THE OHIO STATE UNIVERSITY
COLLEGE OF PUBLIC HEALTH

Environmental Public Health: Biological Basis of Human Disease Risk

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ASPPH Webinar – *Review for NBPHE CPH Exam*

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Biographical Abstract

Michael Bisesi, PhD, REHS, CIH, is currently the Senior Associate Dean and Director of Academic Affairs, and Professor and Chair (interim) of Environmental Health Sciences in the College of Public Health at The Ohio State University (OSU). Prior to his appointment at OSU in 2009, he served for 19 years as a scientist (including 12 years as tenured Professor of Public Health), Department Chairman, and Senior Associate Dean at the Medical University of Ohio and the University of Toledo College of Medicine and Health Science Campus. He was also the co-founder and Director of the tri-university Northwest Ohio Consortium for Public Health. At the beginning of his career, he held positions as an occupational health (industrial hygiene) specialist at the corporate Tenneco Chemicals Environmental/Medical Affairs Division and as an Assistant, and then tenured Associate, Professor of Health and Safety at Indiana State University.

Dr. Bisesi is an Environmental Health Scientist, Board Certified Industrial Hygienist, ABIH Diplomat, AIHA Fellow, and Registered Environmental Health Specialist (inactive, NJ). His primary scientific expertise includes assessment (monitoring) of human exposure to and control of toxic and infectious agents; applied environmental toxicology and microbiology; and hazardous material/emergency incident recognition/response. He is actively engaged in international work via the *Ohio State-Eastern Africa One Health* projects and the OSU *Global One Health initiative* (GOHi).

Dr. Bisesi has authored/co-authored several journal articles as well as chapters in major reference books, including the *Occupational Environment: Its Evaluation and Control* (1st and 2nd ed) and also several in *Patty's Industrial Hygiene and Toxicology* (4th and 5th ed). In addition, he is author of the highly touted textbooks *Industrial Hygiene Evaluation Methods* (2nd ed) and co-author of two other volumes of the *Handbook of Environmental Health* (4th ed) entitled Volume 1 - *Biological, Chemical and Physical Agents of Environmentally Related Disease* and Volume 2 - *Pollutant Interactions in Air, Water and Soil*. He serves on numerous committees and councils at the university-, state- and national-levels. This includes his recent appointment by Governor Kasich to serve on Ohio’s Radiation Advisory Council.

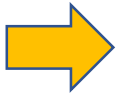
Purpose of Webinar and Module

Provide a succinct overview of some relevant content to assist learners preparing to take the *Certified in Public Health* (CPH) exam offered by the National Board of Public Health Examiners (NBPHE) . . .

The focus of this Webinar is on the CPH Domain (*Environmental*) *Public Health Biology and Human Disease Risk*

Webinar participants are encouraged to review the CPH Study Resources located at https://www.nbphe.org/cph-study-resources/

CPH Domains:	Social Behavioral Sciences	Epidemiology	Environmental and Occupational Health	Health Policy and Management	Biostatistics
Evidence-based Approaches to Public Health					
Communications					
Leadership					
Law and Ethics					
Public Health Biology and Human Disease Risk					
Collaboration and Partnership					
Program Planning and Evaluation					
Program Management					
Policy in Public Health					
Health Equity and Social Justice					



Applicable NBPHE CPH Exam "Domain Tasks"

1. Apply biological concepts to inform public health laws, policies, and regulations
2. Assess how biological agents affect human health
3. Identify risk factors and modes of transmission for infectious diseases and how these diseases affect both personal and population health
4. Identify risk factors for non-infectious diseases and how these issues affect both personal and population health

Webinar Learning Objectives

Upon completion of the modules, learners will be better prepared to:

- ***define the categories and subcategories of hazardous environmental contaminants;***
- ***identify the four major environmental matrices vulnerable to contamination by hazardous physical, chemical and biological agents;***
- ***summarize the relationship between a contaminated environmental matrix and exposure hazards based on exposure pathways, exposure modes and routes, and characteristics of the environmental contaminants;***
- ***differentiate between and among exposure, hazard and risk of disease***
- ***name major applicable federal regulations and key focus areas***

Module Topics

- Hazardous Agents, Human Exposures and Disease Risks
- Categories, Subcategories and Characteristics of Hazardous Agents
- Environmental Matrices and Sources of Contaminants
- Pathways, Modes and Routes of Exposure
- General Categories of Adverse Effects
- Direct and Indirect Exposure
- Factors Associated with Vulnerability to and Risk of Disease
- Guidelines/Regulatory Points Air, Water and Food
- One Health
- Some Approaches to Environmental and Medical Monitoring

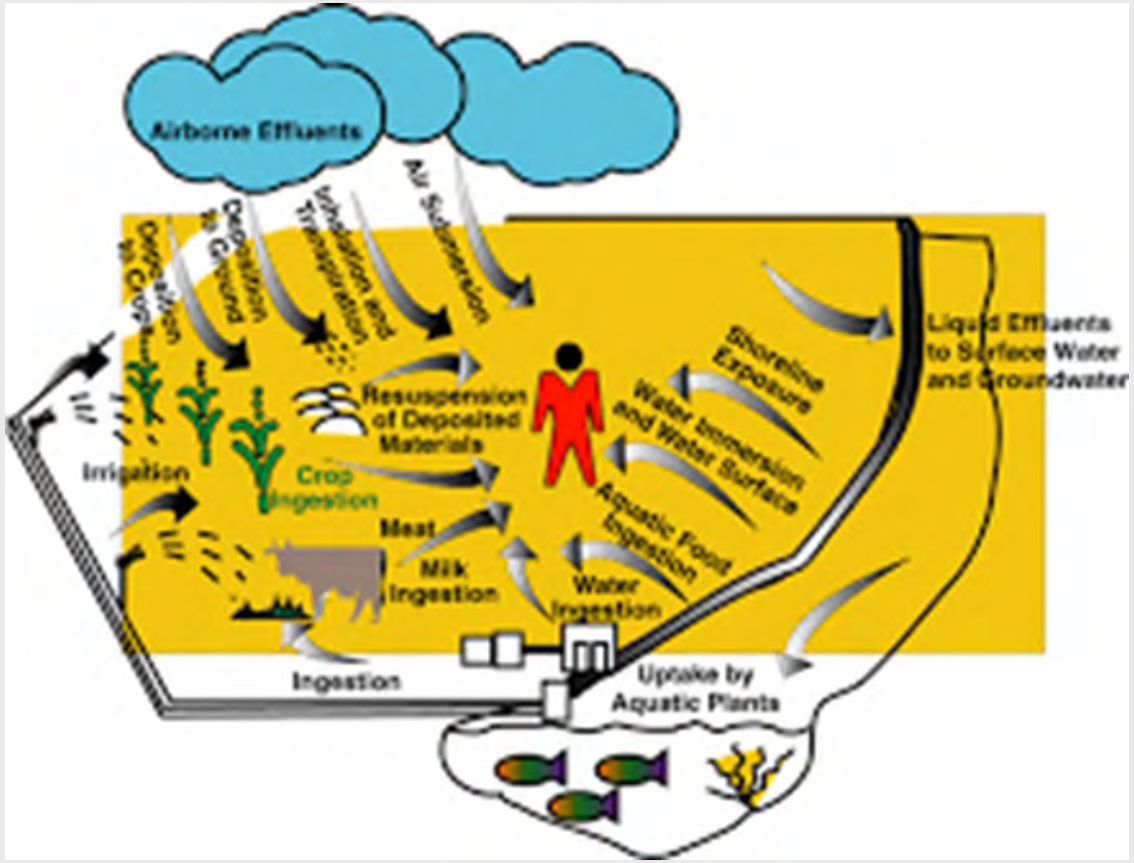
What is the major distinction between "hazards" and "risks"?

“Hazard” and “Risk” … each is related to “Exposure”

***Hazard*:** (1) Inherent *harmful characteristics* of an agent; and, (2) Potential for *exposure* to occur. . .

***Risk*:** Probability that an adverse effect will occur when *exposed* to a given concentration or in the presence of a given dose of a hazardous agent . . .

"***Hazard***" refers to the more generic potential for danger based on the possibility of exposure due to specific conditions. . .

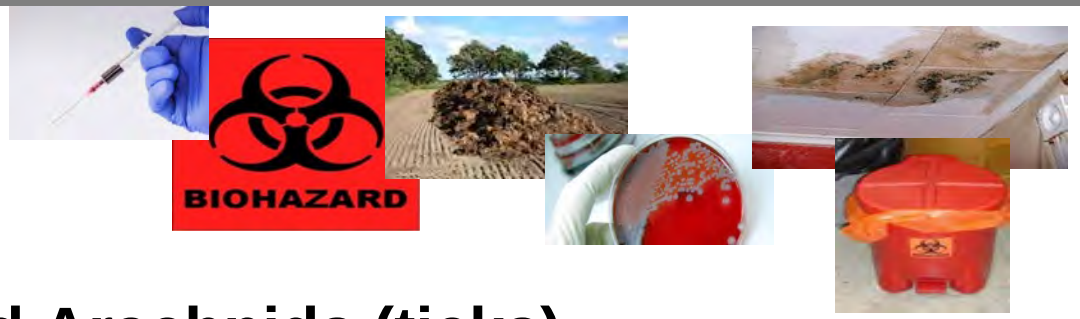


"***Risk***" refers to the probability that a response will occur based on specified conditions of exposure (i.e. mode, type, concentration, time, etc…)

What are the major categories, subcategories and characteristics of <u>hazardous</u> environmental contaminants associated with human <u>exposures</u> and <u>risk</u> of initiating disease?

Categories and Types of Hazardous Agents in the Environment

- **Biological:**
  - **Infectious Microbes (bacteria; fungi; protozoa; viruses; helminths)**
  - **Vector Insects (flies; mosquitoes) and Arachnids (ticks)**



- **Chemical:**
  - **Toxic Organics and Inorganics**

- **Physical:**
  - **Toxic Ionizing and Nonionizing Radiation**
  - **Noise**
  - **Temperature fluctuations and extremes**

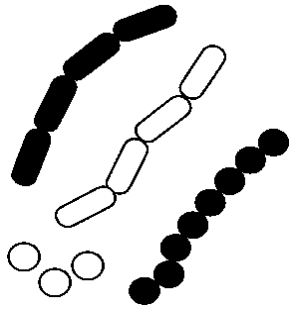
Biological Agents

- Types of Microbial Agents:
  - Viruses
  - Bacteria
  - Fungi
  - Protozoans
  - Helminths

- ***Pathogen*** *= viable organism which produces illness in a host due to an infection (invasiveness) or intoxication (release of toxic metabolite)*

Biological Agents: Subcategories

- **Infectious**
  - Microorganisms (H1N1 virus; *B. anthracis*)
- **Allergenic**
  - Microorganisms (molds)
  - Mesoorganisms (plant pollens)
- **Toxic (synthesize biochemical "Toxins")**
  - Microorganisms (*C. botulinum*)
  - Mesoorganisms (Poison Ivy urushiol)
  - Macroorganisms (venomous snakes)



Infectious Microbes

- Organisms that proliferate within human systems, along with a combination of their virulence and the host's resistance, can cause disease or dysfunction

Allergenic Microbes

- Organisms that interact specifically with human's immune system, which in turn, can cause an exaggerated response

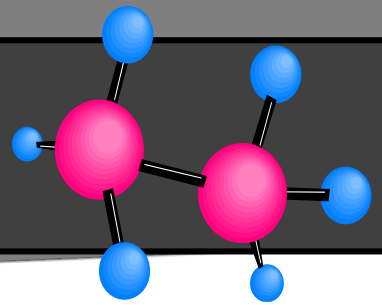
…organisms do not need to be alive to cause immune response ("allergens" remain active)

Toxic Microbes

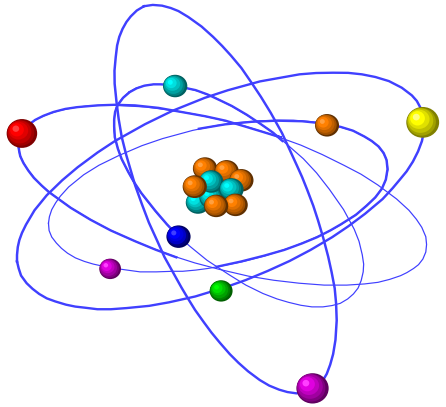
- Organisms that **synthesize and contain and/or release chemical/biochemical compounds (“toxins”)** that interact molecularly with subcellular components of human systems and cause alterations of biochemistry and physiology, which in turn, can cause disease or dysfunction

  …organisms do not need to be alive for “toxins” to remain active

Chemical Agents



- **Inorganic Chemicals** (e.g. metals, nitrites/nitrates,…)
- **Organic Chemicals** (e.g. solvents, pesticides,…)
- **Forms:**
  - Elements (e.g. Pb, Cl . . .)
  - Compounds (e.g. $PbCl_2$)
  - Molecules (e.g. H_2O, C_6H_6)



Chemical Agents: Subcategories

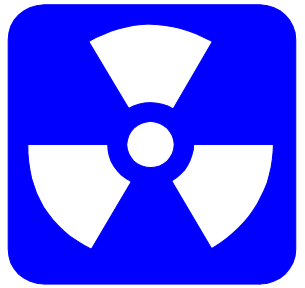
- ***Toxic*** *= potential to produce abnormal biochemical and physiological responses to an exposed individual*
- ***Flammable/Combustible*** *= produces a flame upon ignition. . . potential for explosion if concentration of chemical gas, vapor or particulate cloud reaches the mid-point of the respective flammability range . . . Yields flame, heat, toxic smoke and toxic gases*
- ***Corrosive*** *= dehydrates tissue causing a burn or serious irritation upon contact . . . severely corrosive at < pH 2 and > pH 12*
- ***Reactive*** *= mixture/interaction w/ another substance yields an explosion and/or release of toxic gases*

Physical (Energy) Agents

- **Energy:**
  - Electromagnetic waves
  - Particles
  - Pressure
- Types:
  - Radiation (Non-ionizing and Ionizing)
  - Sound (Unwanted Sound = Noise)
  - Thermal Stressors (Heat and Cold Stress)

Physical Agents: Subcategories

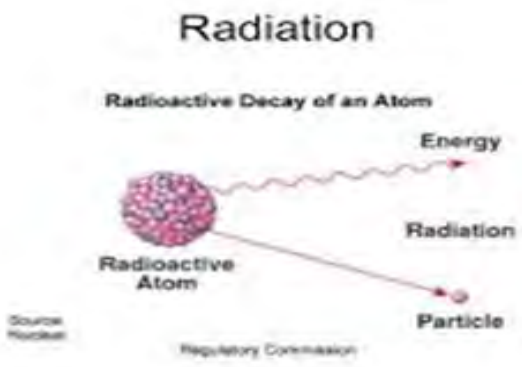
- **Toxic Radiological Agents**
  - Ionizing (e.g. Uranium; Radon; …)
  - Nonionizing (e.g. UV; MW; ELF; …)
  - Ionizing and nonionizing energies (via particles or photons) that interact molecularly with subcellular components of human systems and cause alterations of biochemistry and physiology, which in turn, can cause disease or dysfunction

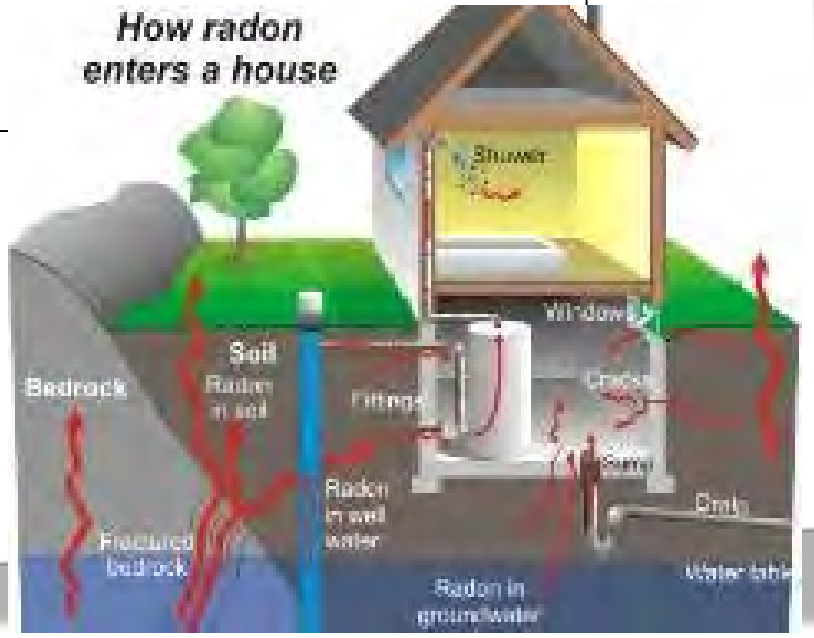


- **Toxic (?...damaging) Sound (Noise)**
  - Oscillating energies (pressure) that interact physically with human systems, which in turn, can cause disease (?) or dysfunction

Radiological Agents

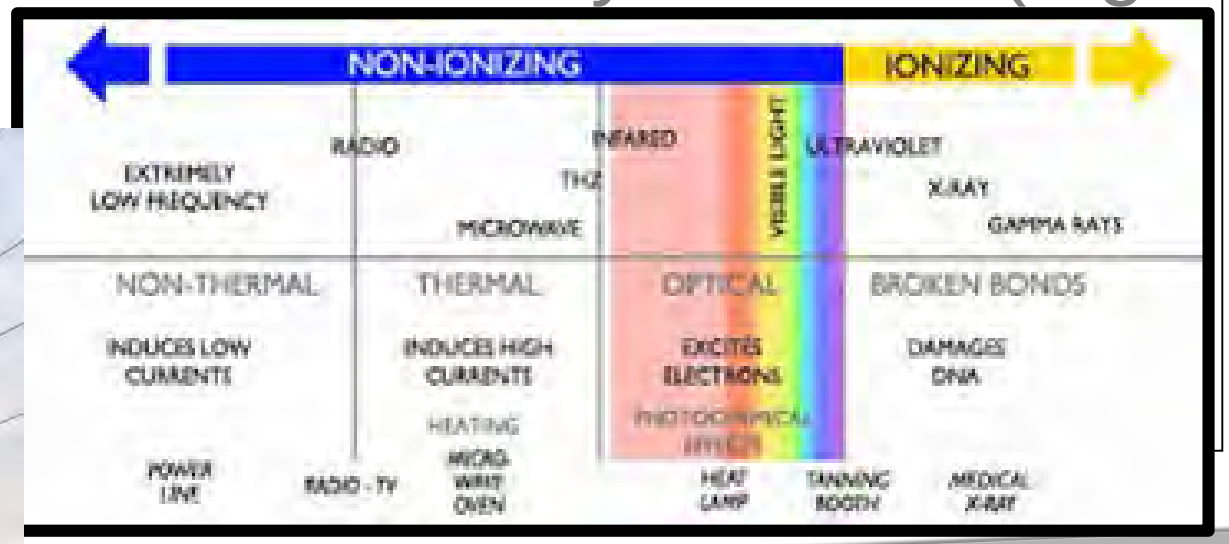
- ***Ionizing*** energies that interact molecularly with subcellular components of human systems and cause alterations of biochemistry and physiology, which in turn, can cause disease or dysfunction (e.g. **Radon**)





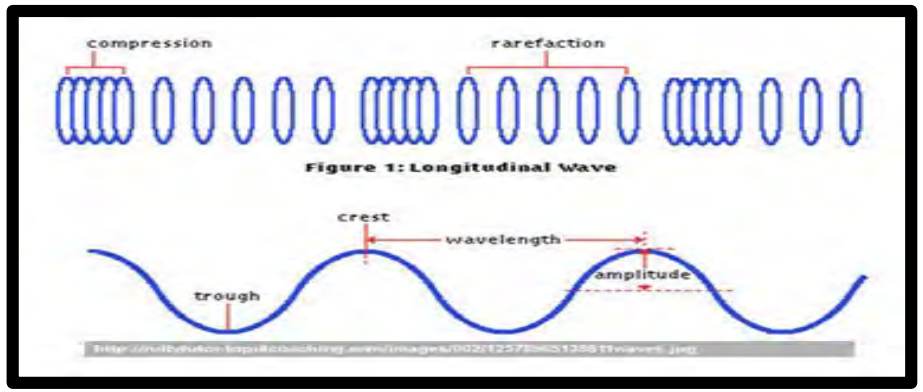
Radiological Agents

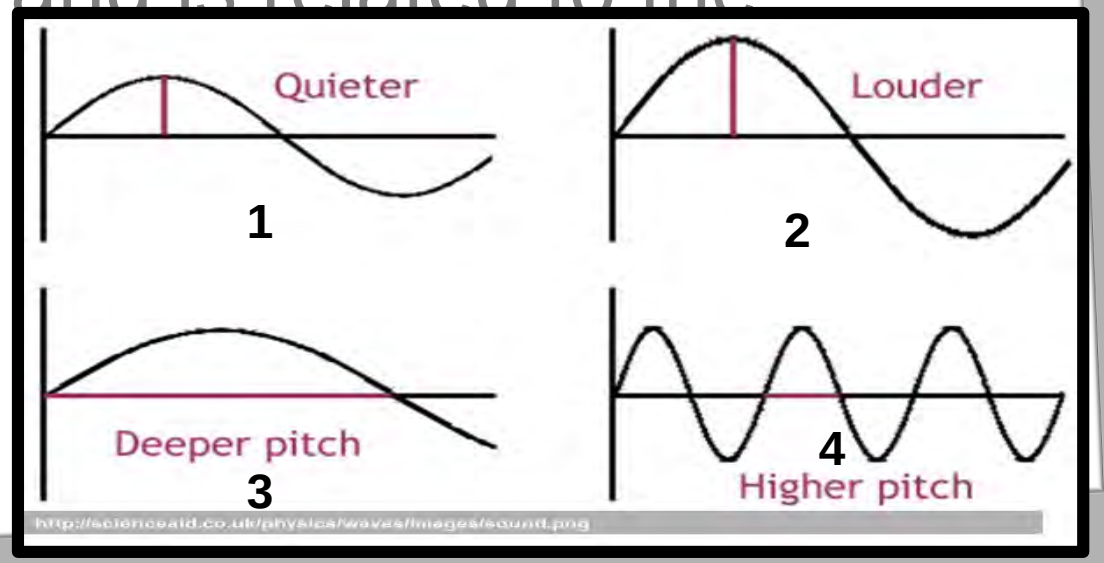
- ***Nonionizing*** energies that interact molecularly with subcellular components of human systems and cause alterations of biochemistry and physiology, which in turn, can cause disease or dysfunction (e.g. **UV (sun); MW; ELF**)



Sound (Unwanted Sound = Noise)

- ***Sound*** is an *energy* form of vibration that may be conducted through various media including solids, liquids, or gases.
- ***Sound pressure*** is the **deviation of air pressure from normal atmospheric pressure** and is related to the ***amplitude* of sound**.



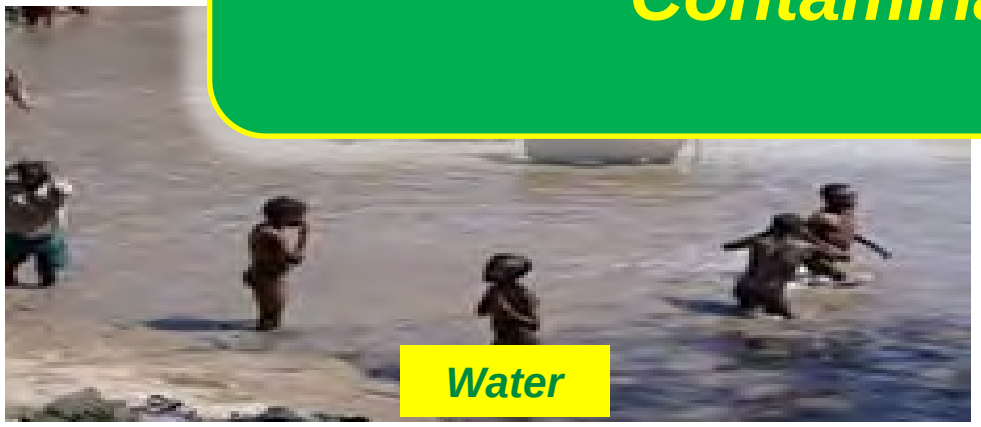


What are the environmental matrices and major sources of environmental contaminants and human exposures?

Dr. Michael S. Bisesi

Environmental Matrices

Sources, Types, Levels and Fate of Contaminants in Matrices



Environmental Settings

- ***Occupational (Workplace)*** **Environmental Settings:**
  - **Industries/Manufacturing facilities**
  - **Offices**
  - **Schools**
  - **Hospitals**
  - **Agriculture**

- ***Non-Occupational*** **Environmental Settings:**
  - **Hotels, Apartments, Homes**
  - **Outdoors (Ambient)**

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What are the major pathways, modes and routes human exposures to environmental contaminants?

Matrices and Pathways of Exposure

- **Air**
  - Outdoor
  - Indoor
- **Water**
  - Surface Water
  - Groundwater
  - Drinking/Cooking
  - Bathing/Washing
  - Irrigation
  - Recreational

- **Soil**
- **Food (including Beverages)**
  - Plants-Based
  - Animal-Based
- **Carriers/Transporters**
  - Vectors
    - Living organisms
  - Vehicles
    - Fomites
    - Building Materials

"*Ambient*" Environmental Matrices and Settings . . .
Air - Surface Water - Ground Water – Soil - Food












"*Workplace* and *Residential*" Environmental Settings. . .

Hazardous Exposure Contributing to Risk of Disease

Exposure (Internal Dose)

➡ ***Susceptibility to Disease***

➡ ***Biologically Effective Dose***

➡ ***Biological Response (Disease)***

NOTE: Reference for classification Perera, FP and Weinstein, IB (1982). Molecular epidemiology and carcinogen-DNA adduct detection: New approaches to studies of human cancer causation.
J. Chronic Dis 129:89-102

Environmental *Exposure* Can Ultimately Cause *Disease/Dysfunction*

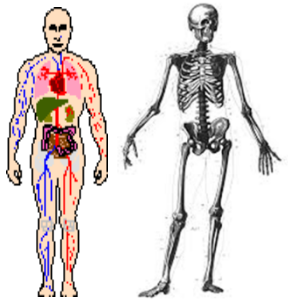
- **Environmental Agents + Human Contact**
  - → **External Exposure**
- **Absorption of Agent**
  - → **Internal Exposure (Internal Dose)**
- **Effective Exposure (Dose at Target Site)**
  - → **Early Interaction and Biological Effects**
- **Altered Morphology, Biochemistry and/or Physiology**
  - → **Clinical Disease/Dysfunction**
- **Clinical Diagnosis (?) and Prognosis (?)**

Exposure

- **Concentrations or levels of agents or factors to which individuals come into contact while in environmental settings . . .**

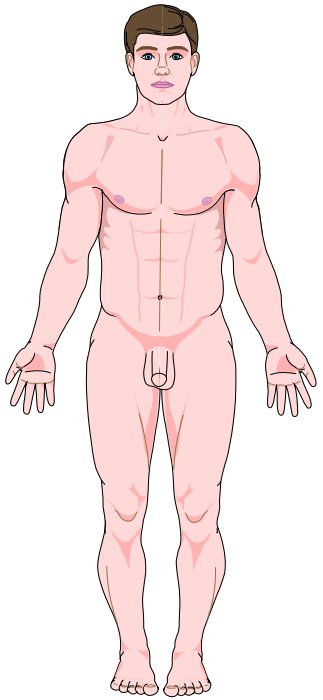
- **Initially, *external contact* which may lead to "*local*" effects at the point of contact**

. . . Transport across membranes yields *internal contact* which may lead to "*systemic*" effects.



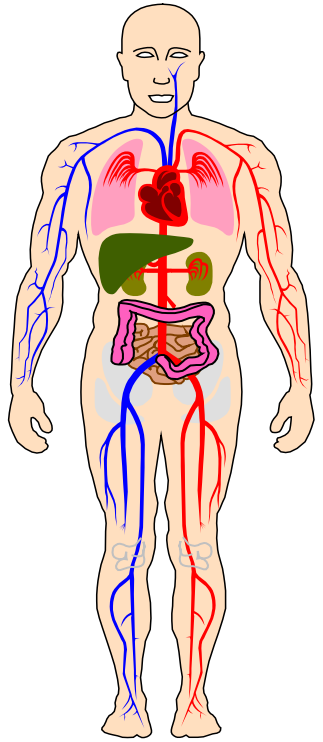
External Exposure

- Calculation and estimation of concentrations or levels of agents or factors to which individuals are exposed externally while in environmental settings
- Evaluation of external exposures encountered by individuals (e.g. workers) is based, in part, on environmental (e.g. industrial hygiene) monitoring



Internal Exposure

- Detection and measurement of concentration or dose of agent deposited or absorbed into the body
- Evaluation of internal exposures encountered by individuals in based, in part, on medical monitoring



Effective Exposure

- Impact (“Response”) caused by excessive external and subsequent internal exposures…

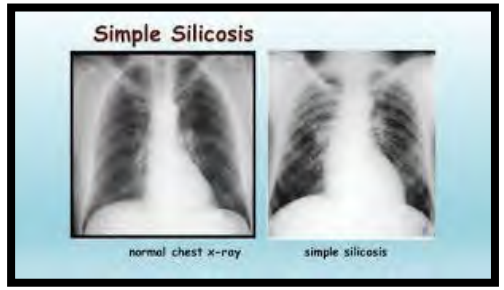
→ **Human Illness or Death**

Relationship: Environment and Disease

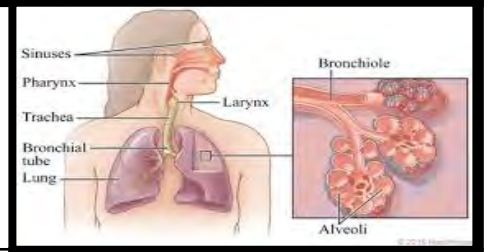
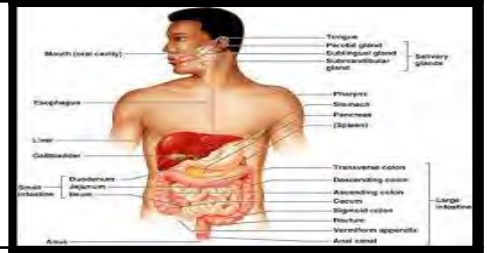
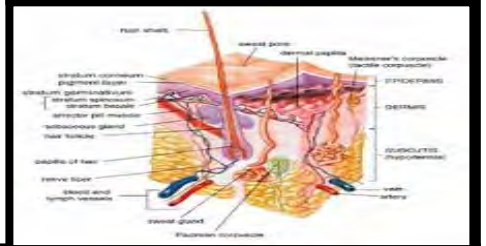
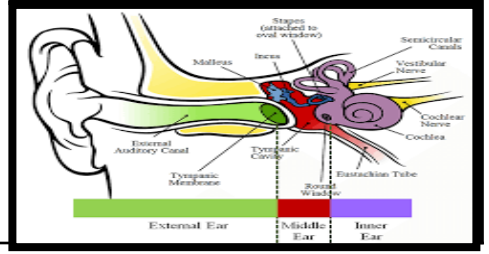
Broad Scope and High Levels of Contaminants in the Environment

Increased "Hazard Potential" for Human (and Animal) Exposures

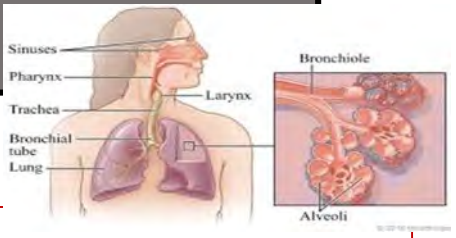
Increased "Risk" for Higher Morbidity and Mortality



Entry of Hazardous Agents/Contaminants

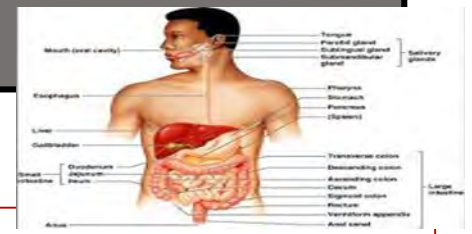
Modes ("How")	Routes/Portals ("Where")	
Inhalation	Respiratory System	
Ingestion	Gastrointestinal System	
Contact/Absorption/ Injection	Dermal(Skin)/Ocular(Eyes) ("Integument") System	
Hearing	Auditory(Ears) System	

Inhalation Mode via Respiratory Route



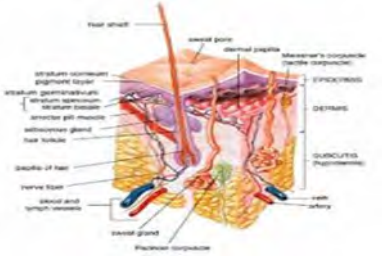
- The **quickest mode to get a toxicant into the blood stream other than direct i.v. injection**. The lungs are designed to allow entry into the body with thin membranes, **large surface area (~100m^2)**, and immediate access to capillary beds.
- There are basically **two types of airborne substances**, chemicals subject to the gas laws such as **gases and vapors**, and **particulates or aerosols** governed by physical factors of the respiratory tract that facilitate or preclude their entry.

Ingestion Mode via Gastrointestinal Route



- The **route is especially important for accidental or deliberate ingestion of chemicals and drugs**. Even inadvertent ingestion occurs with food contamination, placing contaminated non-edible material in the mouth (cigarettes), or respiratory excretions.
- The presence of the microvilli in the **intestines provides substantial surface area (~300m^2) for absorption**. In addition, all absorbed material is directly transported to the liver for possible metabolism.
- **GI tract has active transport mechanisms the skin does not have and bacteria that can transform chemicals before absorption to blood**.

Contact and Dermal Route Absorption

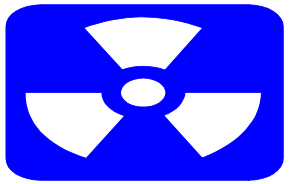


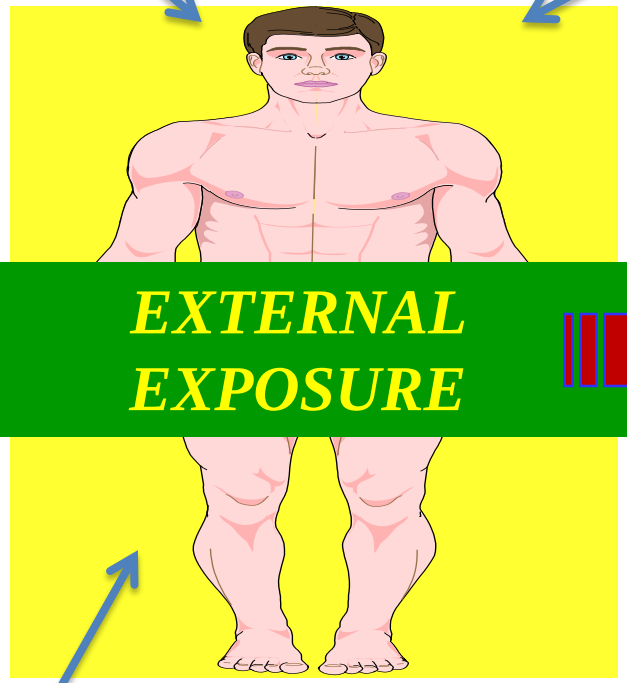
- The **surface (~2m^2)** is exposed to the environment, but the **skin is relatively impermeable to most compounds. Some exceptions include lipophilic chemical (e.g. many organic solvents) and organophosphorus insecticides**.
- **Once a chemical penetrates the epidermis, the other layers are traversed rather rapidly**. Not only is the skin a passive barrier, but it also is involved in metabolism of toxicants.

Physical Agents:
- Toxic Ionizing and Nonionizing Radiation
- Noise

Chemical Agents:
- Toxic Inorganic and Organic Elements or Compounds

Human Health





EXTERNAL EXPOSURE

INTERNAL EXPOSURE

EFFECTS

Biological Agents:
- Infectious, Allergenic, or Intoxicating Organisms

What are some general categories and characteristics of adverse health effects?

Absorption

- Entry of an agent into the body across some surface
- Entry can occur across skin and went membranes (airways, mouth, eyes, digestive tract, vagina, etc.)

Distribution

- Transport and spread of an agent from site of entry to other body regions
- Where the agent “goes” depends upon several factors including
  - partitioning of the agent in blood, lymph, fat, and muscle, extracellular spaces, and cells of tissue at the site of exposure
  - barriers to distribution such as the blood-brain barrier, cell membranes, lipophilicity
  - rate of metabolism and clearance/excretion that remove the agent before it can distribute throughout the body

Acute and Chronic

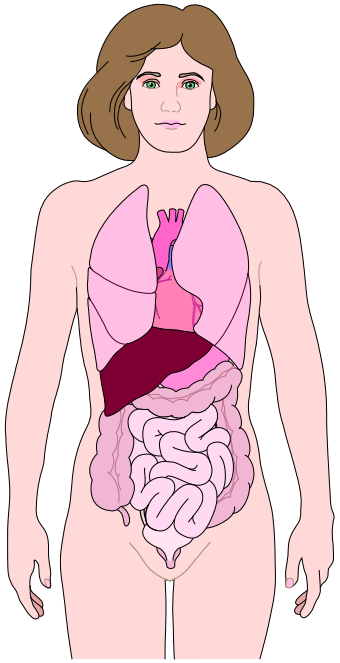
- **Acute Exposure:** Adverse effect from single exposure
- **Acute Effects:** Adverse effect with symptoms developing rapidly
- **Chronic Exposure:** Adverse effect from repeated exposure over prolonged time
- **Chronic Effects:** Adverse effect that develops slowly over long time

Local vs. Systemic

- **Local Effects:** Manifested at the site of initial contact
- **Systemic Effects:** Manifested at a site other than where initial contact or exposure occurred

Major Target Sites

- **Target Sites: Organ- and System-Effects**
  - Respiratory System (Nasal Passages; Lungs)
  - Hepatic System (Liver)
  - Dermal System
  - Hematic System (Blood)
  - Immune System (WBCs; etc.)
  - Renal System (Kidneys)
  - Nervous System (CNS & PNS)
  - Endocrine System
- **Effects**
  - Genotoxic and Non-Genotoxic



Mutagens:

-compounds that induce damage to the genetic material in cells (Deoxyribonucleic acid; DNA)

somatic = aberration is manifested in the exposed individual (i.e. alteration of somatic or body cells)
genetic = aberration is expressed in the progeny of the exposed individual (i.e. alteration of germ or sex cells)

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Carcinogens:

- chemicals (and radiologicals) that induce changes in cells resulting in abnormal growth (invasiveness), proliferation (metastasis) and differentiation (aplasia) . . . malignant neoplasms (cancerous cells and/or tumors)

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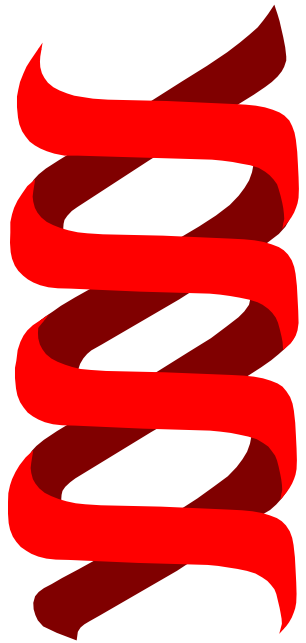
Genotoxic Chemical

- Chemical with affinity for DNA . . . "Electrophilic" Toxicant
- Electrophilic Toxicant (X) bonds with DNA ("Nucleophilic"Biomacromolecule)

→ Form "Adducts" (DNA-X)

→ X alters DNA

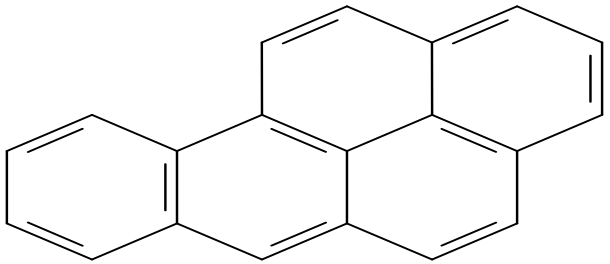
→ Mutation



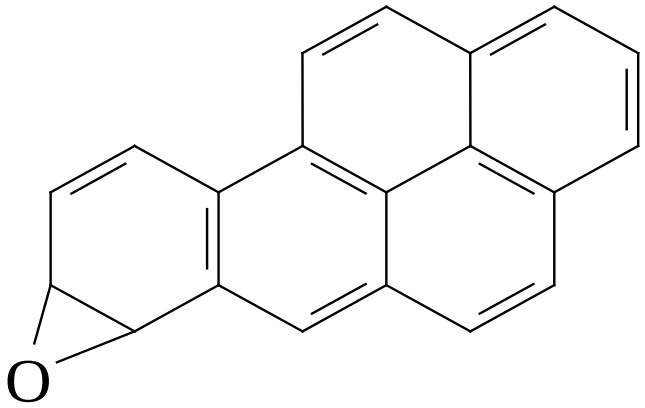
Carcinogenic Agents

- Cancer-causing or carcinogenic agents cause formation of malignant neoplasms characterized by “abnormal cells” exhibiting:
  - uncontrolled growth (rapid cell division and tumor growth)
  - invasiveness (incorporation into surrounding tissues/organs)
  - metastasis (spreading)
- “Genotoxic” Carcinogens
- “Nongenotoxic” Carcinogens

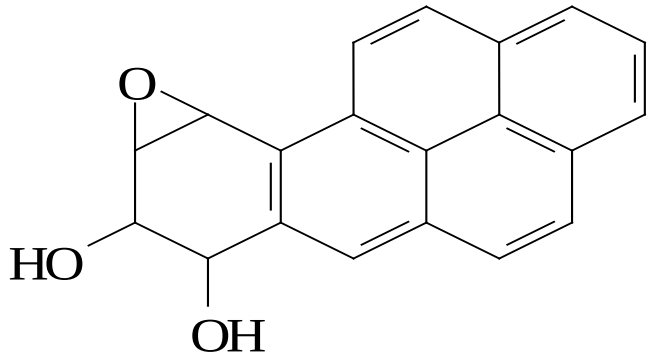
Procarcinogen: Benzo(a)pyrene



Proximate Carcinogen: Benzo(a)pyrene-7,8-epoxide



Ultimate Carcinogen:
Benzo(a)pyrene-7,8-diol-9,10-epoxide



Teratogens:

- chemicals (and radiologicals) that induce perinatal aberrations, yet due to low concentrations, may pose no significant threat to the mother

. . . damage the embryo/fetus (especially during first 8 to 12 weeks . . . organogenesis (cell development/differentiation)

.

.

What is meant by "direct" versus "indirect" exposure?

Dr. Michael S. Bisesi

THE OHIO STATE UNIVERSITY
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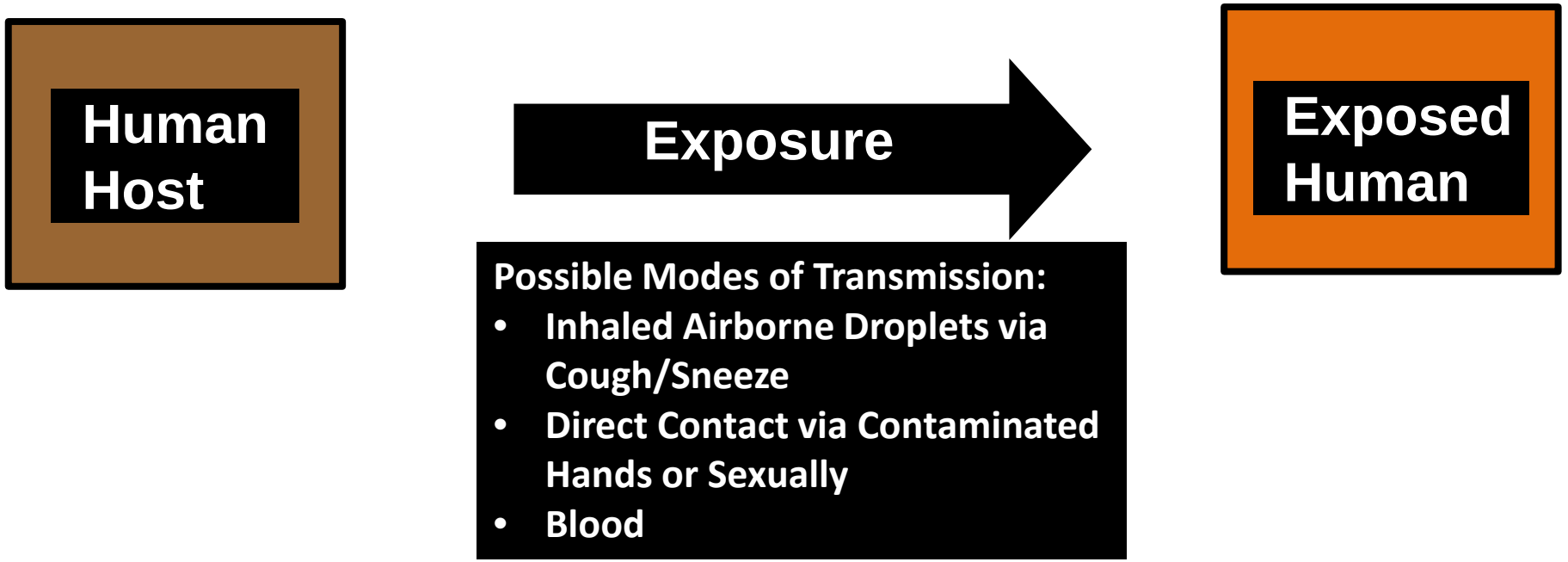
Direct Exposure and Contact via Major Modes Inhalation, Ingestion and Dermal/Surface

EXAMPLE *Direct Exposure*:

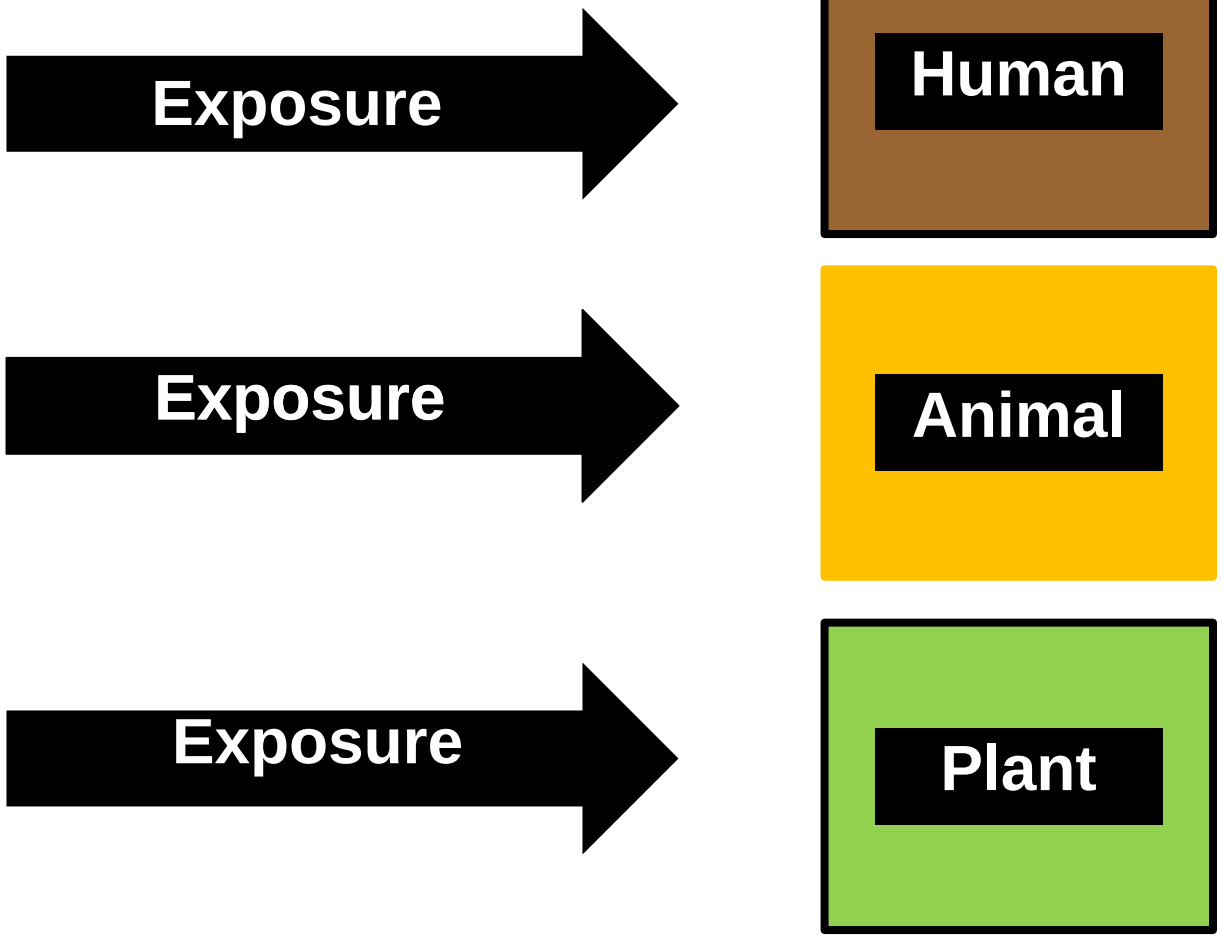
Person-to-Person Transmission



Direct Exposure

Contaminated Environmental Matrix:

- ***Air***
- ***Water***
- ***Soil***
- ***Food***
- ***Human or Animal Host/Reservoir***

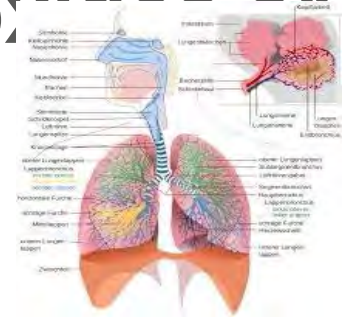


EXAMPLE – Biological Agent: Infectious Zoonotic Agent

- **Transmissible Directly or Indirectly from Animal to Human . . .**
- **<u>Direct transmission</u> via *air* and <u>inhalation</u> of *Mycobacterium bovis* from animal to human**
- **<u>Indirect transmission</u> via *milk* and <u>ingestion</u> of *Mycobacterium bovis* from animal and human**

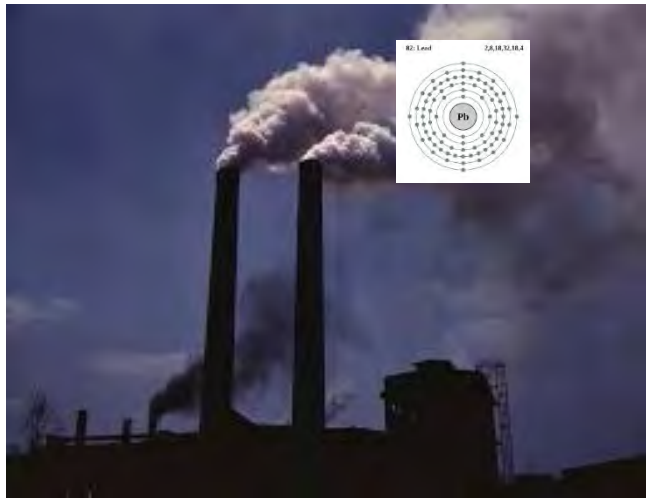
Direct Exposure and Contact to Humans via *Inhalation*

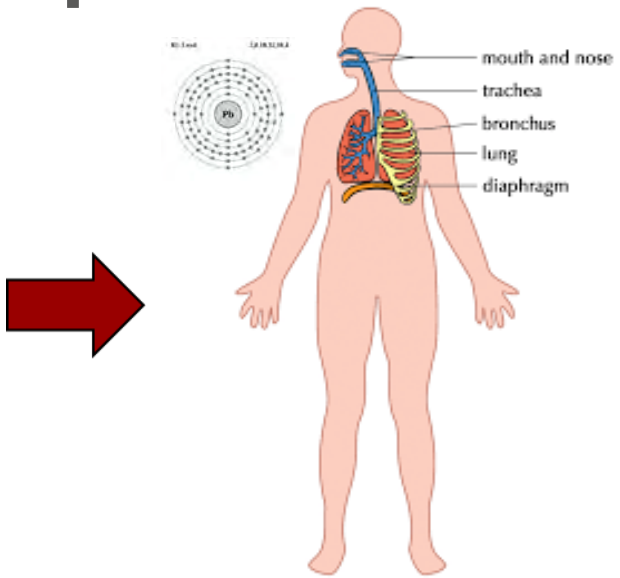
- **Respiratory system contact and adsorption locally and/or absorption systemically of infectious or toxic agents from contaminated air . . .**
  - **Particulate Matter (e.g. bioaerosols; metals; hydrocarbons; etc.)**
  - **Vapors (e.g. volatile organic chemicals - VOCs)**
  - **Gases (e.g. various oxides or hydrides of C, N, S; etc.)**



EXAMPLE: Direct Exposure and Contact to Humans via *Inhalation*

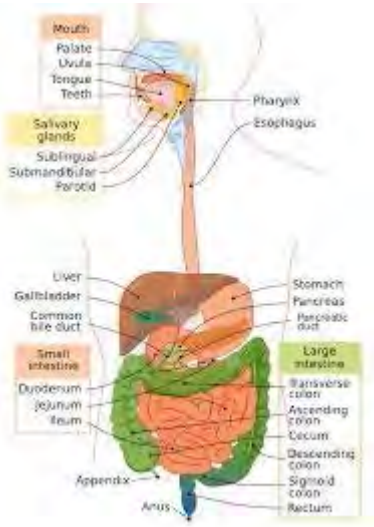
- **Inhaled airborne lead (Pb) dust and fume from contaminated air (Pb-discharge) yields increased Pb in blood which leads to potential anemia, cognitive issues, etc.**





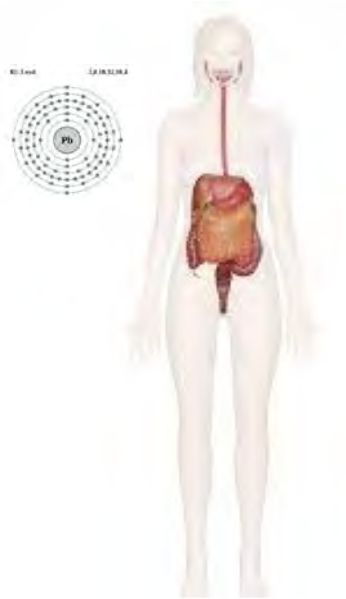
Direct Exposure and Contact to Humans via *Ingestion*

- **Gastrointestinal system contact and adsorption locally and/or absorption systemically of infectious or toxic agents from contaminated food, water, fomite. . .**



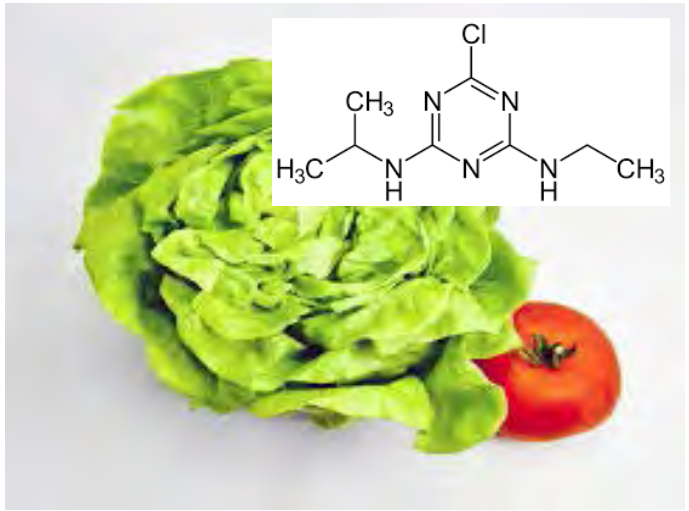
EXAMPLE: Direct Exposure and Contact to Humans via *Ingestion*

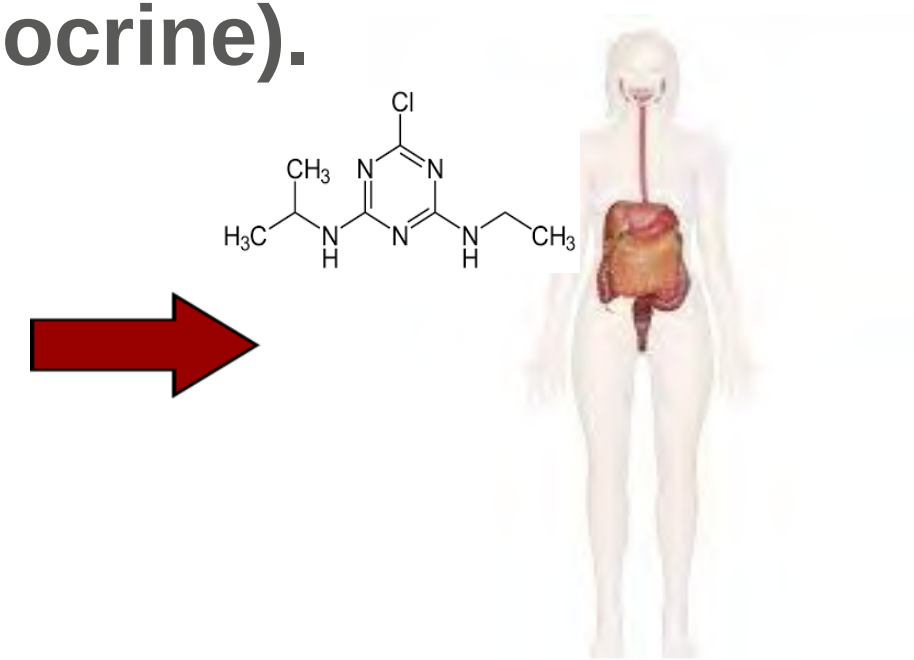
- **Ingested lead (Pb) dust from contaminated surfaces and soils (e.g., Pb-Based Paint) yields increased Pb in blood which leads to potential anemia, cognitive issues, etc.**



EXAMPLE: Direct Exposure and Contact to Humans via *Ingestion*

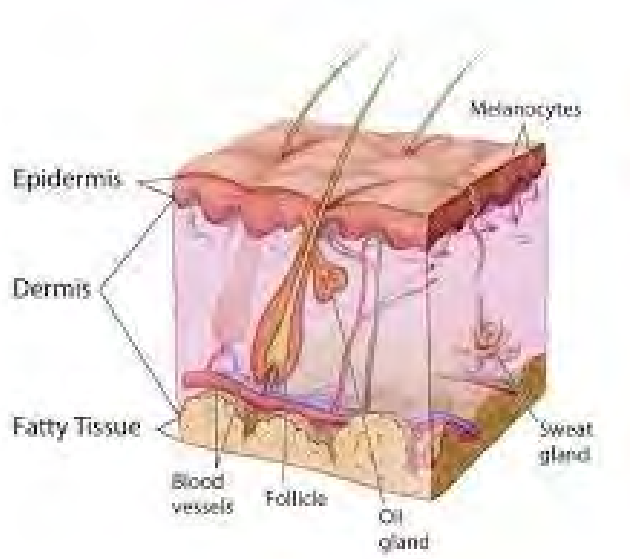
- **Ingested herbicide (Atrazine) from contaminated vegetables (e.g. lettuce; tomato) yields increased chlorinated metabolites which may cause various effects (e.g.neurotoxicity; endocrine).**





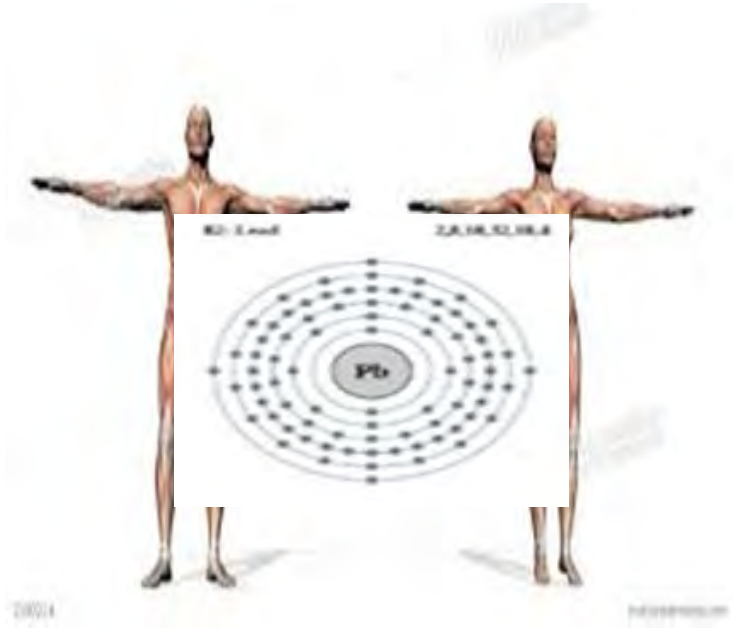
Direct Exposure to Humans via *Dermal Contact*

- **Dermal contact and adsorption and/or absorption of inorganic and organic chemicals from contaminated air, water, soil and surfaces**



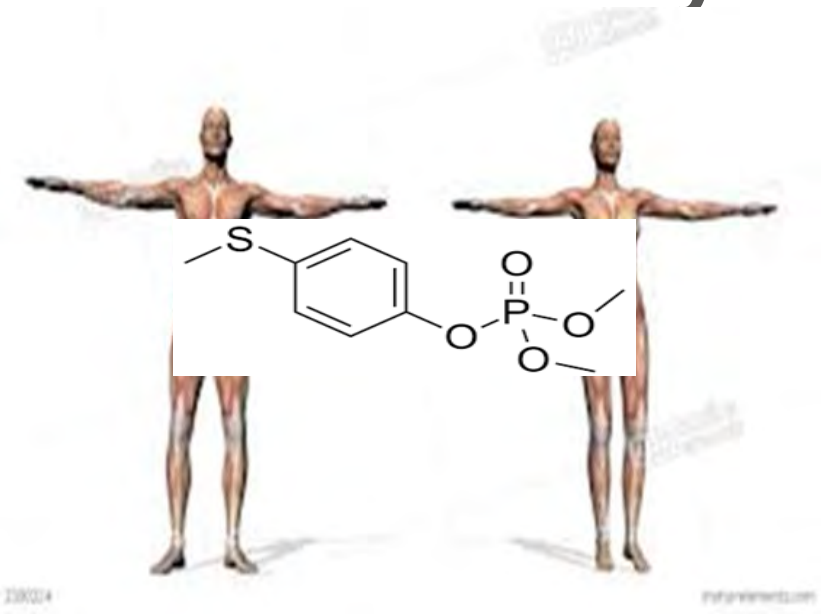
EXAMPLE: Direct Exposure to Humans via *Dermal Contact*

- **Dermal absorption of inorganic lead (Pb) from contact with contaminated surfaces (e.g. Pb battery manufacturing facility) was correlated with elevated Pb in blood among workers.**



EXAMPLE: Direct Exposure to Humans via *Dermal Contact*

- **Dermal absorption of organophosphate insecticide (e.g. parathion) from contact with contaminated spray and/or surfaces (e.g. agriculture application) associated with acetylcholine esterase inhibition/neurotoxicity among workers.**



Chemical Toxicants: Direct Exposure and Contact to Plants via Surface or Roots

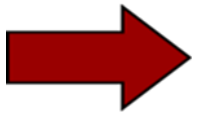
- **Surface contact and adsorption and/or absorption of inorganic and organic volatile organic chemicals from air, water (e.g. irrigation) and applied compounds (e.g. herbicides; insecticides)**

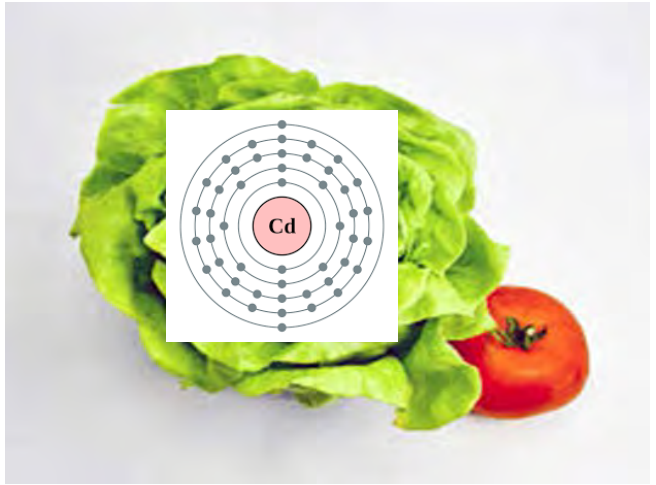
- **Root absorption of contaminated water and other substances from contaminated soil**

…Chemicals contaminate plant surfaces (leaves; stems; fruits) and/or incorporate into plant tissues

EXAMPLE: Direct Exposure and Contact to Plants via Surface or Roots

- **Surface contact and adsorption and/or absorption of metal cadmium from air or water (e.g. irrigation); or, Root uptake/absorption from Cd contaminated soil.**





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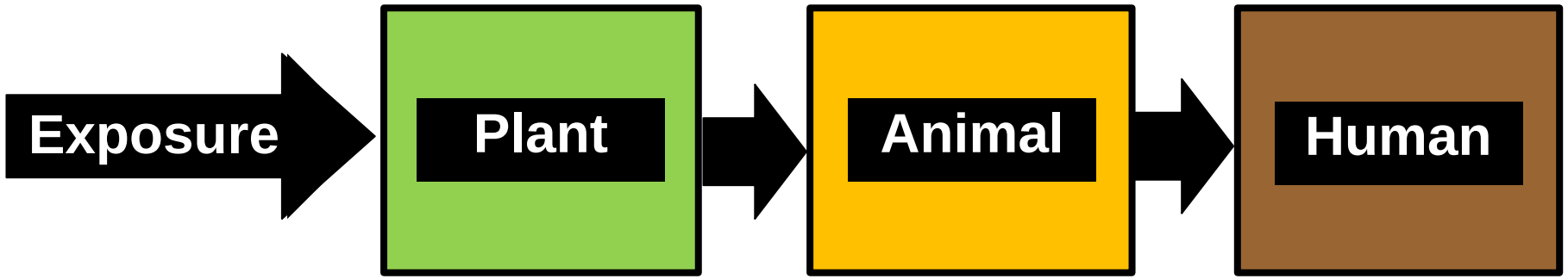
Indirect Exposure and Contact via Food Chain/Food Web, Bioaccumulation, and Biomagnification

Indirect Exposure

Contaminated Environmental Matrix, Vehicle or Vector

- ***Air***
- ***Water***
- ***Soil***
- ***Food***
- ***Vehicle***
- ***Vector***



Transmission of Hazardous Agents via "*Vehicles*" and "*Vectors*"

"*Vehicles*"

- **Contaminated Non-Living (Inanimate) Objects**

. . . "*Fomites*"

- **Eating Utensils**
- **Water/Food**




"*Vectors*"

- ***Contaminated Living Organism***
  - **Ticks**

  - **Mosquitoes**

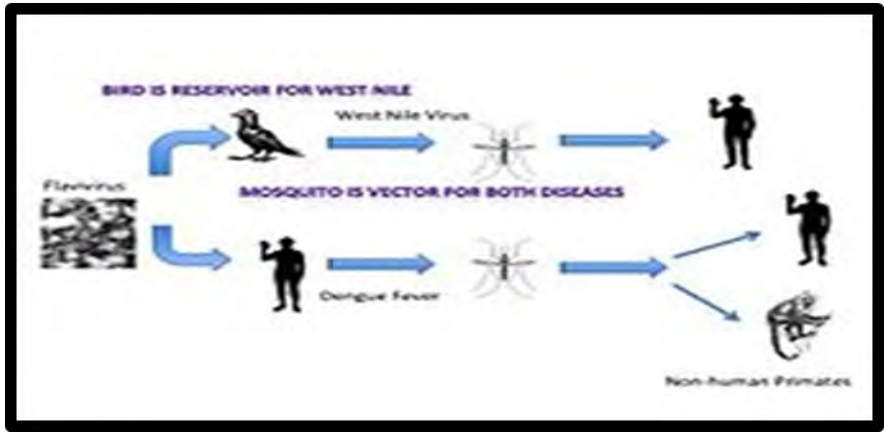
EXAMPLE *Indirect Exposure*:

Reservoir/Host-to-Vector-to-Person Transmission

Reservoir/ Host → **Exposure** → **Vector** → **Exposure** → **Exposed Human**

Examples of Some Vectors:

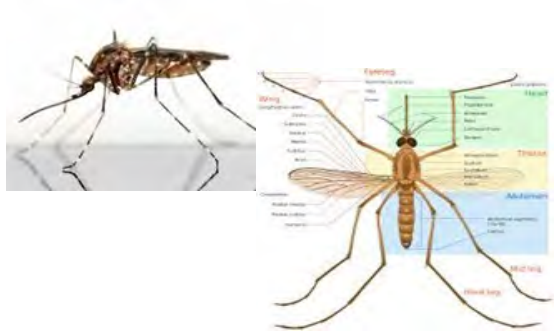
- **Mosquitoes**
- **Ticks**
- **Rodents**
- **etc.**



Example: Tick and Mosquito Vectorborne Infectious Disease

- **Tickborne Diseases:**
  - Lyme (*Borrelia burgdorferi*)
  - Ehrlichiosis (*Ehrlichia* spp.)
  - Rock Mountain Spotted Fever (*Rickettsia rickettsia*)
  - Tularemia (*Francisella tularensis*)

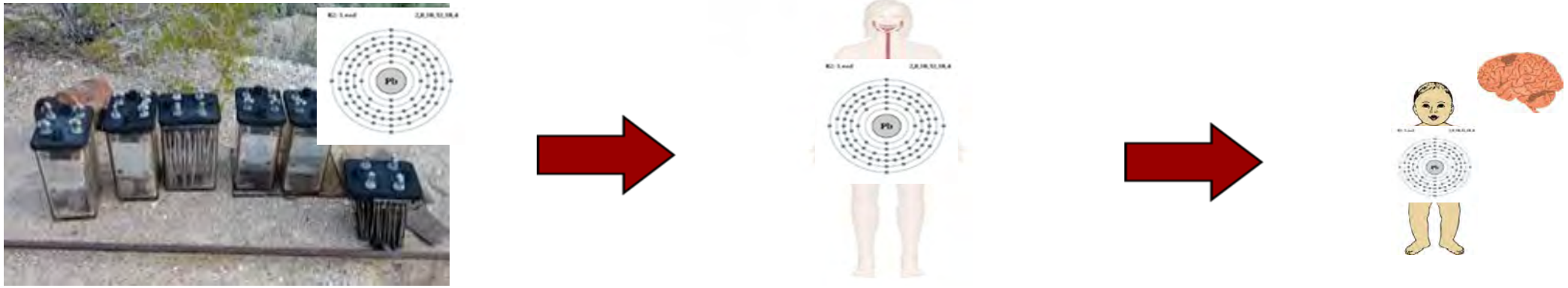
  https://www.cdc.gov/ticks/diseases/index.html
- **Mosquitoborne Diseases:**
  - West Nile Virus (most common in USA)
  - Chikungunya Virus
  - Dengue Virus
  - Zika Virus
  - LaCrosse Encephalitis https://www.cdc.gov/media/dpk/diseases-and-conditions/mosquito-borne-diseases/



(Note: Malaria and Yellow Fever not in USA but elsewhere)

EXAMPLE: Food Chain . . . Inhalation and Ingestion Lactating Mother to Offspring

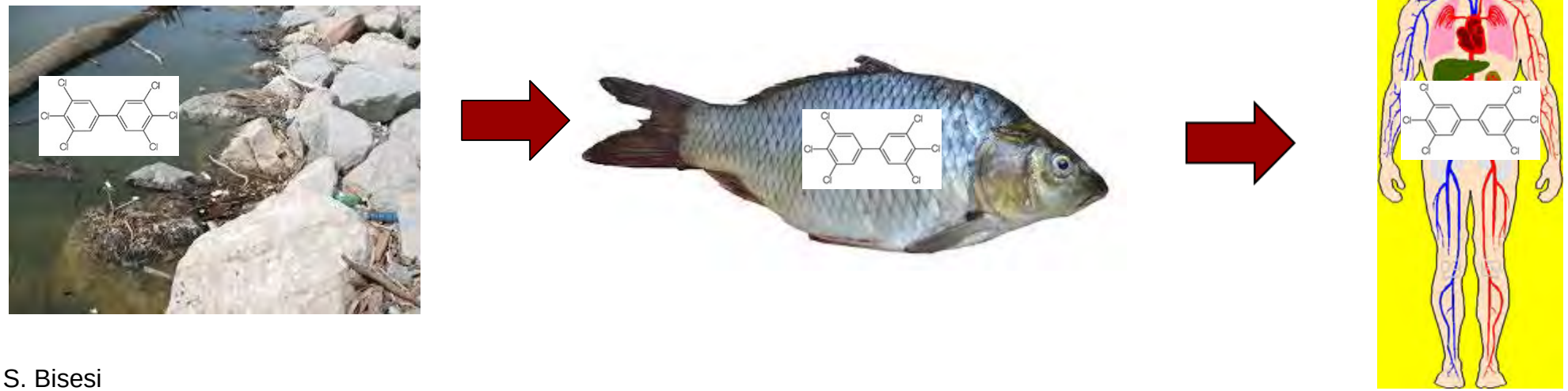
- **Mother <u>inhales</u> airborne lead (Pb) dust from contaminated air in lead battery factory (Pb) which yields increased Pb in blood which leads to potential anemia, cognitive issues, etc.**



- **Breast milk of mother contains Pb too . . . Breastfeeding is source of Pb-contaminated milk <u>ingested</u> by the nursing neonate . . . Yields Pb in blood which leads to potential anemia, cognitive issues, etc.**

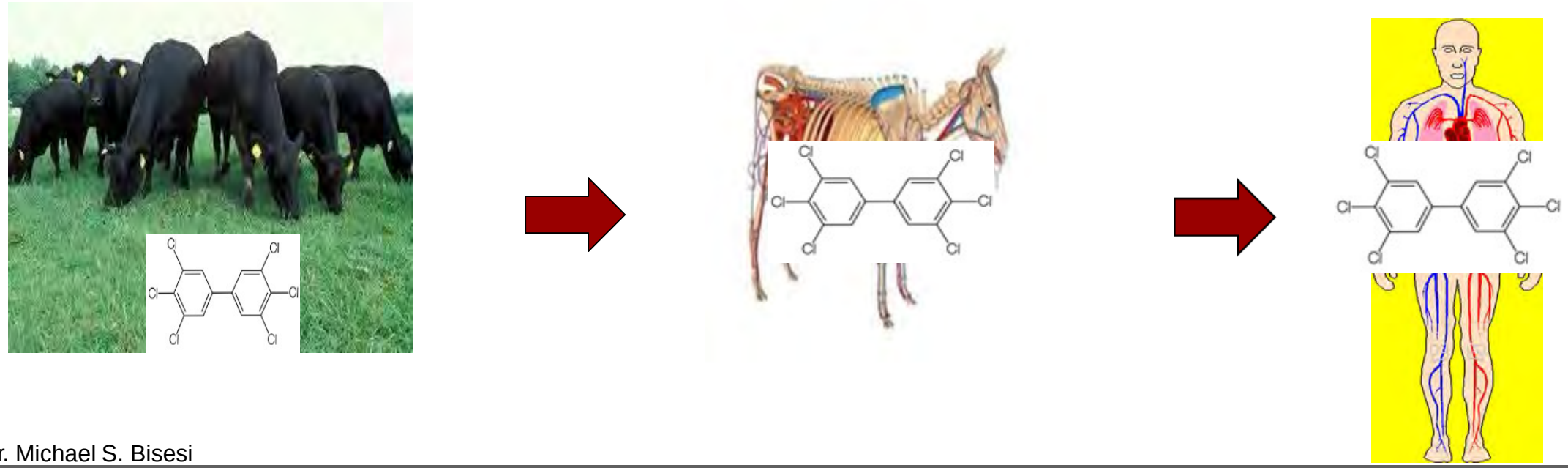
EXAMPLE: Food Chain . . . Ingestion of Contaminated Water by Fish Contaminates Human too . . .

- **Ingestion of fish caught from surface waters contaminated with "persistent organic pollutants" such as polychlorinated biphenyls (PCBs) . . . Bioaccumulated PCBs in the fish can be absorbed by those consuming them.**



EXAMPLE: Food Chain . . . Ingestion of Contaminated Plant by Cattle and Contaminates Human

- **<u>Ingestion</u> of grass contaminated and bioaccumulated with "persistent organic pollutants" such as polychlorinated biphenyls (PCBs) . . .**

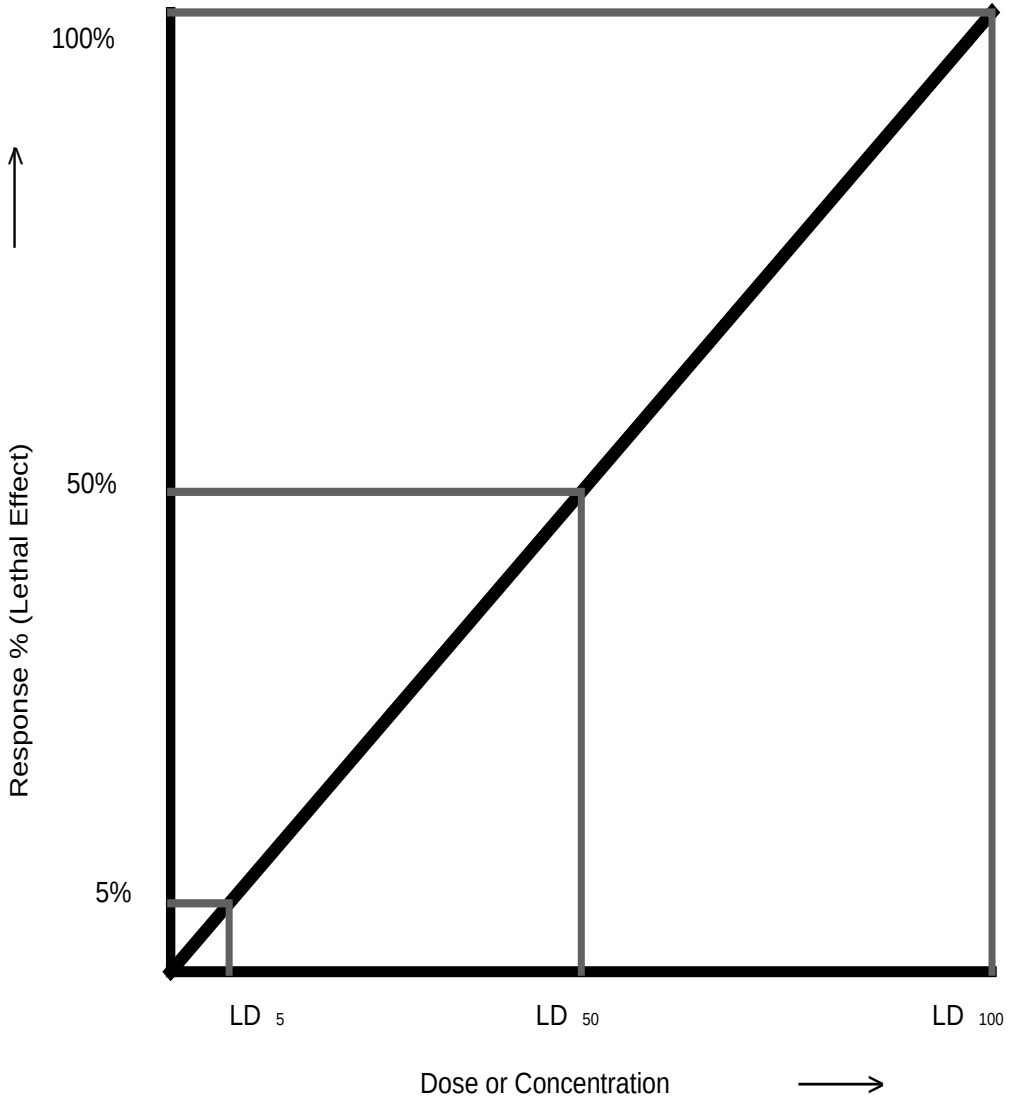


What are the major factors associated with vulnerability to or risk of disease from exposures to infectious biological and toxic chemical and physical agents?

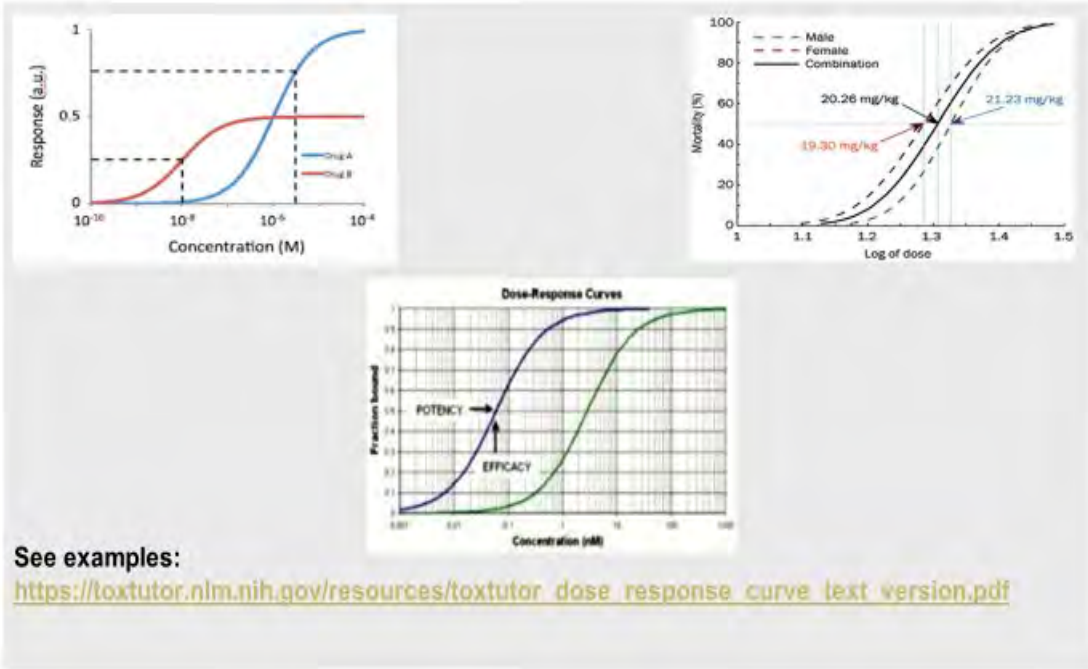
Dr. Michael S. Bisesi

Factors that Influence Intensity of Effect/Response to Exposure

- Rate of Exposure: hourly, daily, monthly
- Concentration and Dose
- Mode (how) and Route (where) of Exposure
- Acute vs Chronic Exposure
- Effects of Exposure
  - acute, chronic, local, and systemic Effects
- Dose – Response relationship
- Age and State of Health
- Previous Exposures (e.g. hypersensitivity)
- Simultaneous and Confounding Exposures (additive; synergistic)…Environmental variables
- Genetic factors (e.g. hypersusceptibility)

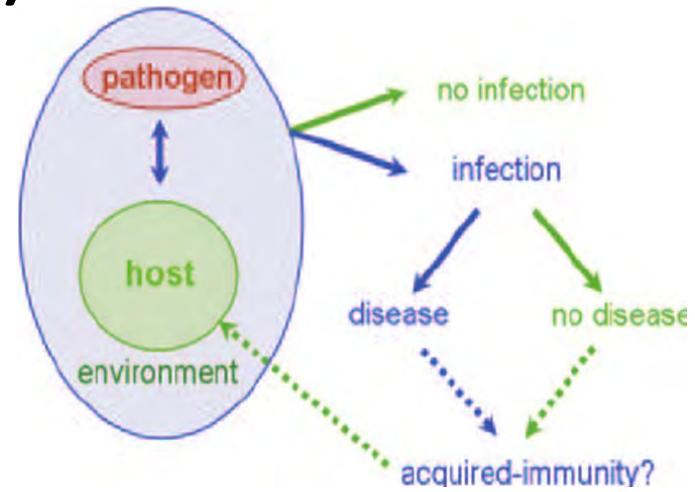


Dose/response curves for a chemical agent administered to a uniform population of test animals.



Exposure Factors – Infectious Microbiological Agents

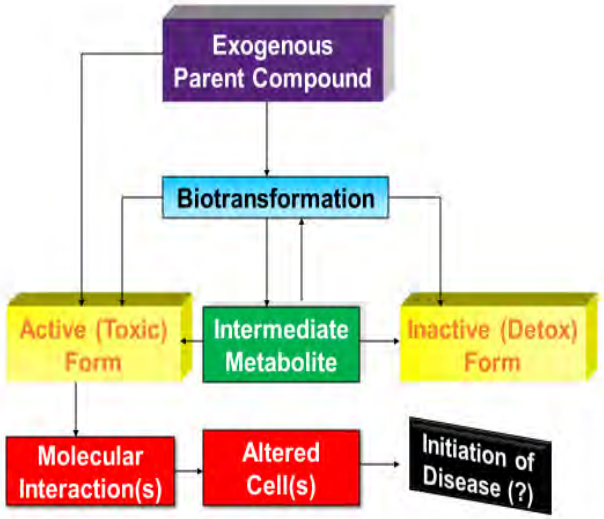
- **Host Immunity (influenced by overall health and age)**
- **Virulence of the Infectious Microbiological Agent ("Pathogen")**
- **Amount (Concentration/Dose) of Exposure**
- **Duration of Exposure**



https://www.researchgate.net/profile/KA_Krogfelt/publication/5226057/figure/fig2/AS:310008131670019@1450923106989/Schematic-representation-of-host-pathogen-interactions-in-campylobacteriosis.png

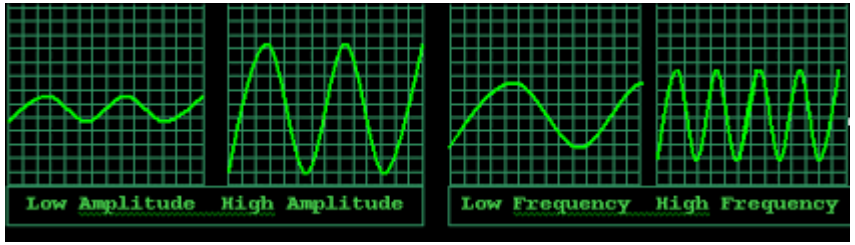
Exposure Factors – Toxic Chemical and Radiological Agents

- **Health of the Exposed Individual (influenced by genetics, age, health status . . .)**
- **Potency of the Toxic Chemical Agent (Energy of Physical Agents)**
- **Amount (Concentration/Dose) of Exposure**
- **Duration of Exposure**



Exposure Factors – Toxic (Harmful) Sound ("Noise")

- **Health of the Exposed Individual (influenced by genetics, age, health status…**
- **Frequency of Sound *("A-Scale frequency in Hertz (Hz)" is 500 to 10,000 Hz (Hz) which is within the overall range of frequencies for human hearing 20-20,000 Hz*)**
- **Amount (Concentration/Dose) of Exposure (*"Decibels (dB)" are log_{10} measurement of sound or noise intensity/loudness* . . . Express measurements as *dBA*, that is, *sound intensity or loudness within the A-scale frequency range*)**
- **Duration of Exposure**



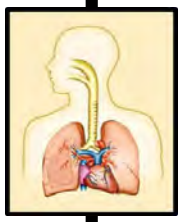
What are some major contaminants and regulatory points regarding the air matrix?

Air Matrix

- Outdoor (Ambient) Air
- Indoor Air

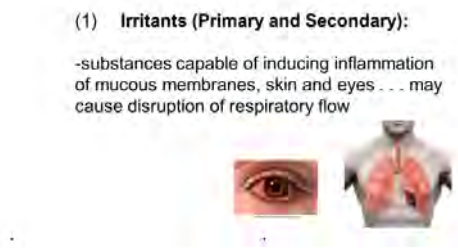
Air Matrix

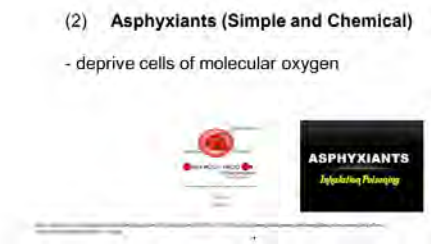
- Major Categories of Air Contaminants Indoors and Outdoors (Ambient):
  - Solid and Liquid Chemical (and Biological) Particulate Matter (PM)
    - "Inhalable and Respirable" PM <10 microns in equivalent diameter
    - "Total" PM all sizes of equivalent diameter
    - NOTE: If airborne bacteria, fungi or viruses for examples, then designated as "*Bioaerosols*"
  - Gaseous Chemicals (including "vapors" from volatile liquids/solids)
- Major sources are volatile emissions and combustion products too from vehicles, coal power, fires, industry etc.
- Human exposure mainly via the "*inhalation mode*" and "*respiratory route*"

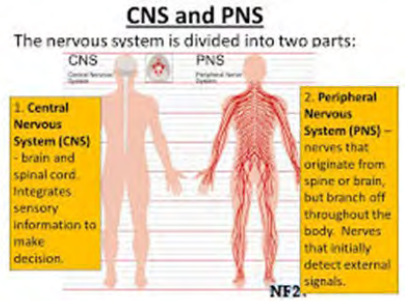


Common Illnesses - Air Matrix

- **Respiratory Irritation and Inflamation**
  - Solvent Vapors
  - Various Dusts
- **Respiratory Infections**
  - Bioaerosol (bacteria; virus; fungi)
- **Dermal Rash**
  - Solvents and Acids/Alkalis
- **Various Organ Systems (Nervous; Renal; etc.)**







What is the National Environmental Policy Act?

https://www.epa.gov/nepa/what-national-environmental-policy-act

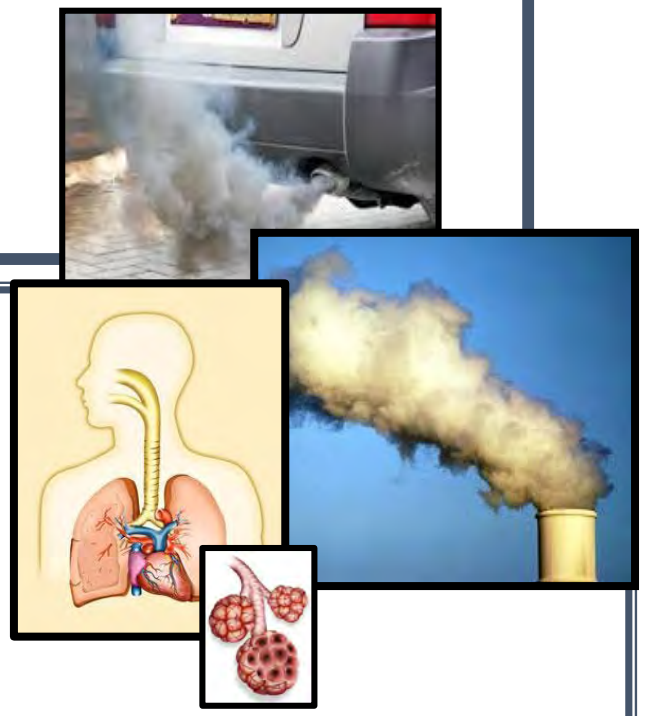
- *The National Environmental Policy Act (NEPA) was signed into law on January 1, 1970. NEPA requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions. The range of actions covered by NEPA is broad and includes:*
- *making decisions on permit applications,*
- *adopting federal land management actions, and*
- *constructing highways and other publicly-owned facilities.*
- *Using the NEPA process, agencies evaluate the environmental and related social and economic effects of their proposed actions. Agencies also provide opportunities for public review and comment on those evaluations.*

Clean Air Act

- regulates emissions from "***mobile***" and "***stationary***" **sources**
- ***"Criteria Pollutants"***
  - https://www.epa.gov/criteria-air-pollutants
- "***Primary pollutants***" refer to the form of a contaminant at the point of emission **(e.g. NO_2)** . . . ***"Secondary pollutants"*** refer to the form of a contaminant after chemically changing after in the atmosphere **(e.g. NO_2 can change to HNO_3 or combine with other molecules to form the "*smog*" component Peroxyacetyl nitrate (PAN) $C_2H_3NO_5$)** . . .
- established emission discharge standards and permit system

Clean Air Act – 6 Criteria Pollutants

https://www.epa.gov/criteria-air-pollutants



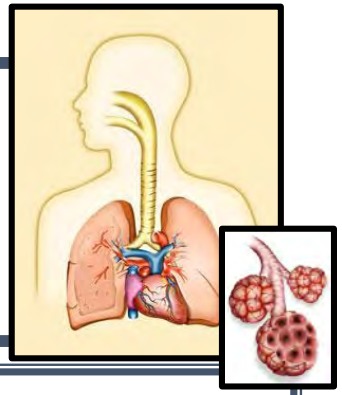
- **Ozone (Ground-Level, not Stratospheric O_3):**
  - Respiratory Irritant (free-radicals; inflammation)
  - Bronchoconstriction
  - Exacerbates COPD, asthma and other respiratory diseases

- **Carbon Monoxide:**
  - Chemical Asphyxiant
  - Competes with oxygen and prevents binding to hemoglobin molecules in RBCs

- **Sulfur Dioxide:**
  - Respiratory Irritant (inflammation)
  - Exacerbates COPD, asthma and other respiratory diseases
  - Combines with atmospheric H_2O to form sulfuric acid component of "***Acid Rain/Precipitation***"

Clean Air Act – Criteria Pollutants (continued)

https://www.epa.gov/criteria-air-pollutants



- **Nitrogen Dioxide:**
  - Respiratory Irritant (inflammation)
  - Exacerbates COPD, asthma and other respiratory diseases
  - Combines with atmospheric H_2O to form nitric acid component of "***Acid Rain/Precipitation***"

- **Lead:**
  - May have local effects on lungs but a major concern are the systemic effects that adversely affect nervous system (e.g. cognition), kidneys, cardiovascular, immune, etc. . . . Inhibits normal RBC synthesis resulting in anemia and reduced oxygen transport capacity.

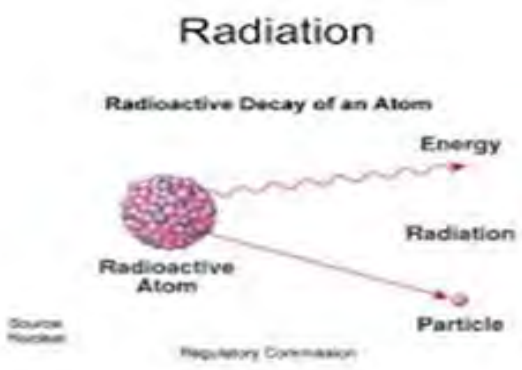
- **Particulate Matter (PM . . . PM_{total} ; "Inhalable" PM_{10} ; Fine Inhalable" $PM_{2.5}$:**
  - May have local impacts to respiratory system, but also systemic effects too including impacts to nervous system, kidneys metabolism (diabetes?), and cardiovascular…
  - Exacerbates other respiratory diseases
  - Generated as primary but also formed as secondary pollutants

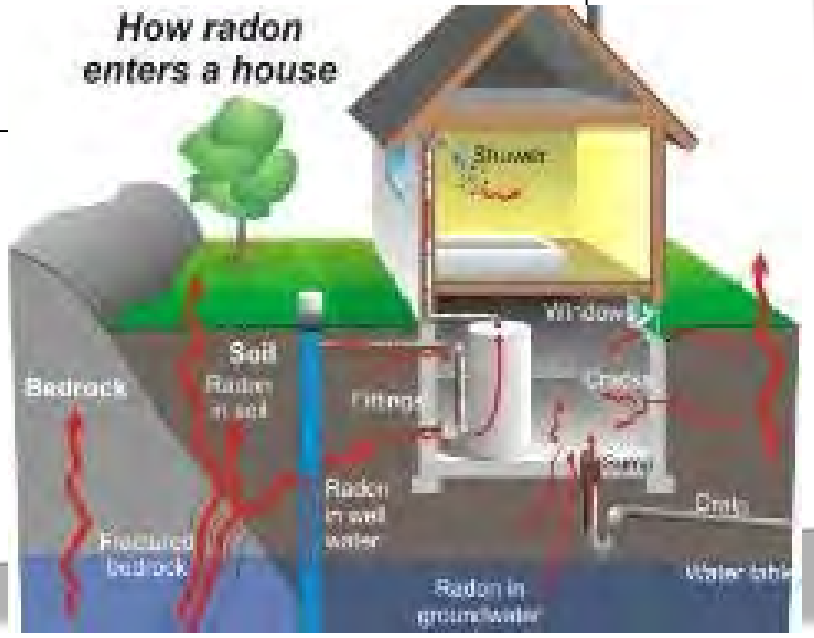
Indoor Air Contaminants

- **Major Sources of Indoor Air Chemical Contaminants:**
  - Combustion:
    - Stoves and Cooking
    - Open fires (fireplaces)
  - Volatilization/Evaporation
    - Cleaning Agents
    - Paints
    - Off-gassing from wood and plastics
- **Major Sources of Indoor Air Biological (mold; bacteria) Contaminants:**
  - Water infusion
  - Carpets
- **Major Sources Radiation:**
  - Electronics
  - Basements

Radiological Agents

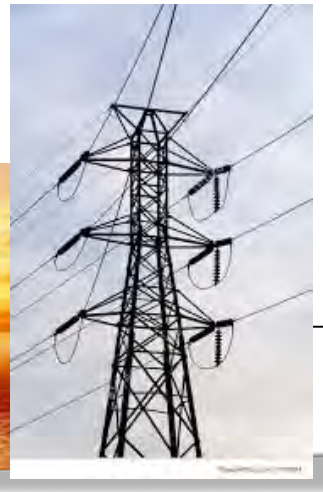
- ***Ionizing*** energies that interact molecularly with subcellular components of human systems and cause alterations of biochemistry and physiology, which in turn, can cause disease or dysfunction (e.g. **Radon**)

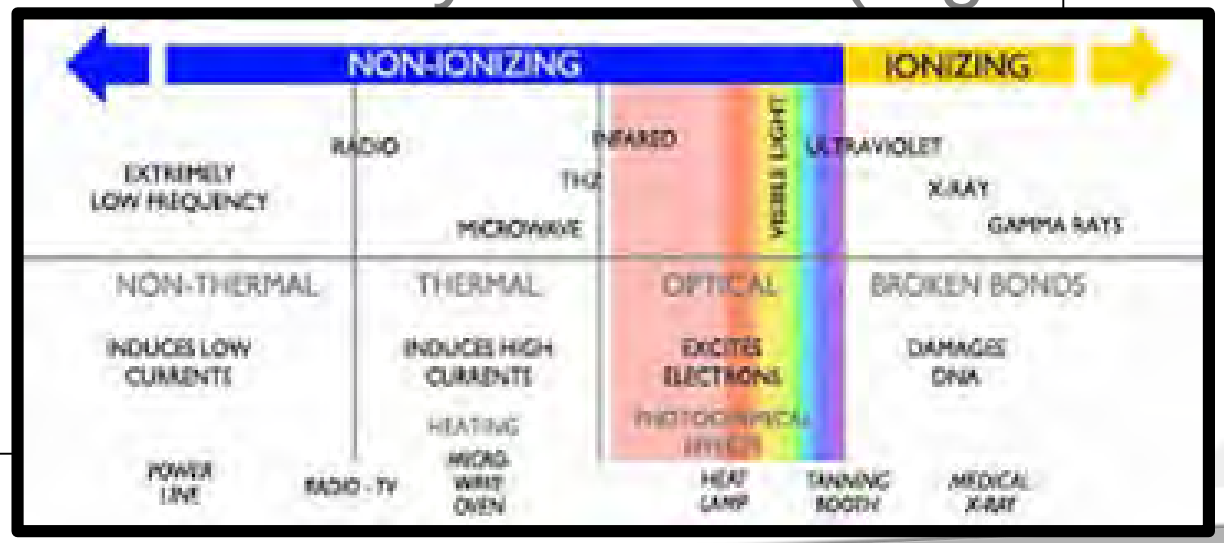




Radiological Agents

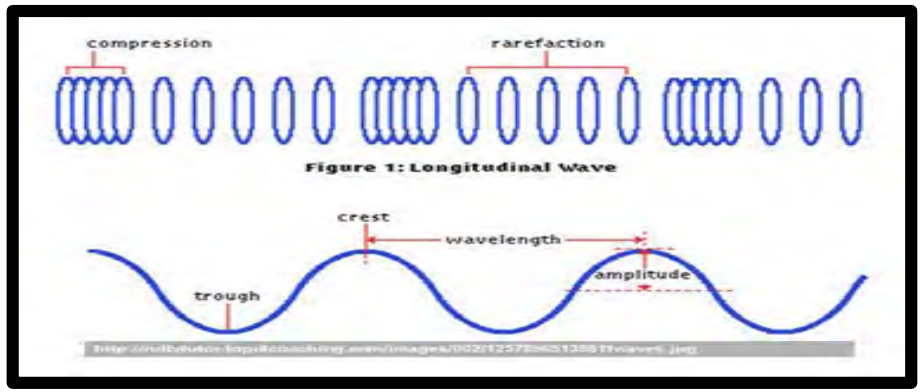
- ***Nonionizing*** energies that interact molecularly with subcellular components of human systems and cause alterations of biochemistry and physiology, which in turn, can cause disease or dysfunction (e.g. **UV (sun); MW; ELF**)





Sound (Unwanted Sound = Noise)

- ***Sound*** is an *energy* form of vibration that may be conducted through various media including solids, liquids, or gases.
- ***Sound pressure*** is the **deviation of air pressure from normal atmospheric pressure** and is related to the ***amplitude*** **of sound**.



What are some major contaminants and regulatory points regarding the water matrix?

Water Matrix

- **Surface Waters**
  - **Oceans**
  - **Seas**
  - **Lakes**
  - **Rivers**
  - **Streams**
  - **Ponds**
- **Ground Water**
  - **Underground Aquifers**
- **Waste Water**
- **Human exposure mainly via the “*ingestion mode*” and “*gastrointestinal route*”, and, also “*dermal/ocular contact mode*” and “*dermal/ocular route*” (*integument*)**

Sources of Contamination and Human Ecxposures - Water Matrix

- Potable
- Recreational
  - Swim
  - Boat
  - Water parks
- Fish
- Shower/Bath
- Humidifiers
- Water Storage

Common Microbial Agents - Water Matrix

- **Most common effect is gastrointestinal illness . . .**
- **Several biological infectious agents:**
  - ***Cryptosporidium parvum***
  - ***Giardia lamblia***
  - ***Entamoeba histolytica***
  - ***Legionella* spp.**
  - ***Naegleria fowleri* ("brain necrosis")**
  - **Hepatitis A**
  - ***Campylobacter jejuni and C. coli.***
  - ***Pseudomonas* spp. (dermal rashes; "swimmer's itch"; respiratory)**

Common Illnesses - Water Matrix

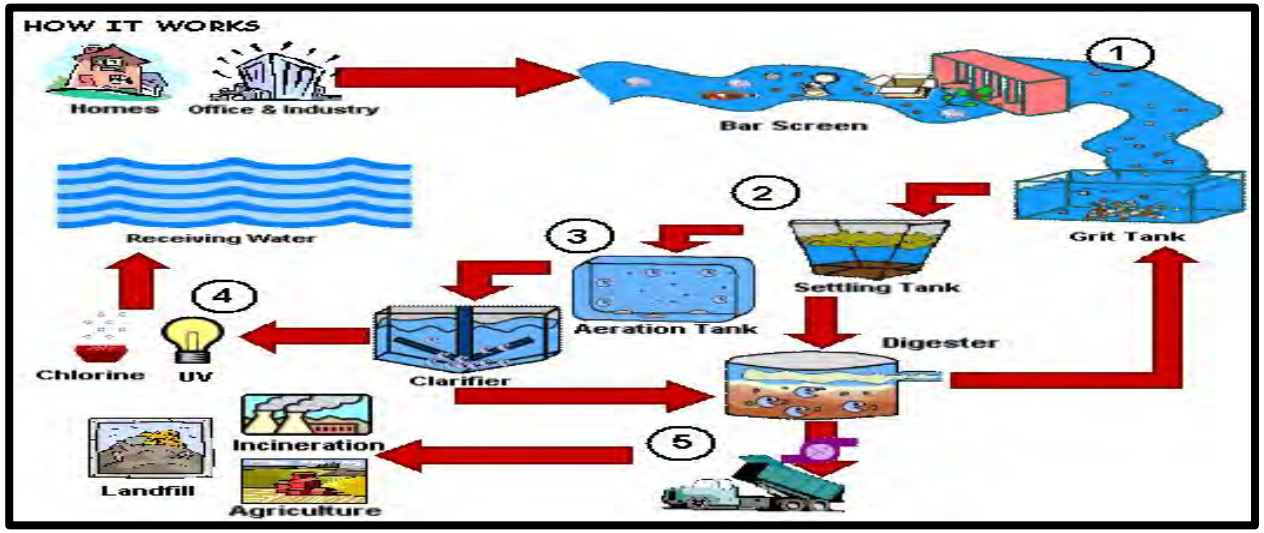
- GI – Diarrhea
- Respiratory
  - Legionella
- Dermal Rash
- Ear Infection (“Swimmer’s Itch”)

Major Federal Requlations for Water Matrix

- Clean Water Act (USEPA)
  - Point Pollutants
  - Non-Point (Runoff) Pollutants
- Safe Drinking Water Act (USEPA)

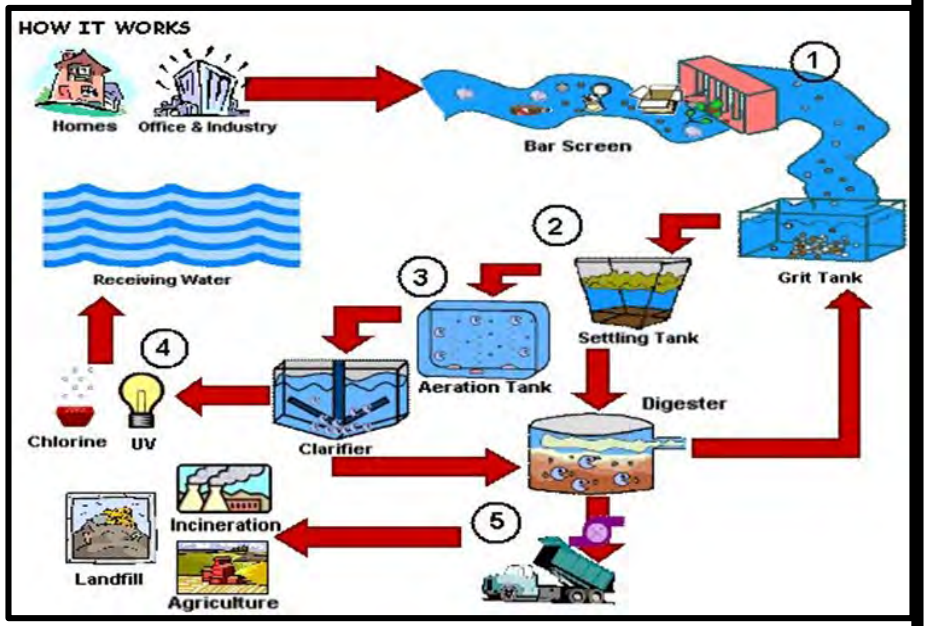
Clean Water Act

- regulates **“*point*”** and **“*non-point*” discharges**
- Toxic and Priority Pollutants
  - http://www2.epa.gov/sites/production/files/2015-09/documents/priority-pollutant-list-epa.pdf
  - http://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol29/xml/CFR-2014-title40-vol29-sec401-15.xml
- established discharge standards and permit system “National Pollutant Discharge Elimination System” (NPDES)
- **Waste Water Treatment Facilities**

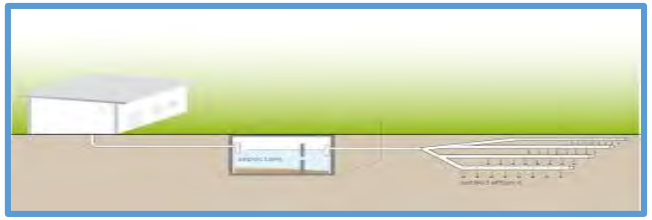


"Used" or Wastewater Treatment

- **Waste Water Treatment for Receiving Waste Water from Both Sanitary and Storm Sewers (or Combined if Both) to Generated Treated Effluent for Discharge Back to Environment**
  - **Large-scale Municipal Treatment**
    - **Waster Water Treatment Plants/Facilities**
    - **Primary+Secondary+Tertiary Treatment Phases yields treated (<u>not</u> potable) *effluent* plus *sludge* …*UV light, Chlorine or Ozone* to partially disinfect effluent prior to discharge.**



- **Small-Scale On-site Treatment**
  - **Septic Systems**
  - **Pit Privies**



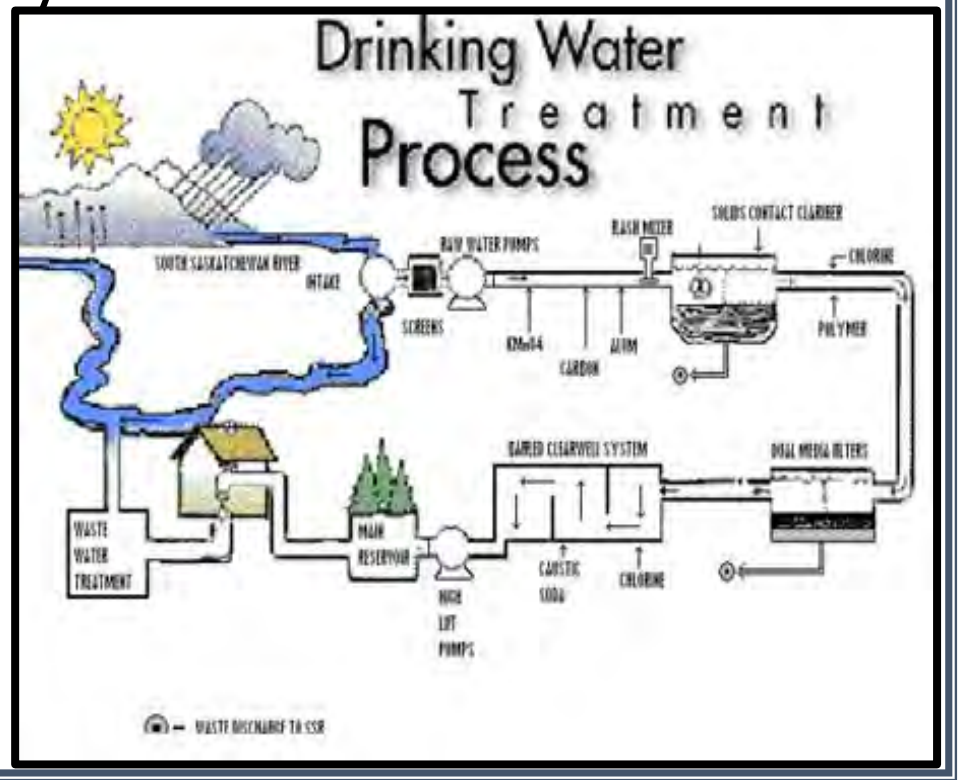
Major Indicators for Water and Wastewater Quality

- **pH** (associated with acid or alkaline)
- **Conductivity and Salinity** (associated with dissolved solids and salts)
- **Color** (associated with humic substances)
- **Turbidity** (associated with suspended solids)
- **Biological Oxygen Demand** (BOD_5 directly associated with amount of labile organic matter)
- **Fecal coliform bacteria** (associated with fecal matter from warm-blooded animals)
- **Total, Suspended and Dissolved Solids**
- **Chlorine** (associated with dose and residual)

Safe Drinking Water Act

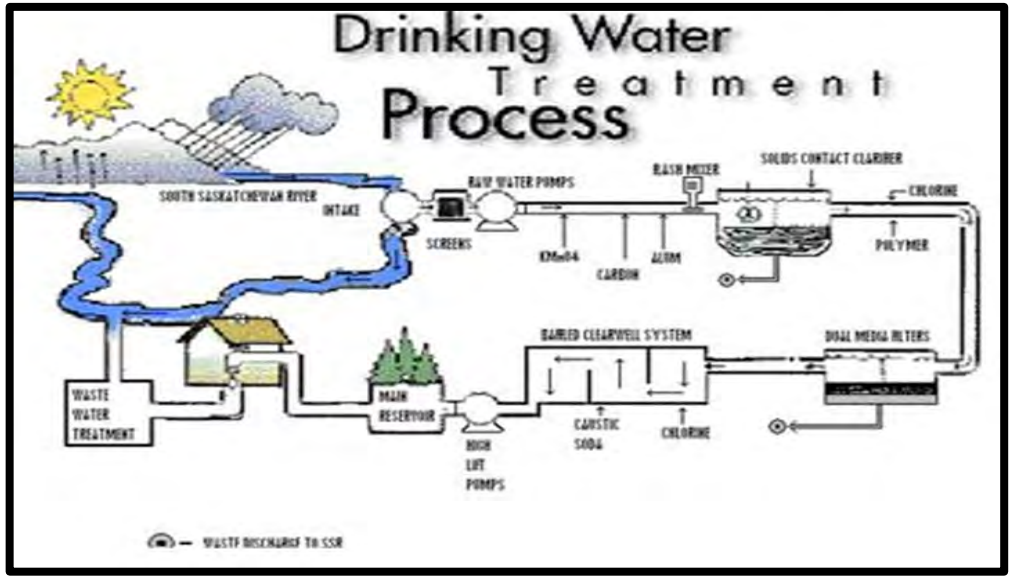
- regulates contaminants in public water systems used for "potable" drinking water

- **Water (Potable) Treatment Facilities**

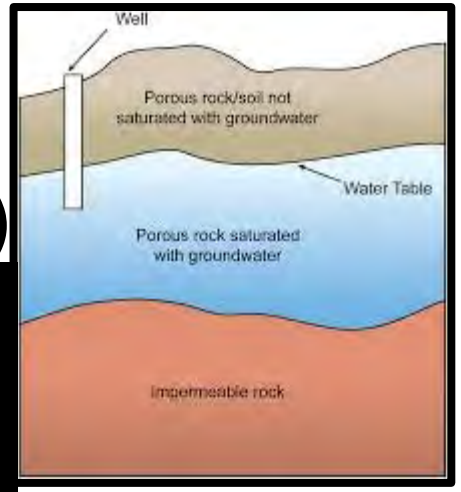


Potable Water Treatment

- **Water Treatment for Generating "*Drinking*" or "*Potable*" Water**
  - **Large-scale Municipal Treatment**
    - **Water Treatment Plants/Facilities**
    - ***UV light*, *Chlorine or Ozone* to disinfect water to distribution. . . (only chlorine has desired "residual")**



  - **Small-Scale Onsite**
    - **Ground Water Wells (Water from Aquifer)**



One major concern is elevated **nitrates** in drinking water since **not tolerated by neonates** and can cause **methemoglobinemia**

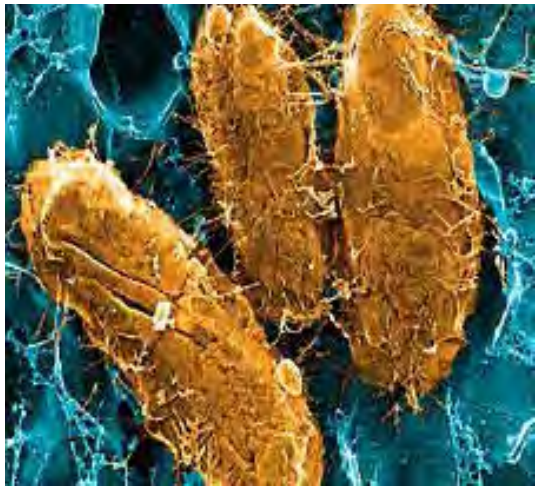
Potability based on "contaminants" and other water quality parameters meeting the Safe Drinking Water Act criteria (i.e. Maximum Contaminant Levels, MCLs). . .

https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

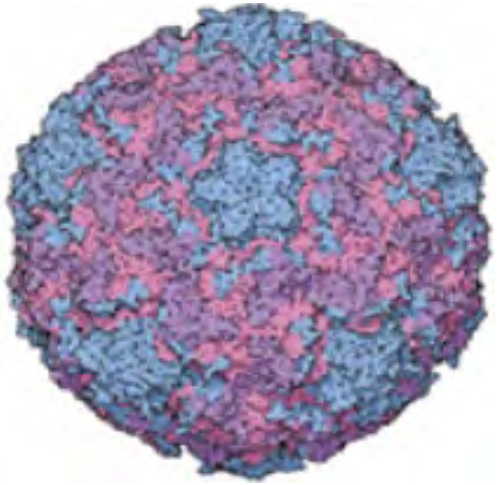
https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

What are some major contaminants and regulatory points regarding the food matrix?

Pathogens of Food and Waterborne Illnesses



Bacteria

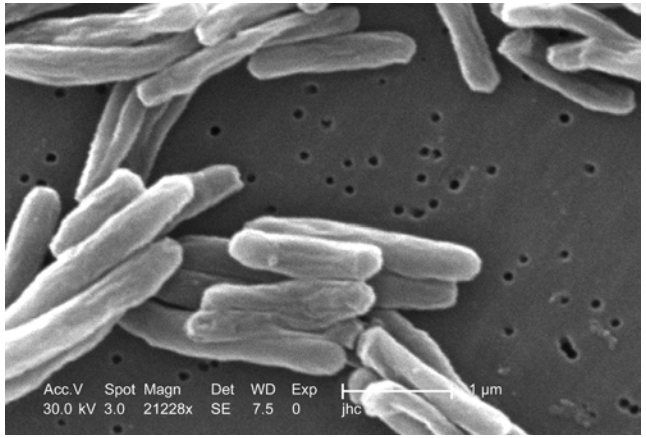


Viruses

Parasites

Foodborne Hazards

- **Biological**
  - Bacteria
  - Viruses
  - Parasites
  - Molds



- **Chemical**
  - Natural toxins from molds, plants, or fish (e.g. Aflatoxin)
  - Human origin (e.g. pesticides, cleaning solvents, metals, PCB)

- **Debris** such as stones, bone fragments, glass, staples

- **Radiological** isotopes that make their way into the food chain

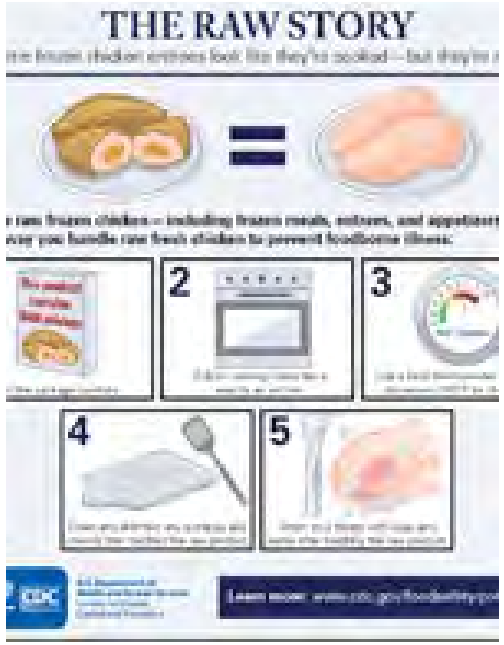
Food Matrix

- Beef
- Poultry
- Pork
- Seafood
- Vegetation
- Milk and other Dairy Products

Food Matrix

- **Temperatures for Cooking and Storing**
- **Food Handling**

- https://www.foodsafety.gov/keep/charts/mintemp.html



Food Matrix

- Norovirus
- Salmonella spp. (non-typhoidal)
- Bacillus cereus
- Clostridium perfringens
- Campylobacter spp.
- Hepatitus A
- Toxoplasma gondii
- Listeria monocytogenes
- Shiga-toxin producing Eserichia coli O157
- Yersinia enterocolitica
- Shigella spp.
- Vibrio cholerae and V. parhemolyticus
- Staphylococcus aureus

https://wwwnc.cdc.gov/eid/article/17/1/p1-1101_article

Some Categories Food and Waterborne Illnesses

- Diarrhea and vomiting
  - Due to agents that affect the digestive tract (bacterial, viral, and parasitic)
  - Infections occur by ingestion of pathogenic organisms present on food or in drinking water
  - May also occur by contact with infected individual or contact with objects contaminated by infected individual

- Other Types of Diseases
  - Parasitic and Viral Diseases
  - Agents may enter by ingestion, injection (insect bites), or burrowing through skin (certain parasites)
  - May spread to other sites via bloodstream or migration through tissues

Foodborne Illness

- Sickness people experience after consuming food and beverages that are contaminated with pathogenic disease-causing microorganisms, chemicals, or physical agents.
- Outbreak– two or more people experiencing the same illness as a result of eating contaminated food
- Tends to be underreported
  - Mild symptoms therefore do not seek medical care
  - Nonspecific symptoms
  - Laboratory analysis not typically conducted
  - Even if diagnosed, may not be reported
- Obscured contribution from water or human contact
- Exact cause known in <20% of cases
- Disease prevalence in U.S. for 1993: 24-81 million cases resulting in 10,000 deaths

Stages of Pathogen-based Foodborne Illness

- Consumption of contaminated food
- Lag time for microorganism to grow and reproduce
  - organism may grow in the intestines
  - organism may invade blood stream and attack specific organs
  - organism may produce toxin(s)
- Symptoms often include diarrhea, stomach cramps, nausea
- Two or more days between consumption and onset of symptoms

Hazard Analysis and Critical Control Points (HACCP)

1. **Conduct a hazard analysis**
2. **Determine the critical control points**
3. **Establish critical limits**
4. **Establish monitoring procedures**
5. **Establish corrective actions**
6. **Establish verification procedures**
7. **Establish record keeping and documentation procedures**

- **Focus on food safety via control of hazardous agents:**
  - **Biological**
  - **Chemical**
  - **Physical**
- **Phases included:**
  - **Raw Material Production**
  - **Procurement and Handling**
  - **Manufacturing**
  - **Distribution**
  - **Consumption**

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What is the One Health Approach?

CDC . . . The "Original" Paradigm

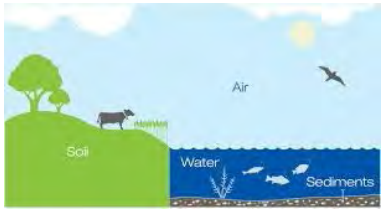
"*The goal of **One Health** is to encourage the collaborative efforts of multiple disciplines-working locally, nationally, and globally-to achieve the **best health for people, animals, and our environment**.*"

"***A One Health approach is important because 6 out of every 10 infectious diseases in humans are spread from animals.***"

U.S. Centers for Disease Control and Prevention
https://www.cdc.gov/onehealth/index.html

Applying *One Health Approach* to Prevent, Identify and Solve Problems

- **Interdisciplinary "approach" addressing issues at the <u>interfaces between and among</u>:**
  - ***Humans*** **. . . Human Health and Disease**
  - ***Animals*** **. . . Animal Health and Disease**
  - ***Environment*** **. . . Environmental Quality and Pollution**



One Health Approach:
Coordinated and Collaborative Clinical Components

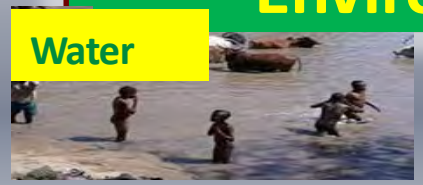
Human Health

Veterinary Health

Environmental Quality

Dr. Michael S. Bisesi

Environmental Quality



contaminants

contaminants

on Health

Human Health

contaminants

Plant Health

Animal Health

Michael Bisesi, PhD
2014

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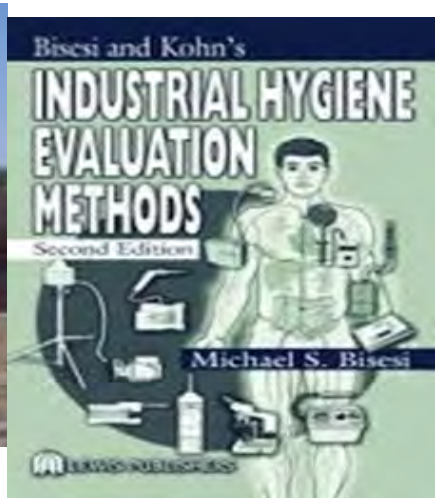
What are some approaches to evaluate environmental settings and exposures?

Evaluation
(What can you collect and measure?)

- Qualitative and quantitative determination of type and magnitude of exposure to humans
- Typically involves instrumentation (field; laboratory) to monitor various physical, chemical, biological and ergonomic parameters
- Interpretation of qualitative and quantitative monitoring data



Conduct Sampling in Various Environmental Settings

- ***Occupational (Workplace)*** **Environmental Settings:**
  - **Industries/Manufacturing facilities**
  - **Offices**
  - **Schools**
  - **Hospitals**
  - **Agriculture**

- ***Non-Occupational*** **Environmental Settings:**
  - **Hotels, Apartments, Homes**
  - **Outdoors (Ambient)**

Collect Samples from Various Matrices

- ***Occupational (Workplace)*** **and** ***Non-Occupational*** **Indoor Environmental Settings:**
  - **Primarily Air, Surfaces and Materials**

- ***Ambient*** **Outdoor Environmental Settings:**
  - **Air, Water, Soil, Food . . .**

Sampling and related analyses are conducted to evaluate environmental matrices to determine concentrations or levels of various agents . . .

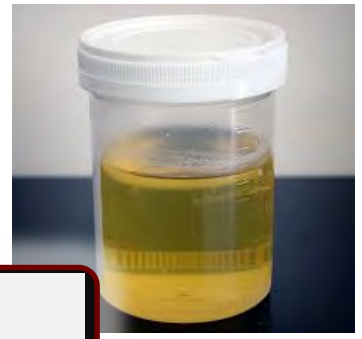
Other sampling is also conducted to evaluate contamination of various building/surface materials . . .

Sampling and related analyses are conducted to evaluate humans and animals to determine concentrations or levels of various agents . . .

Biological Matrices

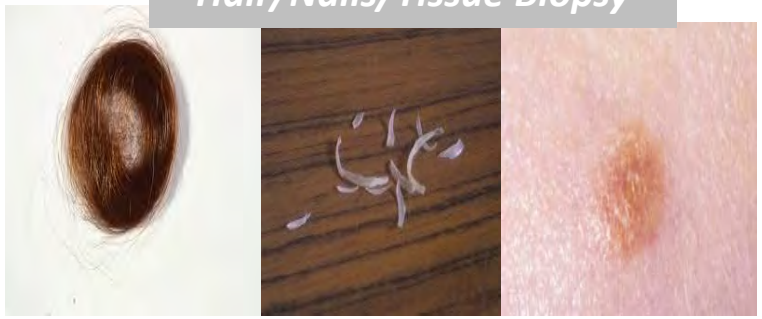
Blood

Urine



Exhaled Breath

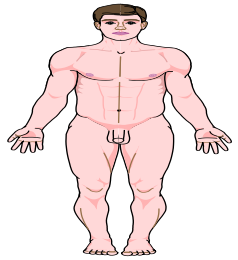
Hair/Nails/Tissue Biopsy



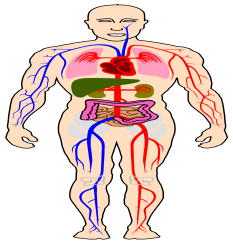
Other surveillance is also conducted to evaluate/diagnose illness potentially associated with environmental exposures . . .

Complementary and Coordinating Roles of Field and Clinical Practitioners Relative to Assessing Exposures

- **Environmental and Occupational Health Field Practitioners**
  - Focus on **external** exposures
  - Identify potential and real **"*causes*"**



- **Environmental and Occupational Medicine Clinical Practitioners**
  - Focus on **internal** exposures
  - Identify clinical **"*effects*"**



- **Environmental and Occupational Epidemiologists**
  - Focus on determining the relationship or association between hazardous agents ("cause"?) and illnesses ("effect"?)

Biologic Markers (“Biomarkers”)

- ***Biomarkers*** are molecular, subcellular or cellular structures detected in body fluids and other tissues that provide measurements and information relative to internal exposure and disease.

Generic Types of Biomarkers

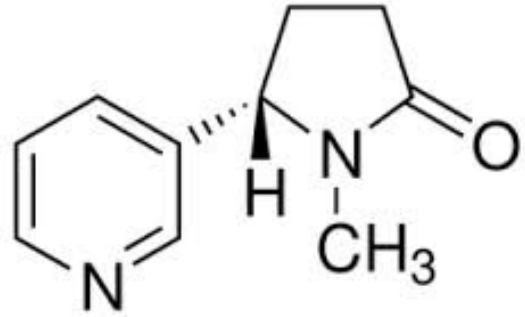
- Parent agent
- Biotransformed parent agent (*metabolite*)
- Increased or decreased endogenous levels of biochemicals and/or cells
- Altered biochemical, cellular component, or cell

Examples – Biomarkers of “Internal Exposure”

- Parent Compound:
  - Lead in blood or urine **Pb**
  - Nicotine in saliva

- Or, for Nicotine, Metabolite:
  - Cotinine (biotransformed Nicotine) in saliva

http://pubchem.ncbi.nlm.nih.gov/summary/summary.cgi?cid=408



Examples – Biomarkers of "*Effective Exposure* or *Response*"

- **Altered Biochemical or Cell Component**
  - Adducts (DNA; Protein)
    - Exposure to electrophilic compound
  - Increased d-amino levulinic acid (d-ALA) due to lead exposure and inhibition of d-amino levulinic dehydratase
- **Increased synthesis of biochemical**
  - Antibodies following exposure to sensitizer (e.g. nickel; TDI)
  - Mutated tumor-suppressor protein p53 associated with cancer

Examples – Biomarkers of "Response" (continued)

- **Decreased Cells**
  - Low-levels erythrocytes (**anemia**) due to lead exposure and inhibition of d-amino levulinic dehydratase
- **Elevated Liver Enzymes**
  - alanine amino transferase (ALT) or aspartate aminotransferase (AST) due to solvent/alcohol exposure
- **Increased Release of Biochemical**
  - Troponin following myocardial infarction and related ischemia and tissue necrosis

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