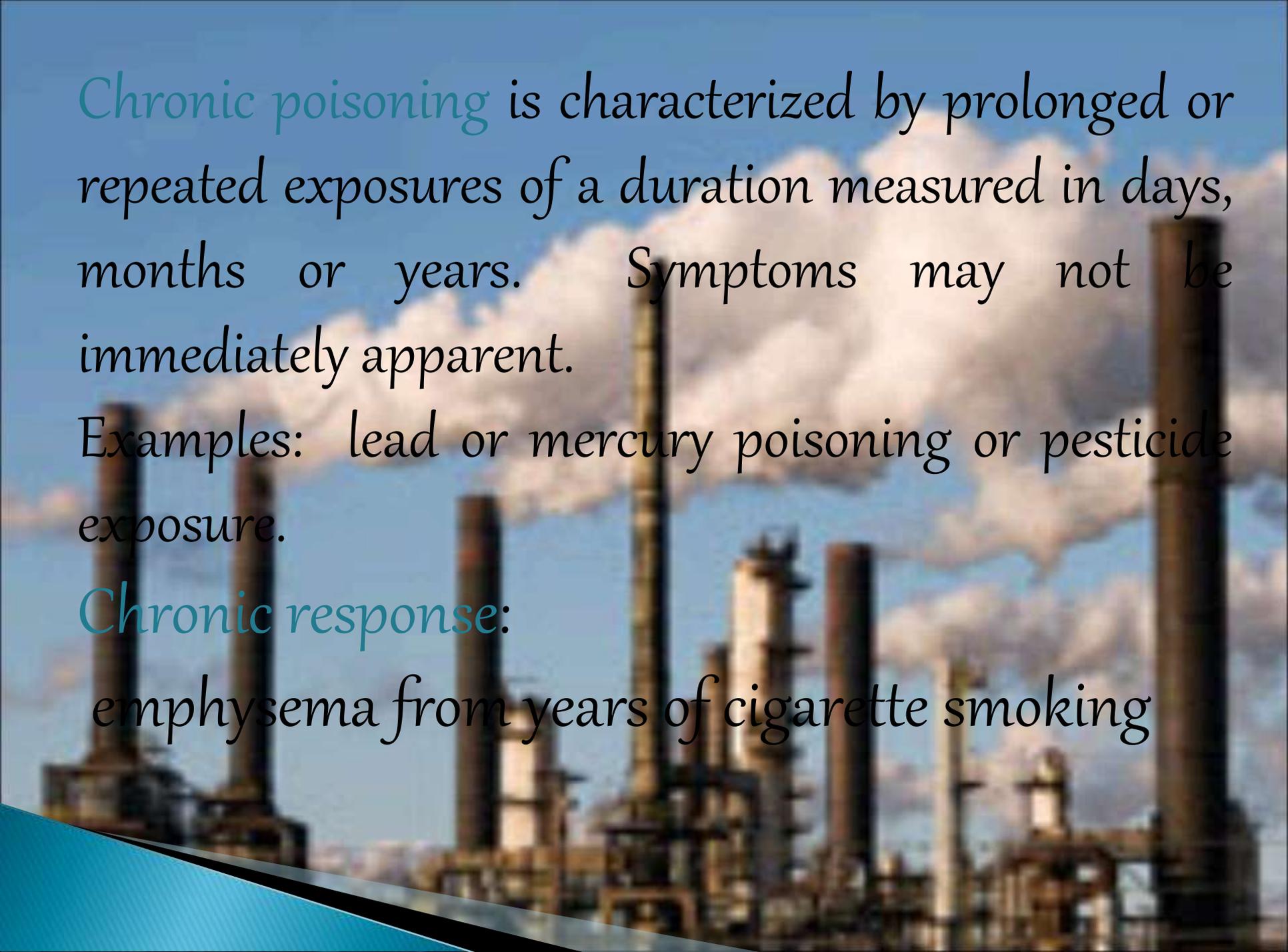
Toxicity Classification	LD₅₀ Oral mg/kg	LD₅₀ Inhalation mg/kg	LD₅₀ Skin mg/kg
Supertoxic	<5	<250	<250
Extremely toxic	5-50	250-1,000	250-1,000
Very toxic	50-500	1,000-10,000	1,000-3,000
Moderately toxic	500-5,000	10,000-30,000	3,000-10,000
Slightly toxic	>5,000	>30,000	>10,000

Health Effects

Acute poisoning is characterized by rapid absorption of the substance and the exposure is sudden and severe. Normally, a single large exposure is involved. Examples: carbon monoxide or cyanide poisoning.

Acute response:

- rash,
- watering eyes,
- cough from brief exposure to ammonia



Chronic poisoning is characterized by prolonged or repeated exposures of a duration measured in days, months or years. Symptoms may not be immediately apparent.

Examples: lead or mercury poisoning or pesticide exposure.

Chronic response:

emphysema from years of cigarette smoking

No response: at low dosage levels there may be no response at all

Threshold dose: the lowest level of dosage at which a response is manifested

NOAEL: no observed adverse effect level

NEL: no effect level

Above threshold dose: response can be positive up to a point and then could become toxic to the organism

Different people or organisms will exhibit a variety of responses

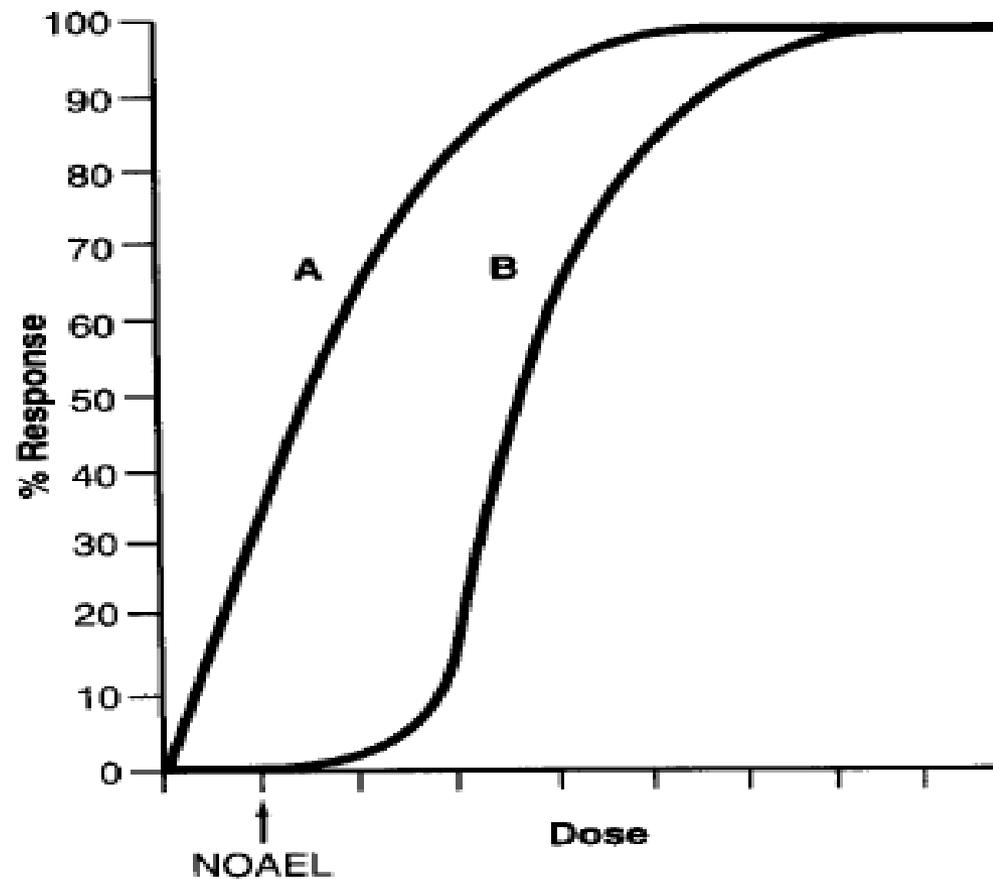


Figure 2-3: Dose-response curves contrasting two different materials with different toxicities. Comparison of the dose-response relationship for different materials can be an aid in evaluating toxicity. The slope of the dose-response curve is generally related to toxicity, with more toxic materials exhibiting a steeper slope.

Classes of Toxins and Toxic Responses

The background of the slide is a photograph of an industrial facility, likely a refinery or chemical plant. Several tall, dark smokestacks are visible, each emitting a plume of white smoke that rises into the sky. The sky is a clear, bright blue. The industrial structures themselves are complex, with various pipes, tanks, and scaffolding visible. The overall scene suggests a source of environmental pollutants and toxins.

- ▶ Irritants and Sensitizers
- ▶ Systemic Toxins
- ▶ Neurotoxins
- ▶ Reproductive Toxins
- ▶ Carcinogens

Irritants

- ▶ Localized, some physical damage
- ▶ To skin, eyes, respiratory system
- ▶ Corrosion – most severe response
 - Ulceration, tissue damage, usually permanent
 - E.g., chemical burns from acids and bases
- ▶ Acute irritations
 - Redness, inflammation, usually reversible

Sensitizers

- ▶ Substances that stimulate a response from the immune system, usually the second exposure
 - Triggering exposure can be extremely low dose
- ▶ Immune system – recognize and reject foreign objects in the body, including infectious disease and hazardous materials
- ▶ Allergic reaction releases antibodies to attack
- ▶ Reaction ranges from skin rash to anaphylactic shock (life threatening)

Systemic Toxins

- ▶ Toxins that affect target organs
 - Vinyl chloride – liver (cancer)
 - Cadmium – kidney
 - Benzene – blood marrow (leukemia)
- ▶ Toxicity mechanism is often related to the normal function of the target organ

Neurotoxins

- ▶ Compounds that negatively affect the nervous system
- ▶ Response can be mild to severe
 - Effects can impact thinking ability, motor control, regulation of breathing and heartbeat
- ▶ Central Nervous System [CNS] (brain, spinal cord)
 - Coordination, emotion, speech, memory
- ▶ Peripheral Nervous System [PNS] (all but brain, spinal cord)
 - Sensory info (touch, heat/cold, proprioception, pain)
 - Motor impulses (movement)
- ▶ Autonomic Nervous System [ANS]
 - heart rate, breathing, organ control, reflexes
- ▶ Neurotoxins can produce **neuropathy** – a toxic effect characterized by progressive decline and death of nerves

Portion of Nervous System	Primary Function/Control	Examples of Agents that Cause Damage or Other Adverse Effects
Central nervous system (brain and spinal cord)	Body movement, memory, emotions and behavior	Mercury Lead Carbon monoxide Organic solvents Pesticides
Autonomic nervous system (sympathetic and parasympathetic)	Heartbeat, breathing, reflexes	Organophosphorous compounds Vibration Metals (Lead, mercury, arsenic)
Peripheral nervous system* (peripheral nerves, brain stem, and spinal cord) <ul style="list-style-type: none"> – Sensory – Motor 	<ul style="list-style-type: none"> – Senses (heat, cold, touch, pain, pressure, proprioception) – Voluntary motor control 	Metals (Lead, organic mercury, arsenic) Organic solvents (hexane, carbon disulfide, methanol) Organophosphorous compounds Vibration Traumatic injury Compressive injury (repetitive motion/use)
* Agents listed for peripheral nervous system often present symptoms involving both sensory and motor function impairment.		

Table 2-7: This table summarizes the functions of the different parts of the nervous system. Some materials have damaging effects on only one part of the system; others affect more than one. Damage to the nervous system may be manifested in striking ways, such as behavioral changes or changes in motor coordination.

**Substances Associated with
Central Nervous System Effects**

Organic solvents	Arsenic
Lead and lead compounds	Organic mercury
Asphyxiant gases	Organochloride compounds
Carbon monoxide	Organophosphate compounds
Cyanide compounds	Manganese

**Substances Associated with
Peripheral Nervous System Effects**

Arsenic	Lead
Organic mercury	n-Hexane
Methanol	Organophosphate compounds
Ethylene glycol	Organochloride compounds

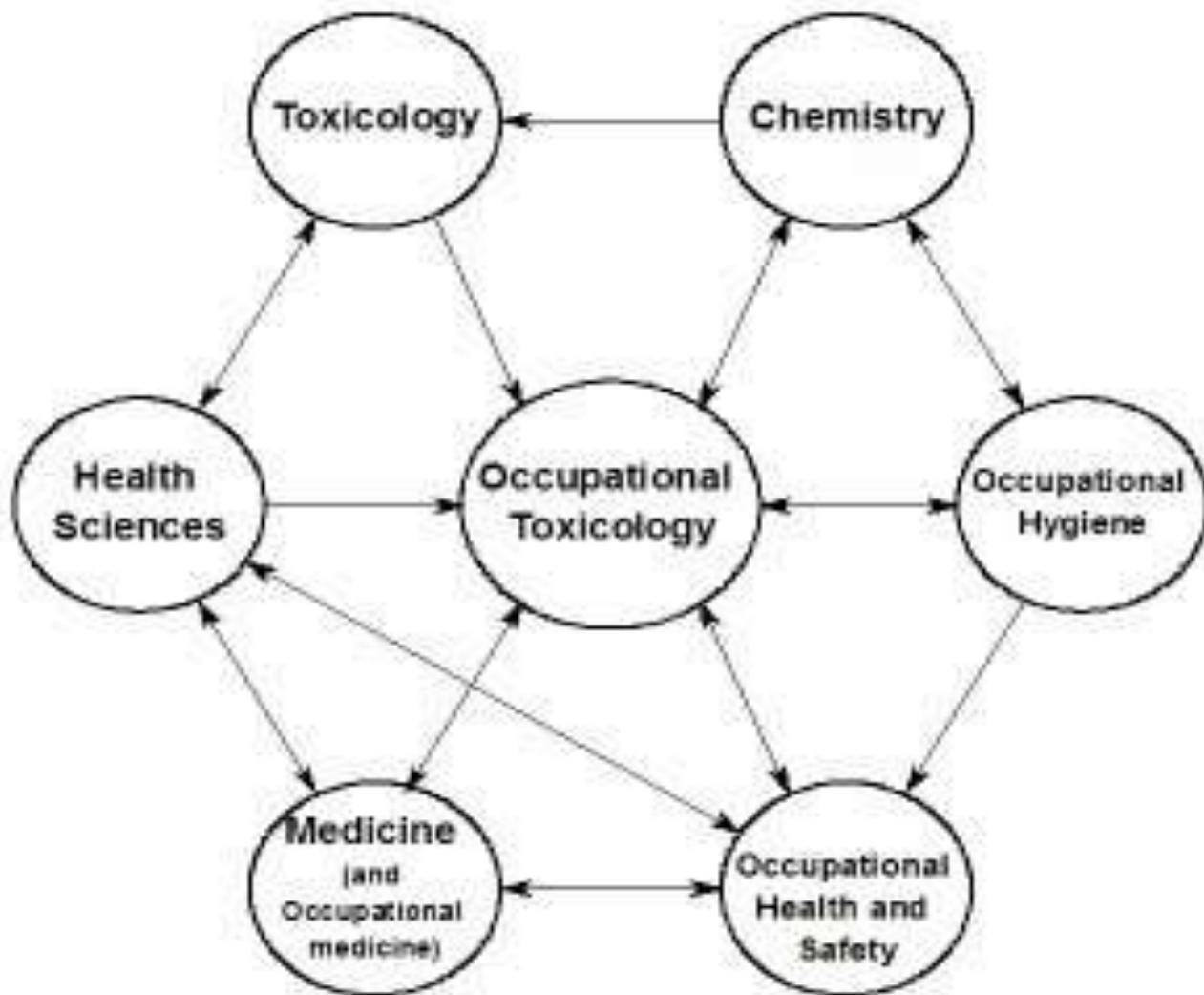
Table 2-8: Many substances that workers are exposed to can affect the nervous system. These include metals, solvents, and pesticides. Effects of these materials include temporary dizziness from solvent exposure, loss of motor control from pesticides, and developmental defects from exposure to metals.



What is Occupational Toxicology

The discipline which:

Identifies chemical, physical or biological hazards encountered in the work environment Recognizes adverse health effects that arise out of workers' exposures to these toxicants Establishes control measures to prevent or minimize exposures



Learning Objectives

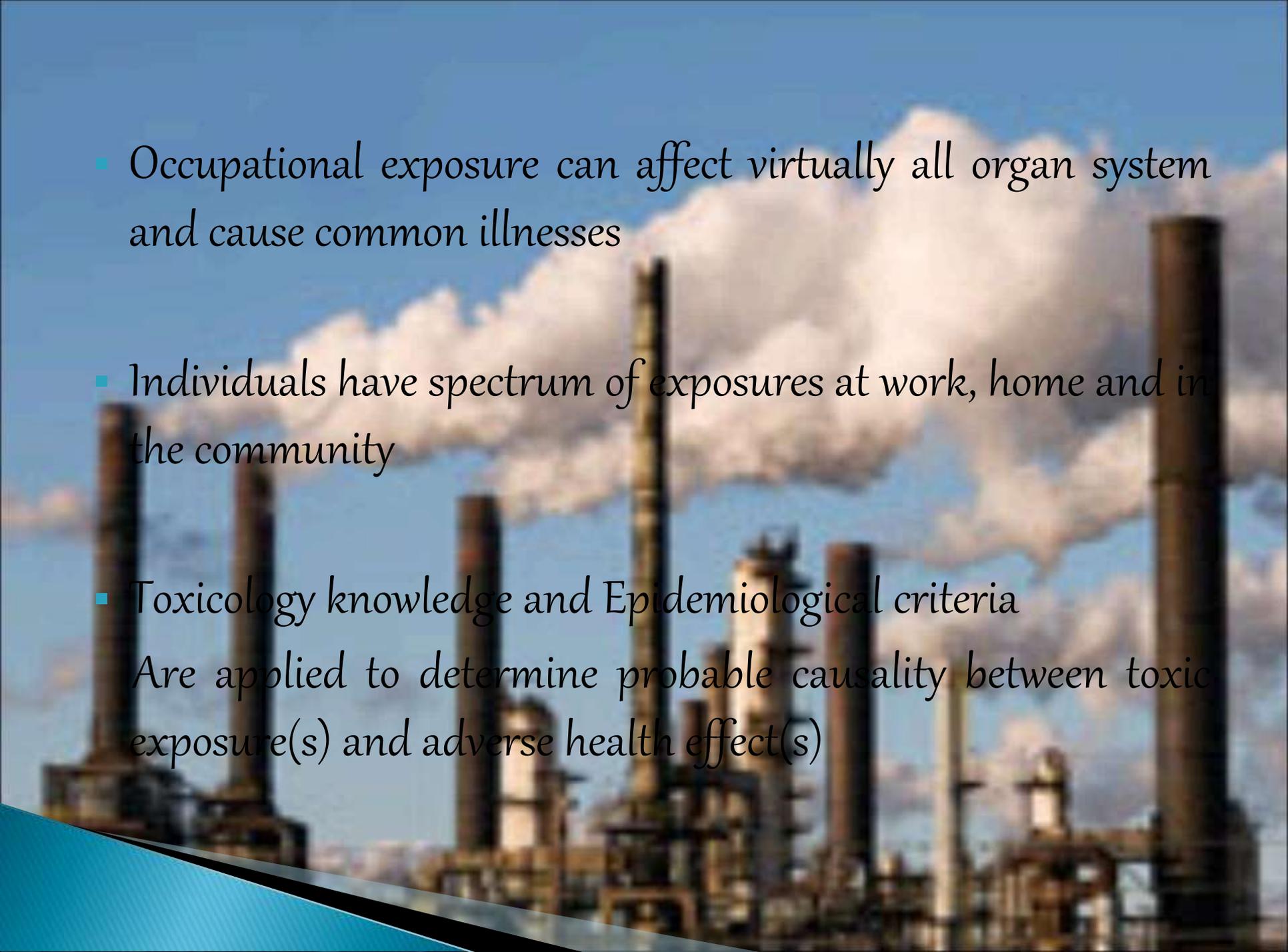
- To recognize occupational exposures to toxicants (Exposure History)
- To monitor exposures and their impacts on the environment
- To prevent exposures and their adverse health effects



Exposure History

Importance & Implications

- Worker (limitation of temporary or permanent disability)
- Public health risk (co-workers, children at home, environment)
- Occupational illnesses are preventable

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- Occupational exposure can affect virtually all organ system and cause common illnesses
 - Individuals have spectrum of exposures at work, home and in the community
 - Toxicology knowledge and Epidemiological criteria
Are applied to determine probable causality between toxic exposure(s) and adverse health effect(s)

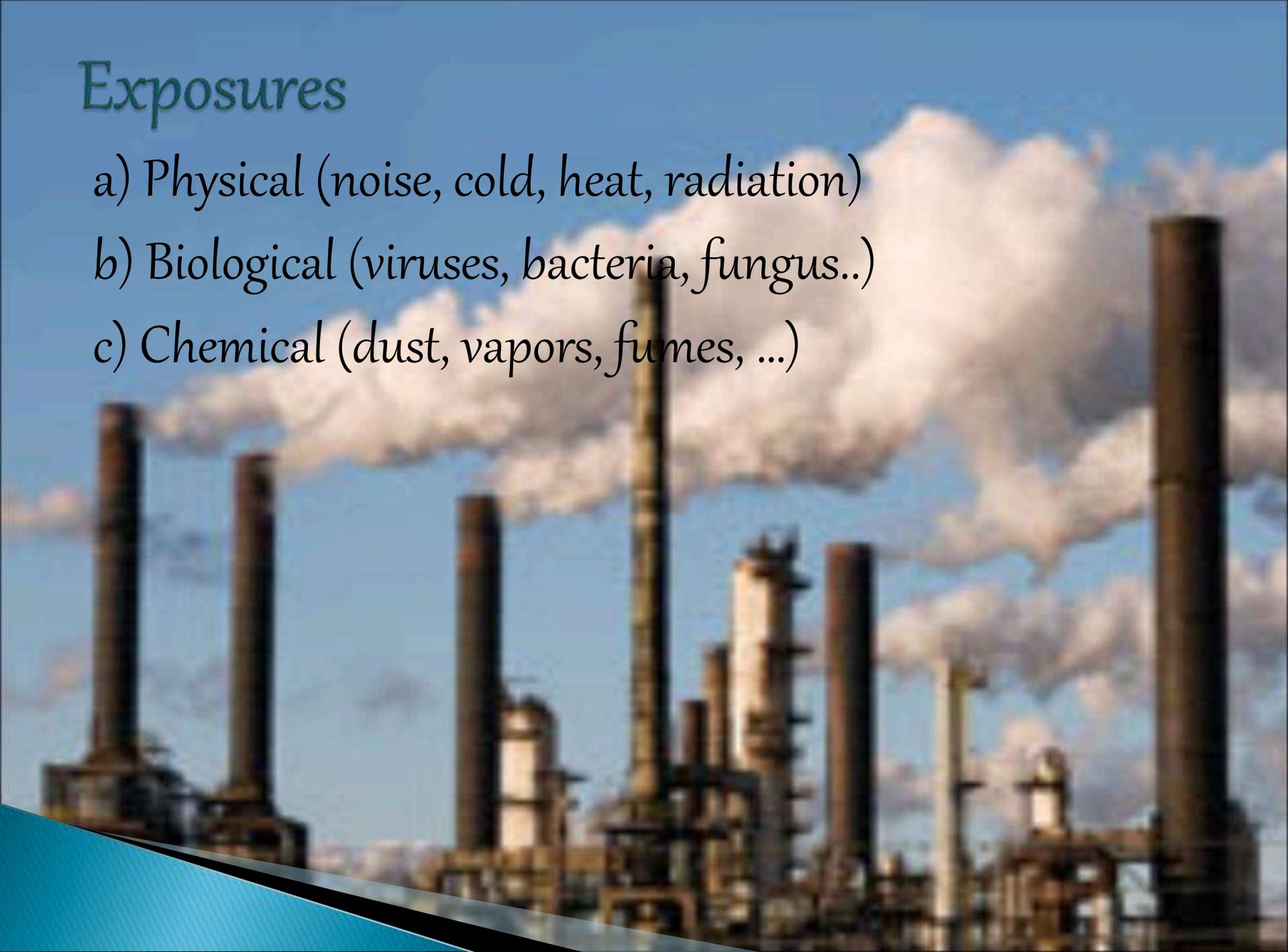
Work history (present and past)

Type of work (physical and psychological demands, working practices)

- Exposures (physical, chemical or biological)
- Control measures (protective equipment, monitoring...)
- Co-workers (similar illness, absent, turnover)

Exposures

- a) Physical (noise, cold, heat, radiation)
- b) Biological (viruses, bacteria, fungus..)
- c) Chemical (dust, vapors, fumes, ...)



Control measures

- a) Personal Protective Equipment (PPE)
- b) Monitoring the workplace, enclosed operation
(Safety Officer/Industrial Hygienist)
- c) Medical Surveillance



Monitoring Exposures

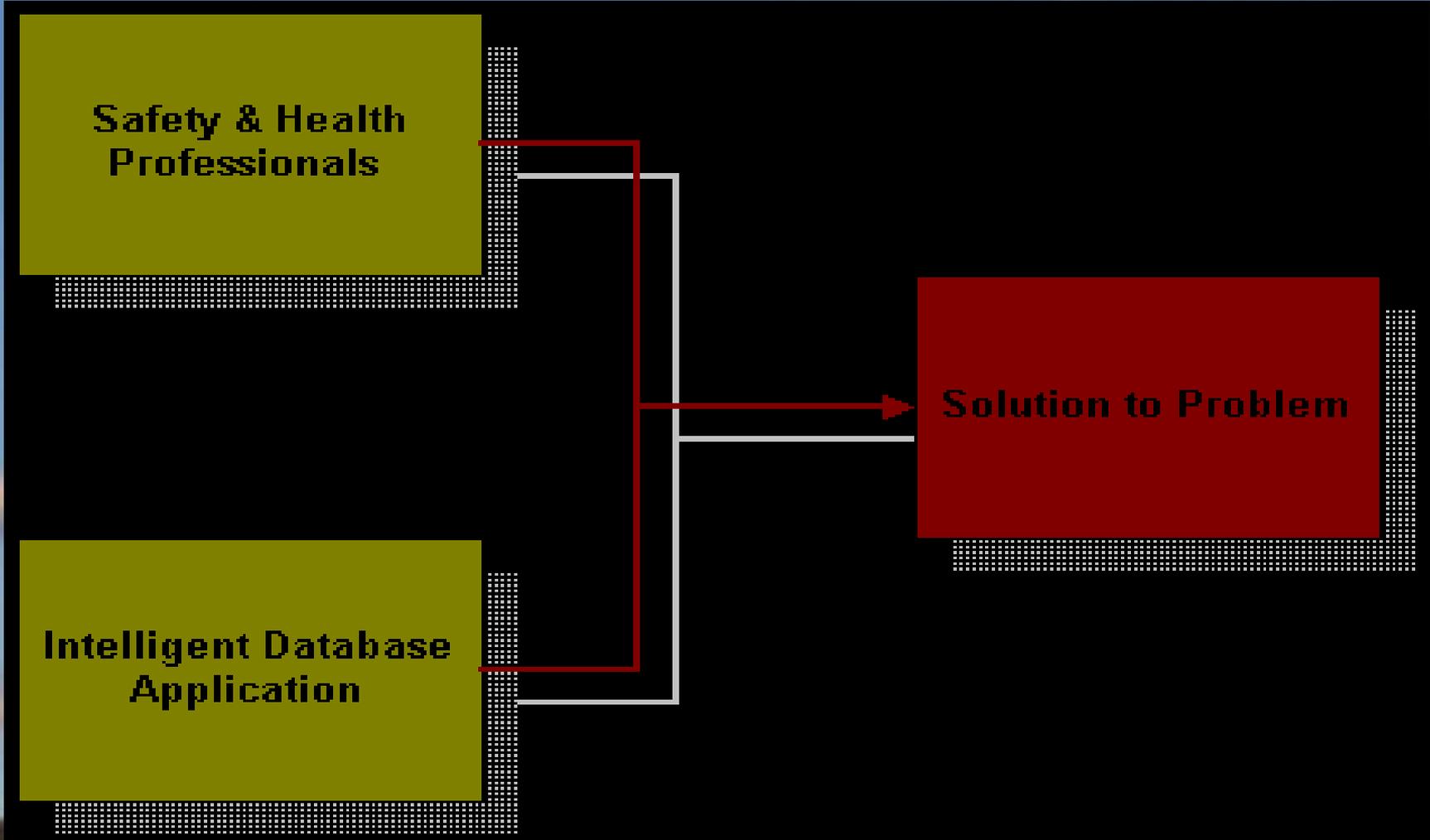
Risk Management

- Determination & Implementation of the appropriate control measures to reduce the risk
- Providing information & educating workers
- Establishing & Implementing policies in compliance with the standards & regulations
- Monitoring the effectiveness of the program and keeping records

Prevention

- Implementing control measures
- Monitoring workers (screening)
- Limiting worker's disability





**Safety & Health
Professionals**

Solution to Problem

**Intelligent Database
Application**

Thank you

