ENVIRONMENTAL HEALTH SCIENCE

LESSON 1- INTRODUCTION

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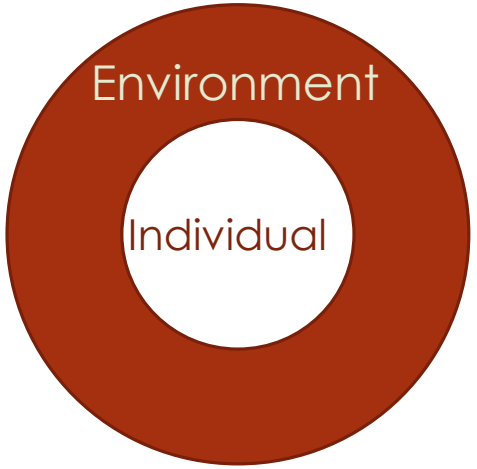
OBJECTIVES

- Define
  - Environment
  - Health
  - Environmental Health
- Describe
  - The factors that affect environmental health
  - The types of pollution
- Define the facets of environmental health
- Describe some of the effects of pollution on human health and the environment

Introduction



- "If you want to learn about the health of a population, look at the air they breath, the water they drink, and the places where they live."

  Hippocrates (5th century B.C.)

- "The environment is everything that isn't me."

  Albert Einstein (1879-1955)

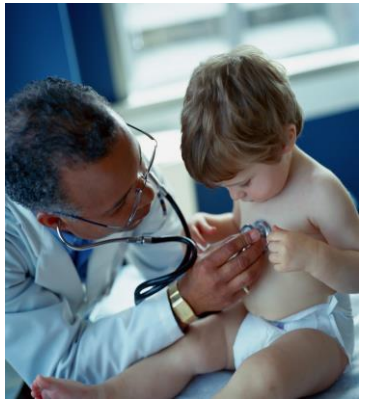
Introduction

Environment

- The circumstances, objects or conditions that surround all living organisms and that affect their development and survival.

Introduction

Health



- A state of well-being: physical, mental, social; not just the absence of disease (WHO, 2015).
  - Physical well-being – absence of measurable disease, disability or dysfunction.
- The three primary factors affecting human development, health and disease are
  - Environment – social, economic, physical
  - Genetics
  - Personal behavior

- Exposure to physical hazards and to hazardous and infectious agents in air, water, soil, food contribute to disease, disability and death.
  - Poor environmental conditions affect most those whose health is already at risk.
  - Deterioration of the environment affects social and economic development.

Connecting Global Priorities: Biodiversity and Human Health A State of Knowledge Review, 2015. http://apps.who.int/iris/bitstream/10665/174012/1/9789241508537_eng.pdf?ua=1
Lippman, M. Enivronmental Toxicants: Human exposures and their health effects. Chapter 1. Third edition. Wiley. 2009.

Introduction

Health

- Recognizable health effects in populations are divided into two categories:
  - Mortality: number of deaths per unit of population per unit time, and to the ages at death.
  - Morbidity: number of non-fatal cases of reportable disease.

- Accidents, infectious diseases or exposures to toxic substances can lead to
  - Increased mortality shortly after exposure to the hazard.
  - Residual disease and/or dysfunction.
- In some cases the relationship between cause and effect cannot be established.

Connecting Global Priorities: Biodiversity and Human Health A State of Knowledge Review, 2015. http://apps.who.int/iris/bitstream/10665/174012/1/9789241508537_eng.pdf?ua=1
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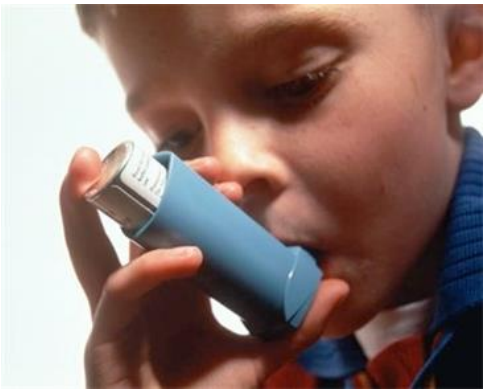


Disease

- "A condition of the body or of one of its parts that impairs normal functioning."
- "A condition that prevents the body or mind from working normally."


- Exposure to physical hazards and to hazardous and infectious agents in air, water, soil, food contribute to disease, disability and death.
  - Those whose health is already at risk are the ones most affected by poor environmental conditions.

http://www.merriam-webster.com/dictionary/

Introduction

Environmental Health Science

- Deals with assessment, understanding and control of the impact of people and the environment on one another.

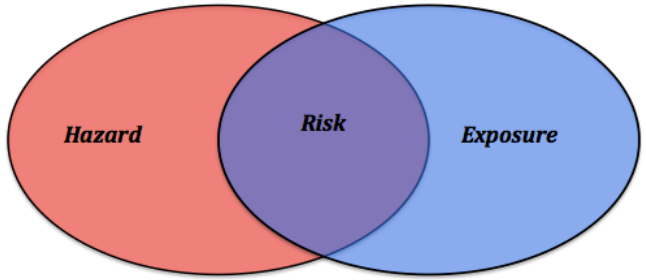
People  Environment

- The study of the environmental factors that affect human health and quality of life.
- Many diseases can be initiated, promoted, sustained or stimulated by environmental factors.

Introduction

Safe

- "*Free* from harm or risk; *secure* from threat of danger, harm, or loss; not threatening danger or harm; *zero* risk."



http://www.merriam-webster.com/dictionary/

Hazard

- A potential source of harm or adverse health effect on a person/living organism.

Risk

- The likelihood (the chance) that a person/living organism may be harmed or suffer adverse health effects if exposed to a hazard.

http://www.hsa.ie/eng/Topics/Hazards/

Environmental Factors

Environmental circumstances that affect the lives and health of living organisms.

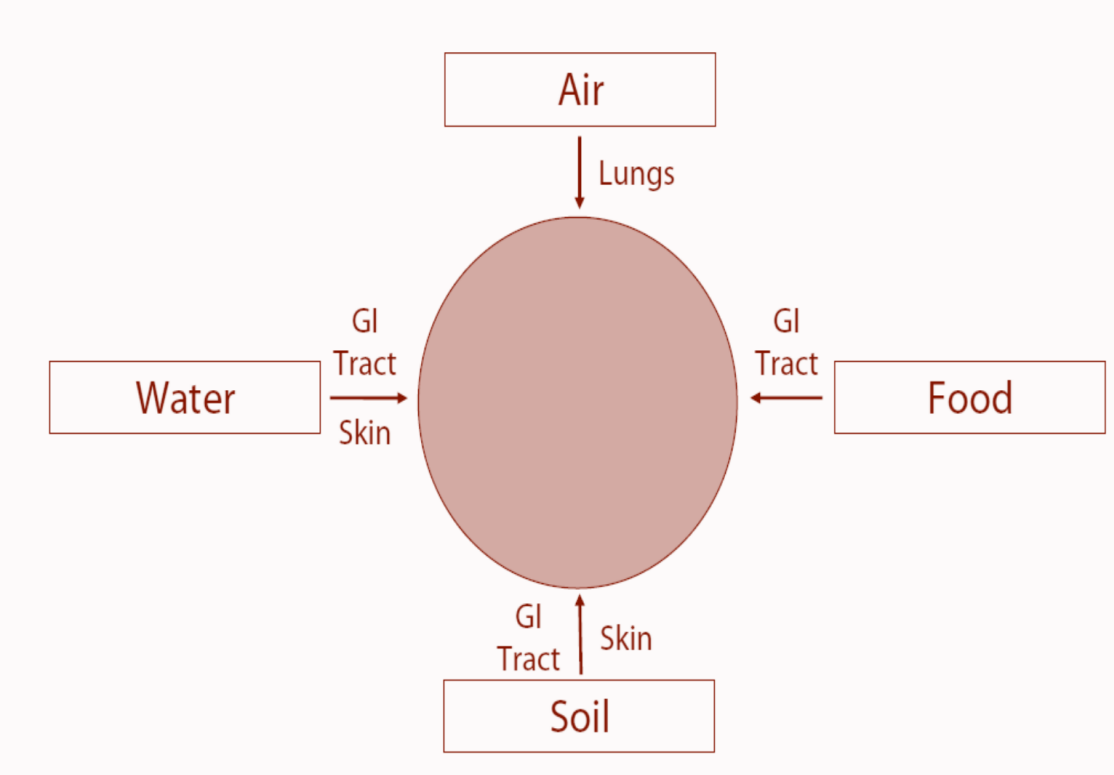
- Chemical
  - Toxic waste, pesticides, Volatile Organic Compounds (VOCs).
- Biological
  - Pathogenic microorganisms, insects, pests, other living organisms.
- Physical
  - Noise, radiation, temperature, climate, landscape.
- Socioeconomic
  - Access to housing, education, health care.
- Psychosocial
  - Human-human interactions in living and working conditions.

Environmental Pollutants

Environmental pollutants

- Substances not normally found in the environment and that in large enough *amounts* produce *adverse health effects*.
- Transferred to humans and other living organisms by *inhalation, ingestion, or absorption*.

Exposure routes and media



National Institute of Environmental Health Sciences, NIEHS.

Moeller DW. Environmental Health. 2005. Third Edition. Harvard University Press

What is contamination and what is pollution?

Contamination

- Refers to the presence of a substance where it should not be or at concentrations above background.
  - Background concentrations are levels of contaminants typical of that environment and can come from natural and man-made sources.

Pollution

- Pollution is contamination that can result in adverse biological effects to the environment and living organisms.
- *All pollutants are contaminants, but not all contaminants are pollutants.*

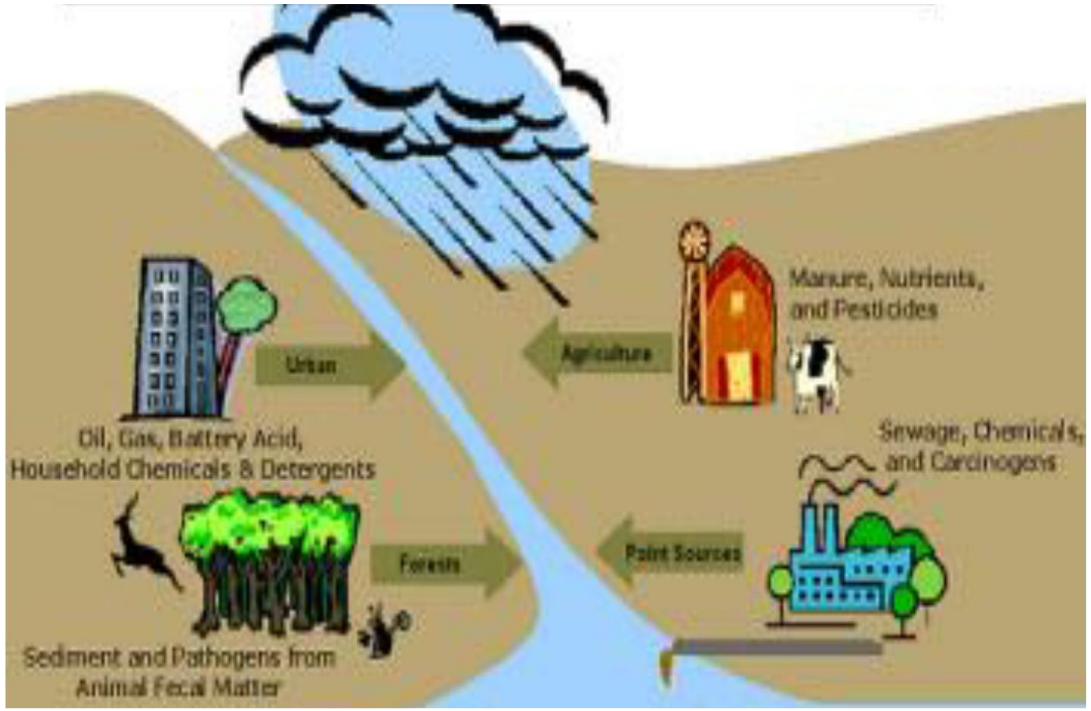
Peter M. Chapman. Determining when contamination is pollution — Weight of evidence determinations for sediments and effluents.

Types of pollution

- Air
- Water
- Soil
- Food
- Thermal
- Radiation
- Light
- Noise
- Indoor
- Outdoor

Sources of pollution

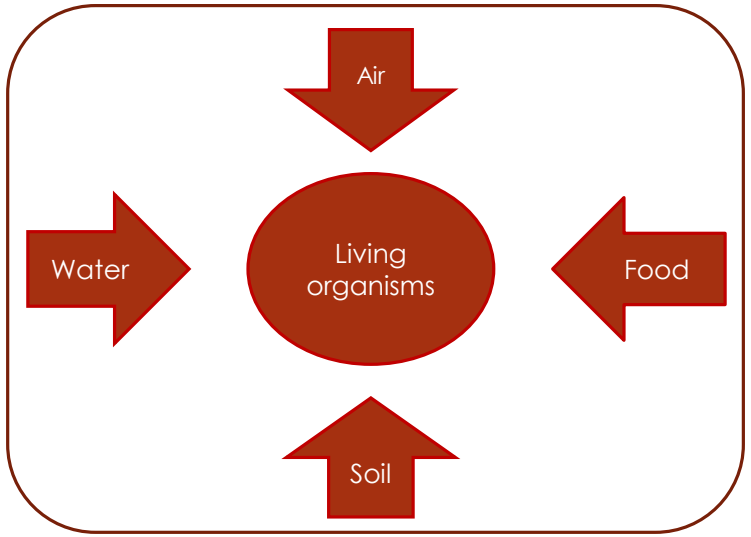
- Natural and man-made
- Point and Non-point



Pollution and the environment

Environmental Degradation

- What is affected
  - Air, water, soil, food, climate, atmosphere.



- Who is affected
  - All living organisms: humans, animals, plants, microorganisms.
- What are some of the effects
  - Disease development.
  - Disruption of reproduction and lifecycles in living organisms.
  - Climate changes.
  - Damage to the ozone layer.
  - Changes in the landscape.
  - Ecosystem changes.

Effect of pollution on human health

Environmental Diseases

- Illnesses and conditions caused by factors in the environment.
  - Chronic and deteriorative diseases.
- Man-made pollutants, natural pollutants, or changes in environmental conditions.

Factors

- Factors that affect the development of environmental diseases
  - The type of pollutant.
  - The amount of pollutant.
  - The length of exposure to the pollutant.
  - The genetic makeup of the individual exposed to the pollutant.

Some Human Environmental Diseases

- Lung diseases.
- Cancers – thyroid, skin, lung,leukemia.
- Immunodeficiency disorders.
- Reproductive disorders.
- Gastrointestinal diseases.
- Nervous system disorders.
- Chronic fatigue.
- Heavy metal poisoning.
- Sick-Building Syndrome.
- Gulf-War Syndrome.
- Post-traumatic stress disorder (PTSD).

"Everything is a poison, nothing is without a poison; only the dose decides that something is not a poison"

Paracelsus (1493-1541)

Environmental quality and disease burden worldwide

- Poor environmental quality, diarrheal diseases and respiratory infections are among the leading illnesses worldwide.

- Children are at a greater risk of dying from environmental hazards, including polluted water and air (WHO).
  - 10% of all children are under the age of five years, but 40% of the burden of all environmental-related diseases falls in this age category.

Johnson, B.L. Environmental Policy and Public Health. 2007. CRC Press. Taylor and Francis Group.

Environmental quality and disease burden worldwide

Main issues related to poor environmental quality

- Unclean water and diarrheal diseases.
  - Cholera, dysentery, guinea worm, typhoid, and intestinal worms.
- Waste water discharge into rivers, lakes and oceans.
- Indoor air pollution as a cause of death in children.
  - Pneumonia and other respiratory infections caused or worsened by use of solid fuels such as wood, coal.
    - Smoke with high content of small particulate solids.

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Facets of Environmental Health

- Environmental Epidemiology
  - Associations between exposure to environmental agents and the development of disease.
- Environmental Toxicology
  - Causal mechanisms between exposure and subsequent development of disease.
- Environmental Medicine
  - Medicine, environmental science, chemistry, pathology.
- Environmental Law
  - Development of legislation to protect public health.
- Environmental Engineering
  - Factors that govern and reduce exposure.

Assessing Problems in the Environment

- Understand interactions between humans and their environment.
  - Protect health and quality of life.
- Determine the problem, its causes, sources, impact on health and environment, and how to control it.
- Toxicology studies on humans and the environment.
  - Routes of entry/exit, level of exposure, metabolism of toxins, environmental transport and degradation.
- *There is no "zero" risk.*
  - "Zero" pollution – unrealistic and unachievable.

Moeller DW. Environmental Health. 2005. Third Edition. Harvard University Press

Chemical contaminants

Chemical exposure

- Toxic chemicals in the environment may reach sensitive tissues and cause changes that lead to disease and loss of function.
  - Route of exposure
    - Skin, respiratory tract, digestive tract.
  - Extent of tissue damage
    - Amount and length of exposure.

- *Exposure:* contact between a concentration of the toxic substance in air, water, food, or other material and the living organism or population of interest.
- *Dose:* amount of chemical that reaches the site of the body where toxic effect takes place.

Lippman, M. Enivronmental Toxicants: Human exposures and their health effects. Third edition. Wiley. 2009.

Chemical contaminants

Concentration units

- Difference when talking about contaminants in soil, water or air.

Medium	Parts per million (ppm)	Parts per billion (ppb)
Soil	(mg/kg)	(µg/kg)
Water	(mg/L)	(µg/L)
Air	(mg/m^3)	($\mu g/m^3$)

Air contaminants

- Can be gases, liquids or solids.
- *1- Gases and vapors:* form true solutions in the air and cannot be distinguished from the air.
- *2- Aerosols:* dispersions of solid or liquid particles in the air. The characteristics of the particles affect their ability to stay in the air and to scatter light.
  - Size, shape, volume and density.

Chemical contaminants

Water contaminants

- Gases: Oxygen is the most important gas for water quality and to sustain aquatic life.
- Gases like hydrogen sulfide (HS_2) or ammonia (NH_3), are usually the product of decay processes, and are toxicants.
- Solids: can be dissolved or suspended.
- Dissolved natural mineral salts like sodium chloride are not considered contaminants.
- Suspended solids can dissolve, grow, coagulate or be ingested by aquatic life.
  - They may "float", be part of an oil film, or fall to the bottom to become sediments.
  - Not all suspended solids are contaminants.

Chemical contaminants

Food contaminants

- Can enter the food during production, harvesting, processing, packaging, transportation, storage, cooking, and serving.
- Natural or man-made.
- Physical, chemical or biological.

- Toxic compounds can enter a food or form within a food by chemical reactions with other food components or additives, or by thermal or microbiological conversion reactions during processing, storage or handling.

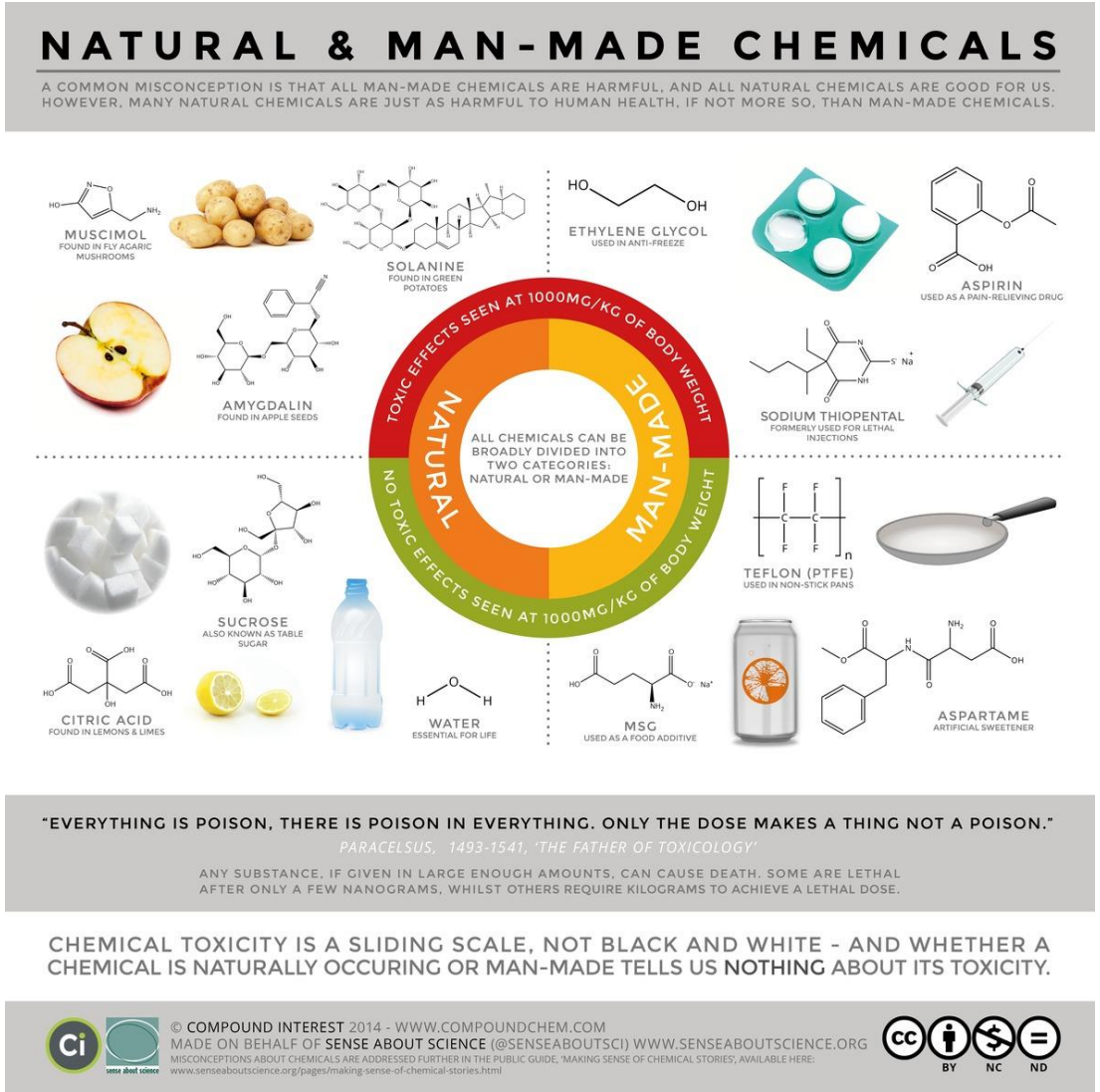
Human exposure to chemical contaminants

- Inhalation – the respiratory tract is the most common route of entry for chemicals into the body.
  - Gases, dusts, mists, fumes, vapors and airborne particulate matter can be breathed in through nose or mouth and into the lungs.
- Absorption – chemicals in the form of dust, smoke, liquids, gases or vapors, can enter the body through the skin or eyes.
- Ingestion – hazardous chemicals that enter the body through the mouth, in the form of dust, particles or mists – inhaled of swallowed.
- Injection – not a common route of entry.
  - Chemicals can enter the body through an accidental impact, cut or puncture to the skin.

http://www.buffalo.edu/facilities/ehs/training/right-to-know-training/how-chemicals-enter-the-body.html

Human exposure to chemical contaminants

- Effects of exposure can happen
  - Directly at the site of exposure (respiratory tract, digestive tract, skin).
  - In any organ after diffusion or transport by blood or lymph.
- Many chemicals are common in the environment at very low doses.
  - Air, water, soil, food, indoor/outdoor.



Chemical exposure and health

Factors affecting the magnitude of the dose

- (1) The *amount of the toxic substance* absorbed, inhaled or ingested.
- (2) The *fraction of the toxic material transferred* across epithelial membranes of the skin, the respiratory tract, and the digestive tract.
- (3) The *fractions transported* via circulating fluids (blood, lymph)to target tissues.
- (4) The *fraction taken up* by target tissues.

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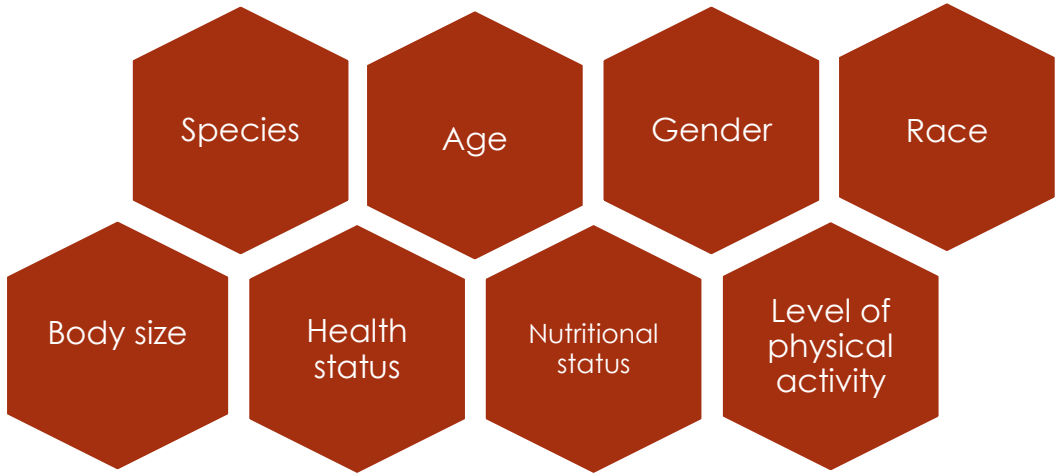
Chemical exposure and health

- Sources of variability for the factors affecting the magnitude of the dose



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Chemical exposure and health

Exposure level

- Low-level exposures to environmental hazards are more common and tend to be chronic.
- Substances that produce very rare or specific diseases may be identified as the causative agent with certainty using a small number of cases (cluster).
  - Rare type of liver cancer caused by inhalation of vinyl chloride vapors.
  - Pleural cancers from the inhalation of asbestos fibers.

Lippman, M. Enivronmental Toxicants: Human exposures and their health effects. Chapter 1. Third edition. Wiley. 2009.

Chemical exposure and health

- Low-level chronic exposure to hazardous compounds may contribute to increased incidence of disease.
  - Co-factor to other exposures.
    - Very high levels of lung cancer in uranium and asbestos workers who smoke but only marginally elevated on non-smoking workers.
- Reporting morbidity may be harder than mortality because it depends on proper diagnosis and reporting of chronic diseases.
- Tools for diagnosis and report of diseases associated to environmental factors vary.
  - Questionnaires by health care providers.
  - Hospital admission records, clinic visits.
  - Work absenteeism.

Lippman, M. Enivronmental Toxicants: Human exposures and their health effects. Chapter 1. Third edition. Wiley. 2009.

Exposure-response relationships

Factors affecting the effective dose

- *Effective dose* is the amount of toxicant reaching the site in the body where the adverse effects occur.
- The effective dose is proportional to the concentrations available in the environment: air, water and food.
- Uptake of a toxicant also depends on the route of entry to the body, and on the physical and chemical form of the toxicant.
- The effective dose varies within and between species, for a given level of toxicant.

Lippman, M. Enivronmental Toxicants: Human exposures and their health effects. Chapter 1. Third edition. Wiley. 2009.

Exposure-response relationships

Factors affecting the effective dose

- Airborne toxicants
  - The dose to the respiratory tract depends on the form: gas or aerosol.
- Ingested toxicants
  - Uptake depends on (1) transport through the membranes lining the digestive tract and (2) whether the substance is water or lipid soluble.
- For toxicants that penetrate membranes, reach the blood, and are transported systemically, retention in the body depends on metabolism and specific toxicity to tissues/organs in which they are deposited.

Lippman, M. Enivronmental Toxicants: Human exposures and their health effects. Chapter 1. Third edition. Wiley. 2009.

Exposure-response relationships

Factors affecting the response to exposure to a toxicant

- Response to environmental exposure can be influenced by several factors that can vary between and among species.
- Interpretation of results from exposure studies must consider these differences.

- Age
- Gender
- Activity level at time of exposure
- Metabolism
- State of immune system
- Prior exposure to similar toxicants
- Temperature stress
- Nutritional deficiencies

Exposure-response relationships

Factors affecting individual susceptibility

- The complete evaluation of the pathogenesis of human disease requires identification and assessment of the genetic, lifestyle and environmental risk factors.
- Individual susceptibility to diseases is influenced by the interaction of different factors :
  - Genetic-lifestyle
  - Genetic-environment
  - Lifestyle-environmental
  - Genetic-lifestyle-environmental

Exposure-response relationships

Factors affecting individual susceptibility

- Examples of interactions:
  - a-1-antitrypsin deficiency-induced chronic obstructive pulmonary disease (COPD) and cigarette smoking *(genetic-lifestyle)*.
  - Glutathione S-transferase P1 deficiency and exposure to second hand smoke or excessive air pollution and increased susceptibility to respiratory infections *(genetic-environmental)*.
- Cigarette smoking and increased incidence of malignant mesothelioma and lung cancer in workers exposed to asbestos *(lifestyle-environmental)*.

Study options for health effect studies

Controlled human exposures

- Useful for studying temporary changes from brief controlled exposures.
- Can control the substance and its level.
- But cannot test for just any substance and the effects have to be temporary.
  - "Do no harm."

Natural human exposures

- For studying acute responses to naturally occurring pollutants.
- Difficult to determine influence of prior exposures, to separate effect of different pollutants, or control for variables like pollutant level, temperature, humidity, activity level.

Study options for health effect studies

Population-based studies

- Epidemiological studies that allow for the study of chronic health effects of environmental pollutants and to study the influence of other environmental factors.
- Associations between variables may be difficult to establish because of uncontrolled factors (confounders).

Controlled exposures *In Vitro*

- Study of biochemical mechanisms.
- Efficient and low cost.
- To make interspecies comparison.
- Interpretation of the in vitro test results in relation to effects on in vivo human cells may be limited – even if human cells are used.
  - Cellular metabolism and function of cells within a living organism may vary compared to isolated cells.

Study options for health effect studies

Controlled exposure of lab animals

- For studying mechanisms and patterns of response to pollutants and interactions between different pollutants.
- Concentration and duration of exposure, age, gender, species, strains, genetic variations, nutrition, other pollutants, etc., can be controlled.
- Study short-term and cumulative responses and the pathogenesis of chronic disease in animals.
- Large numbers of animals can be studied at once.
- The results may be limited in their interpretation to the effects in humans.

Glossary of terms

- Toxicant: any toxic substance that is man-made or that entered the environment as a result of human activity.
- Toxin: a toxic substance produced naturally by a living organism.
- Hazard: any source of potential damage, harm or adverse health effects on something or someone under certain conditions.
- Hazardous: dangerous or risky. Involving the chance of loss or injury. May cause harm or loss unless dealt with carefully.

Chemical exposure and dose to target tissues

Terminology

- Target tissue: a site within the body where toxic effects take place leading to damage/disease. It can be whole organs, specific cells, or sub-cellular constituents.
- Deposition: capture of the toxic substance at a body surface on the skin, respiratory tract or digestive tract.
- Clearance: translocation from a deposition site to a storage site or depot within the body, or elimination from the body.
- Retention: presence of residual material at a deposition site or along a clearance pathway.

Lippman, M. Enivronmental Toxicants: Human exposures and their health effects. Third edition. Wiley. 2009.

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- World Health Organization (WHO). 2016. Health Impact Assessment (HIA): The determinants of health. http://www.who.int/hia/evidence/doh/en/
- National Institute of Environmental Health Sciences (NIEHS). Environmental Diseases from A-to-Z. https://www.niehs.nih.gov/health/assets/docs_a_e/environmental_diseases_from_a_to_z_english_508.pdf

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- Lippmann, M. 2009. Chapter 1. Introduction and Background, in Environmental toxicants: Human exposures and Their Health Effects. Third Edition. John Wiley & Sons.

Class activity – Lecture 1

- What is the difference between
- **Toxin** and **toxicant**
- **Prevalence** and **incidence**
- ***In vivo*** and ***in vitro*** studies
- *Choose five words from this lesson and find their meaning.*