ESSENTIAL PUBLIC HEALTH

# *Essentials of* Environmental Health

SECOND EDITION

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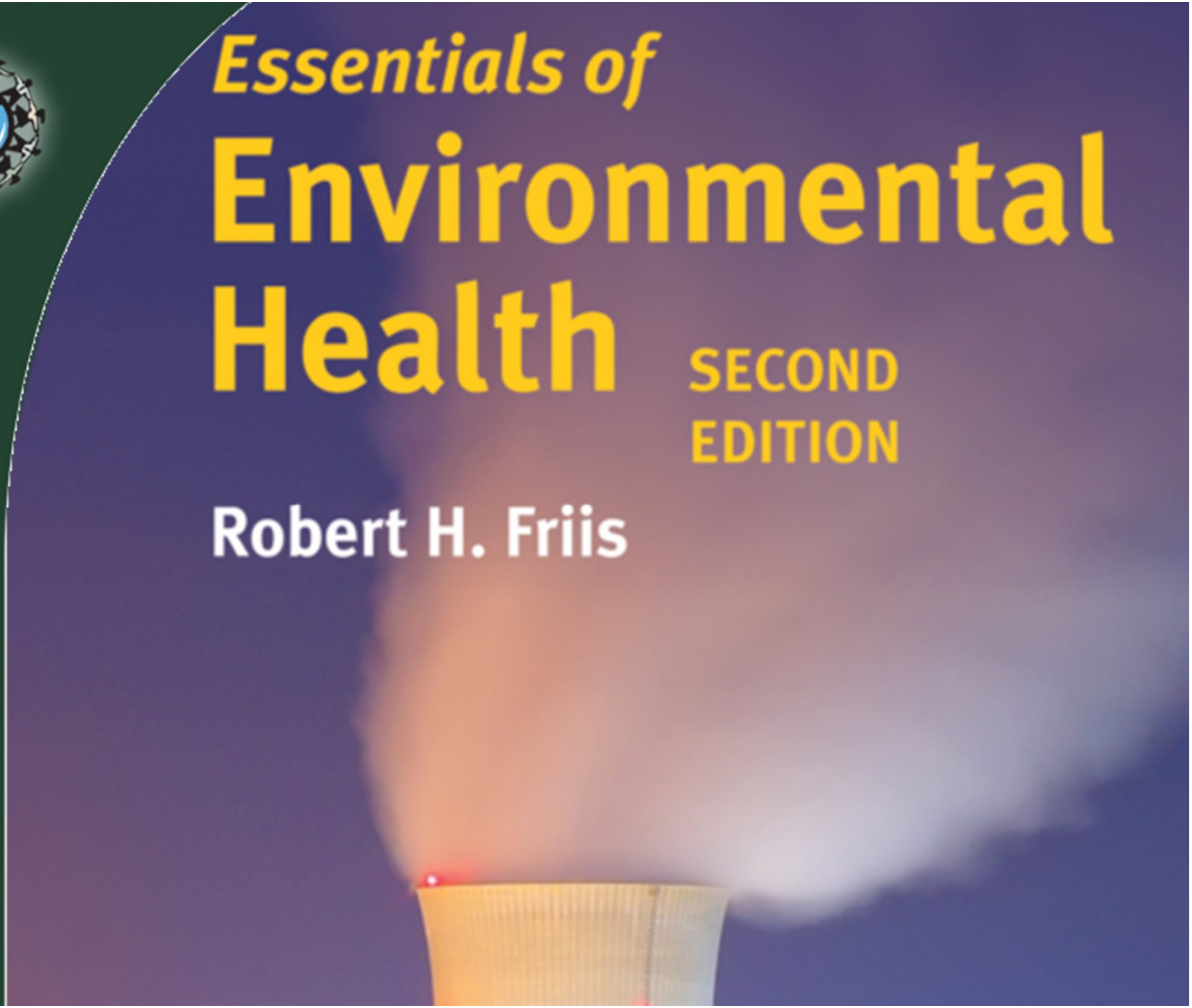


# Chapter 8

## Ionizing and Non-Ionizing Radiation

# Learning Objectives

By the end of the chapter the reader will be able to:

- Define the terms *ionizing radiation* and *nonionizing radiation*
- State the differences between ionizing and nonionizing radiation
- Describe sources and types of ionizing and nonionizing radiation
- Discuss the health effects of exposure to ionizing and nonionizing radiation
- Describe major incidents in which the population was exposed unexpectedly to ionizing radiation

# Radiation

- The term *radiation* refers to “Energy traveling through space. Some types of radiation associated with radioactivity are alpha and beta particles and gamma and X rays.”
- Radiation also includes neutrons, which are uncharged.

# Ionizing Radiation

- Radiation that "has enough energy to remove tightly bound electrons from atoms, thus creating ions."
- Its properties are used to generate electric power, to kill cancer cells, and in many manufacturing processes.

# Anthropogenic (Man-Made) Sources of Ionizing Radiation

- X-rays and other procedures used in medicine (medical tests and therapies)
- Consumer products
- Radioactive substances used in industry
- Nuclear power generators
- Radioactivity (e.g., radioactive fallout) from the production and detonation (primarily for testing purposes) of nuclear weapons.

# Natural Sources of Ionizing Radiation

- Cosmic rays
- Other forms of radiation that impinge upon earth from outer space
- Radiation from geologic formations that contain radioactive elements (radioelements) such as uranium, from which radon gas is formed as a decay product

# Types of Ionizing Radiation

- *Particulate energy* (e.g., highly energetic protons, neutrons, and α and β particles)
- *Electromagnetic energy* in the form of photons (e.g., γ rays and X-rays)

# Radioactivity

- "The spontaneous emission of radiation from the nucleus of an unstable atom.
- As a result of this emission, the radioactive atom is converted, or decays, into an atom of a different element that might or might not be radioactive."

# Absorbed Dose

- "The radiation energy absorbed per unit mass of an organ or tissue and is used in studies of the damage to a particular organ or tissue."

# Dose Equivalent

- Obtained by weighting the absorbed dose in an organ or tissue by a radiation weighting factor that reflects the biological effectiveness of the charged particles that produce ionization within the tissue.

# Exposure

- "A quantity used to indicate the amount of ionization in air produced by X- or gamma-ray radiation. The unit is the roentgen (R)."

# Common Units of Radiation

- *Curie (Ci):* A unit of measure used to describe the amount of radioactivity in a sample of material.
- *Rad:* Radiation absorbed dose. The former unit of absorbed dose of ionizing radiation.

# Common Units of Radiation, continued

- *Rem:* (Roentgen equivalent in man) A measure of radiation dose related to biological effect. A rem is a measure of dose deposited in body tissue, averaged over the mass of the tissue of interest.
- *Roentgen (R):* The unit of exposure from X- or gamma rays

# Factors That Affect the Amount of Radiation Exposure

- The total amount of time exposed to the radioactive source
- Distance from the radioactive source
- Degree of radioactivity (rate of energy emission) of a radioactive material

# Acute Health Effects of Ionizing Radiation

- Include tissue burns and radiation sickness (e.g., nausea, weakness, and loss of hair)
- At low levels: usually does not produce immediately detectable harm
- At high levels: capable of producing fatal injuries

# Stochastic Effects

- The term *stochastic* means that there is an increased probability of the occurrence of an adverse health event.
- Associated with low levels of exposure to radiation over long time periods.
- Carcinogenesis and genetic damage such as changes in DNA are possible stochastic effects of radiation exposure.

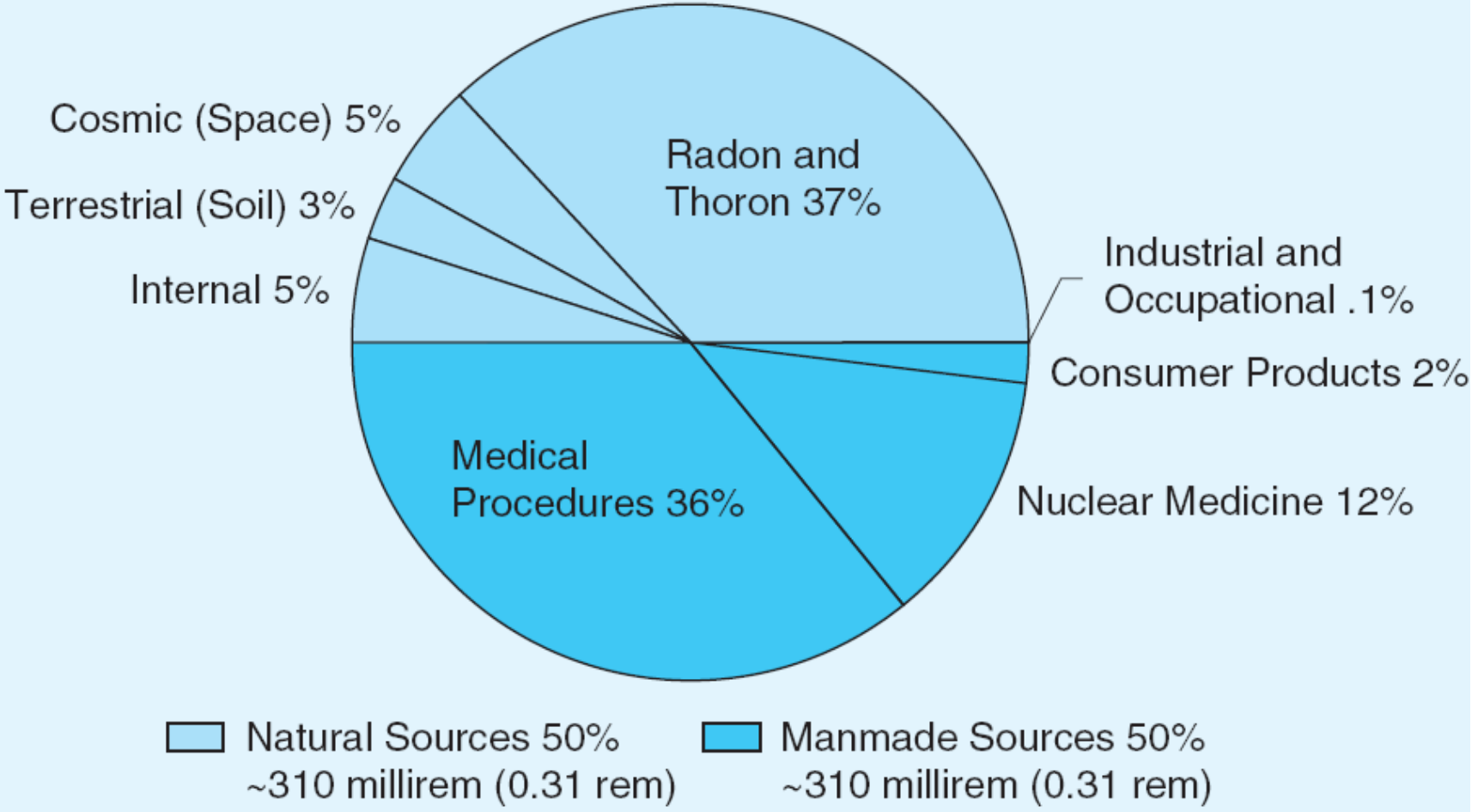
# Natural Sources of Exposure to Ionizing Radiation

- Cosmic radiation (radiation from space)
- Uranium deposits that cause increases in background radiation levels in some geographic areas
- Radon
  - A decay product of uranium, radioactive radon gas may seep into homes, thus exposing the residents.

# Anthropogenic Sources of Exposure to Ionizing Radiation

- Nuclear power plants have been known to leak ionizing radiation into the environment under unusual conditions.
- Radioactive fallout from above-ground nuclear testing has exposed large populations to radiation.
- Decommissioned and abandoned nuclear weapons facilities and storage of nuclear wastes can be a source.
- Medical X-rays and radiation diagnostic and therapy procedures produce exposures to ionizing radiation.

# **Figure 8-4** Sources of radiation exposure in the United States.




*Source:* Reprinted from United States Nuclear Regulatory Commission. Available at: http://www.nrc.gov/images/reading-rm/basic-ref/glossary/ionizing-radiation.jpg. Accessed April 3, 2010.

# Uranium

- A common element in the earth's crust
- Uranium ores uraninite and pitchblende are found in large amounts in North America, Africa, and Australia.
- Nearly all plants, animals, and aquifers contain tiny amounts of uranium.

# Radon

- Inert, colorless, and extremely toxic gas
- Produced by the decay of radium and uranium
- Classified as a Class A carcinogen
- Associated with long-term adverse health effects

# Extraterrestrial Radiation

- Primary cosmic rays originate from outer space (e.g., the earth's galaxy and the sun) and interact with the earth's atmosphere to produce secondary cosmic rays.
- Cosmic rays have the ability to penetrate and cross the human body easily.

# Nuclear Facilities and Accidents

- Nuclear facilities include weapons production plants, test sites, and nuclear power plants.
- The major consequence of the Three Mile Island accident was that no new nuclear power plants have been built in the United States since 1979.
- One of the largest accidents was at a nuclear facility in Chernobyl, Ukraine, in 1986.

# Effects of a Nuclear Explosion

- The blast (damage to or destruction of buildings and those in them)
- Heat (destruction or injury by high temperatures or fire)
- Intense light (damage to eyesight)
- Ionizing radiation (causing Acute Radiation Syndromes of different degrees of severity)

# Further Effects of a Nuclear Explosion

- Persons near the nuclear explosion would experience thermal burns and radiation-induced skin injuries.
- A major byproduct of the detonation of a nuclear weapon is radioactive fallout.
- Radioactivity will dissipate over several weeks, but crops and food animals taken from the area may be unsuitable to consume.

# Medical Uses of Ionizing Radiation

- About 40% of radiation exposure has been attributed to medical exposure.
- Medical procedures include the use of X-ray machines, nuclear medicine, and radiation therapy

# Nonionizing Radiation

- *Nonionizing radiation* refers to "Radiation that has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons, . . . Examples of this kind of radiation are sound waves, visible light, and microwaves."

# Examples of Nonionizing Radiation

- Extremely low frequency (ELF) radiation (e.g., high tension power lines)
- AM, FM, VHF-TV radio waves
- Microwave radiation
- Infrared radiation (IRA, IRB, IRC) - the source of heat in heat lamps used for keeping food warm
- Visible light radiation
- Ultraviolet radiation (UVA, UVB, UVC)

# Health Effects of Nonionizing Radiation

- Extremely low frequency (ELF) radiation does not appear to produce many discernible short-term health effects.
- Higher frequency levels (i.e., radiofrequency and microwave radiation) causes heating of the body.

# Sources of Exposure to ELF (50 to 60 Hertz)

- Originates from electric power poles, wiring in the walls of buildings, and some electrical appliances

# Electromagnetic Frequency

- Electricity that flows through transmission lines may produce electromagnetic fields (EMFs).
- Research literature suggests that findings are inconsistent, not definitive, with respect to EMF exposure and cancer.

# Radiofrequency Radiation and Cell Phones

- Cell phones are a very low-power apparatus that transmits in the radiofrequency range of 900 to 1800 megahertz (MHz).
- As of 2009, there were an estimated 270 million and 4.1 billion cellular telephones in use in the U.S. and worldwide, respectively.
- Widespread popularity of cell phones means that even small adverse health effects could have substantial implications for population health.
- Cell phone antenna banks are themselves a source of RF radiation.

# Sources of Ultraviolet Radiation (UVR)

- Sources of UVR:
  - Welders' arcs
  - Lamps used for tanning beds
  - Some flood lamps used in photography
  - Halogen desk lamps
  - Lightning
  - Electrical sparks
  - Sunbathing

# UVR

- UVR coming from the sun is subdivided into UVA, UVB, and UVC, depending upon the wavelength of the light.
- Of the three forms of UVR, UVB is considered to be the form that is most harmful to human health.

# The Ultraviolet (UV) Index

- To help protect exposed persons from excessive amounts of sunlight, the UV index provides a daily forecast of the expected risk of overexposure to the sun.
- The index predicts UV intensity levels on a scale of 1 to 11+, where low indicates a minimal risk of overexposure and 11+ means an extreme risk.
- The index is calculated on a next-day basis for every ZIP code across the United States.

# Effects of UV Radiation

- Temporary conditions include burns and temporary blinding
- Long-term consequences:
  - Photoaging of the skin
  - Nonmelanoma skin cancer (NMSC)
  - Malignant melanoma (MM)
  - Retinal damage
  - Lens opacities