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ENVIRONMENTAL HEALTH

ECOLOGICAL PERSPECTIVES

Radiation

Chapter 12

Terminology

- Radiation
- UV light
- Infrared
- rems
- Radioisotopes
- Photons
- Ion
- Anode
- Cathode
- Volts
- Microwave
- Electromagnetic

Exposure to Radiation

- All plants, animals, and humans are constantly exposed
- Natural and artificial sources
- The average U.S. citizen receives 350 millirems of radiation per year

Natural Sources of Radioactivity

- 80% of exposure comes from natural sources
- Natural sources include
 - UV light from the sun
 - Radon from the soil
 - Uranium in rocks and soil
- 55% of the exposure is from radon gas

Exposure to Natural Sources

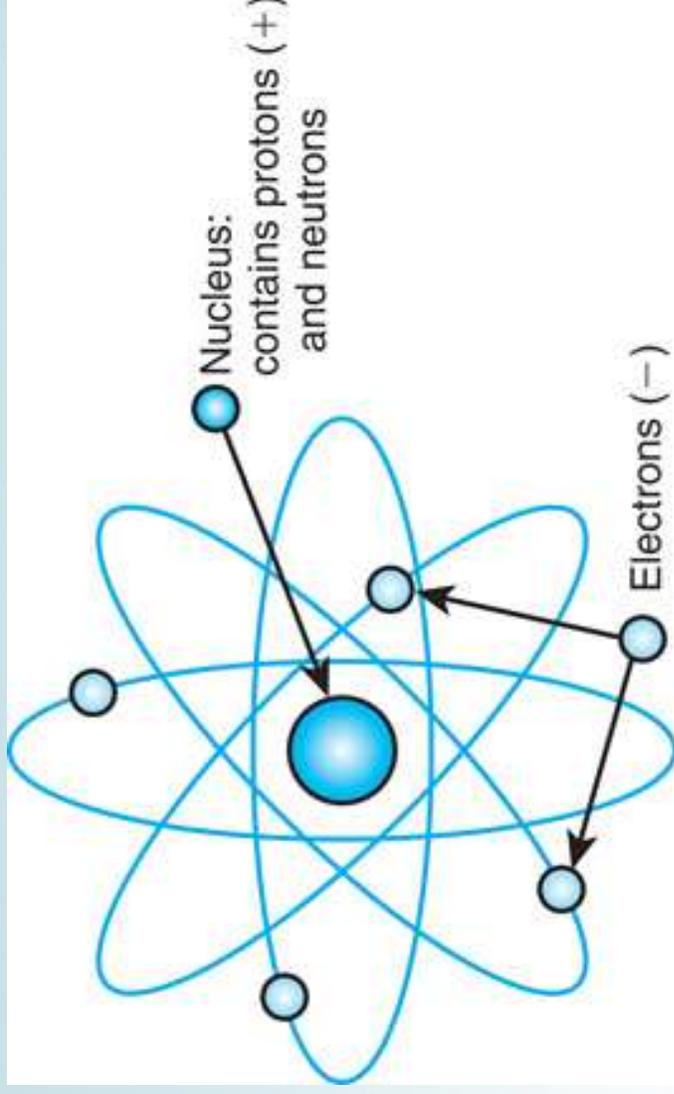
- The geographical area varies in radioactive sources
- Those living in higher elevations (mountains) are exposed to
 - More cosmic radiation
 - Higher concentrations of uranium and thorium in the soil

Artificial Sources of Radioactivity

- **Man-made sources**
 - Communications devices (TVs, radios, computers, cell phones)
 - Microwaves
 - X-rays and other medical devices
- **About 18–20% of radiation exposure comes from these sources**

The Discovery of Radiation

- William Roentgen discovered x-rays in 1895
- Irene and Frederick Joliot-Curie discovered radioactive elements could be produced from stable elements in 1896



What Is Radioactivity?

- All matter consists of atoms with protons, neutrons, and electrons
- Unstable atoms with too many or too few neutrons are radioisotopes
- They emit particles or energy waves known as electromagnetic waves to become more stable
- The type of radiation emitted depends on the type of instability

Two Types of Radiation

Nonionizing

- Has no charged photons
- Includes UV light, visible light, infrared light, microwave, and radio frequencies

Ionizing

- Electronically charged with photons and acts in such a way that particles are changed
- Used for nuclear power, x-rays, and other medical devices
- The effects are cumulative with time

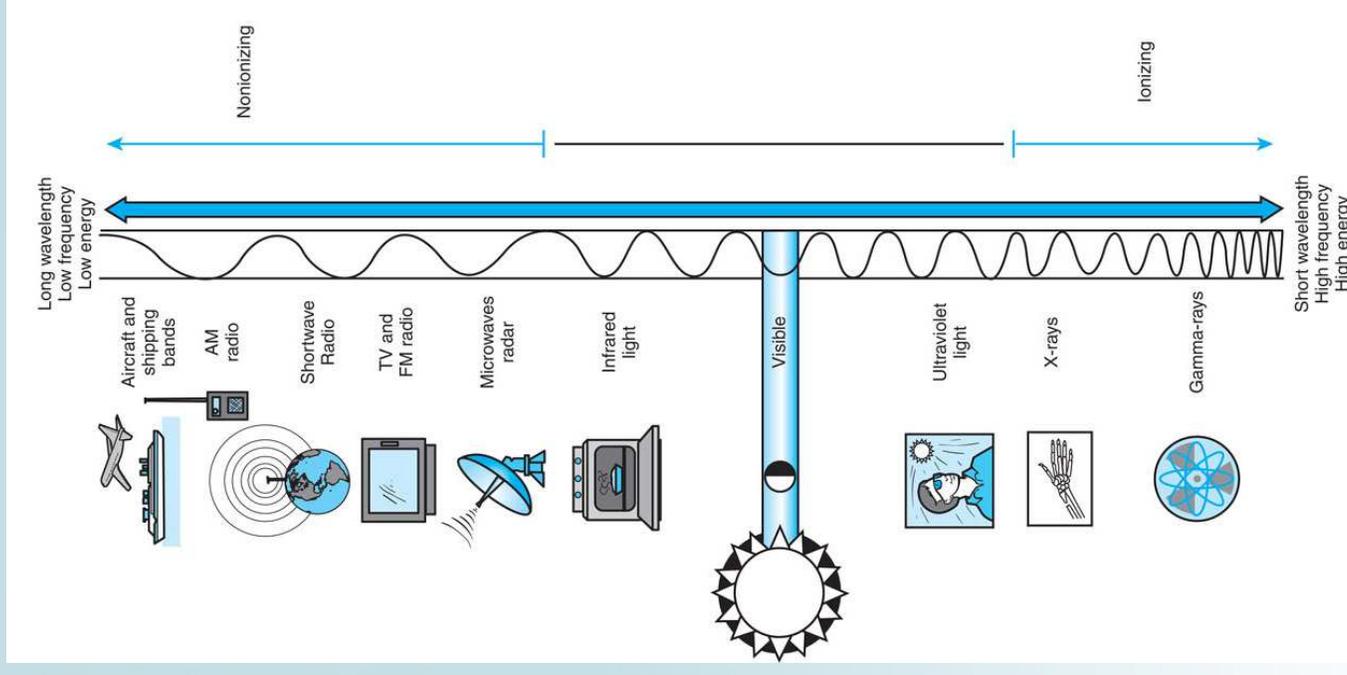
What Are Electromagnetic Waves?

- Waves emitted through space at the speed of light in the form of photons
- Each photon has a particular frequency and wavelength expressed in eV

Types of Electromagnetic Waves

- The waves vary in length (see next slide)
- The longest waves are used for communication devices
- Microwaves are shorter and used for wireless transmissions
- Light rays are invisible, but produce heat
- Shorter lights such as x-rays and gamma rays cannot be seen but penetrate human tissues
- The shortest waves have higher frequencies and sufficient energy to ionize

The Spectrum of Radioactive Frequencies



Measuring Radioactivity

- The measurement of ionizing radiation is especially important because of the potential harm
- When photons are emitted, radiation disintegrates, reducing the charge or radioactive mass
- The rate at which radioisotopes decay is a becquerel (Bq) or curie (Ci)

Measurement Devices Used

- For higher levels of radiation:
 - Ionizing gas detector chambers
 - Proportional counters
- Used to measure beta radiation in laboratories
 - Scintillation counters
- Used by those to locate sources of radioactive contamination
 - Geiger-Mueller detector
- Worn by those who work with radioactivity
 - Film badge
 - Dosimeter

Who Monitors Radioactivity Exposure?

- In hospitals
 - A radiologist
- In nuclear facilities
 - Health physicist
- In public health departments
 - An environmental health specialist

Computed Tomography (CT) Scans

- Invented in 1972 by Godfrey Hounsfield
- The first one was used at the Mayo Clinic
- Produces 3-dimensional images of the human body
- X-ray exposure is longer because the body is “sliced” into parts to see more detail (soft tissue, bone, and blood vessels)
- Accounts for 40% of radiation exposure from diagnostic tests and is increasing

Radon

- Radon is a radioactive gas that forms during decay of uranium-238
- Found naturally in rocks and soil
- Radon gas seeps from underground rock into basement and foundation cracks
- Radon exposure is the second leading cause of lung cancer
 - Smokers are at higher risk for DNA changes

Radon Detection

- Radon detection can be done easily at home
 - Charcoal canister
 - Alpha track detectors
- 4 picocuries per liter is considered “safe exposure” to radon in the home
- Radon gas exposure can be repaired in expensively by sealing cracks with caulk and foam materials

Health Effects of Radiation Exposure

- Cell mutations with ionizing exposure were discovered in 1927
- Early researchers suffered serious effects
- Biological effects are directly proportional to individual cell division and specific function of cells

Cell Damage from Radioactivity

- DNA is damaged in dividing cells
 - Epidermal skin, bone marrow, RBCs, and sperm
- Damage to lipoprotein structures in the nuclear cell membrane
 - Ova and lymphocytes
- The most harm comes to developing fetuses
 - Genetic effects
 - Mental retardation

Cancer Risk

- The biggest concern is the risk of developing cancer
- Effects of ionizing radiation (including overexposure to diagnostic radiation) include a higher risk of
 - Lung cancer
 - Skin cancer
 - Breast cancer
 - Thyroid cancer
 - Leukemia

Measurement of Radiation Exposure

- Dose absorbed (rad)
 - rad = the absorption of 100 ergs of energy from 1 gram of material
 - 1 joule (J) = 100 rads = 1 gray (Gy)
- Dose of equivalency (rem)
 - rem = the biological dose equivalent of a roentgen
 - 1 sievert (Sv) = 100 rems

Exposure to Radiation

- The general population is exposed to
 - 200–300 medical rems per year
 - 100 rems from radon
 - 55 rems from terrestrial sources
 - 30 rems from cosmic sources
 - 4 rems from fallout
 - Less than 1 rem from industrial exposure (nuclear reactors, mines, industrial use, medical uses, and high-voltage devices)

Predicting the Effects of Ionizing Radiation

- Severity depends on the dose of radiation
- Deterministic effects (days or months after an acute radiation dose)
- Threshold effects (**nonstochastic** effects are different from one individual to another)
- Nonthreshold effects (**stochastic** effects differ according to the type of cells affected)
- **Cumulative** effects (the amount absorbed over time)

Regulation by Federal Agencies

- Occupational Health and Safety Administration (OSHA) monitors radiation exposure at the worksite
- The Nuclear Regulatory Commission (NRC) monitors exposure in nuclear facilities
- The Department of Transportation (DOT) monitors transportation of nuclear waste

Public Health Interventions

- The Food and Drug Administration (FDA) monitors use in foods
- The U.S. Public Health Service (PHS) regulate medical procedures
- The Center for Environmental Health assist in the event of nuclear incidents

To Reduce Radiation Exposure

- Increase the distance from a radiation source (UV sunlight, radon, etc.)
- Wear protective shields or clothing
- Dispose of contaminated objects with the help of a radiological health professional or health physicist
- Limit the time exposed to x-rays or radiation treatments
- Use a HEPA filter in furnaces and air conditioning units

Solar Radiation

- Light rays (visible light, UV light, and infrared light)
- Most of the solar radiation reaching the Earth's surface is infrared radiation (55%) and visible light (40%)
- 5% of ground-level solar radiation is UV radiation
 - Primarily in the UV-A range

UV Light

- UV light is between ionizing and nonionizing radiation
- Sunlight consists of
 - UV-A (a.k.a. “black light”)
 - UV-B (a.k.a. “erythematous UV light”)
 - UV-C (a.k.a. “germicidal UV light”)
- UV radiation travels from the sun to the Earth passing through the ozone layer
 - Ozone absorbs most of the UV-A light

Health Risks of UV Light

- UV-A penetrates the skin causing photoaging damage
- UV-B light causes tanning and sunburn (erythema) and damages the immune system
- UV-C light can damage DNA (melanoma) and other molecules
- Direct UV exposure can cause blindness (photokeratitis, “welder’s flash” or “snow blindness”) and cataracts

Monitoring UV Light

- The amount of UV light depends on the season, time of day, latitude, clouds, and altitude
- Monitored worldwide
- National Oceanic and Atmospheric Administration (NOAA) monitors it in the U.S.
- Broadcasted by the National Weather Service (NWS)

Artificial Sources of UV Light

- Welding torches
- Tanning beds (UV-A and UV-B)
- Black lights (UV-A)
- Curing lamps used by dentists
- Germicidal lamps
- Mercury vapor lamps
- Halogen and xenon lamps
- High-intensity discharge lamps used by dermatologists
- Lasers

Laser Light

- Used for welding, surgery, home security systems, light shows, CD/DVD players, supermarket scanners, FAX machines, and printing equipment

Skin Cancer

- The basal cell layer contains **melanocytes** that produce melanin (pigment for tanning)
- Melanocytes produce two pigments
 - Eumelanin (brown)
 - Pheomelanin (yellow and red)
- As the skin is exposed to light, melanocytes increase in activity
- Damage to melanocytes from UV radiation causes cancerous mutations known as **melanoma**

Nonionizing Radiation

- Visible light (VIS)
- Infrared light
- Microwaves
- Radar
- Television
- Radio
- Electric fields
- Magnetic fields

Visible Light

- Natural or man-made
- The speed (temperature) results when photos collide
- Includes
 - UV light
 - Incandescent light
 - Fluorescent light
 - Neon light

Measurement of Light

- **Watt**—fundamental unit of optical power with the rate of energy of one J per second
- Optical power = function of the number of photons and wavelength
- **Lumen**—the photometric equivalent for a watt with visible light

Electromagnetic Fields (EMFs)

- EMFs are charged with electromagnetic radiation (nonionizing)
- As we are exposed to higher levels of ionizing radiation, the risk of EMFs becomes more important
- **Amp** = the magnetic components of an electric field
- **Volt** = the strength of the electric field
- **Hertz** = the frequency of an electric field

EMFs

Static

- Does not change
- Direct current (DC)
- Used for transportation and MRI devices
- Not associated with tumors, immune suppression, or hormones

Pulsed

- Reverses direction at regular intervals
- AC current
- Found in electricity
- Includes RFs, IFs, and ELFs

Radiofrequency Fields (RFs)

- Used for telegraph, telephones, radio, television, air traffic control, radar, and cellular phones
- The shortest radio waves are known as microwaves (MW)
- Microwave towers emit electromagnetic waves to carry over long distances.
- The higher the power of communication microwaves, the better the transmission for analog and digital signals

Health Effects of Microwaves

- Microwaves generate heat
- Microwaves are absorbed by the skin
- Researchers feel high exposure to telecommunication fields increase cancer rates in humans
- The most susceptible organ is the brain
- The location of the cell phone antennae and length of time on the phone is important

Intermediate Frequency Fields (IFs)

- Most likely encountered by hospital (MRI technicians) and military personnel (working with high-range broadcasting communication transmitters)
- For the layperson, exposure comes from computer monitors, TV screens, anti-theft devices in libraries and stores, and security systems

Extremely Low Frequency Fields (ELFs)

- The main source are trains and electrical devices
- There is concern about the use of household appliances, waterbeds, electric blankets, and electric toothbrushes
- A low priority for research

Health Effects of EMFs

- Damage to vegetation and biological systems
- Correlations have been found with
 - Childhood leukemia and location of power lines
 - Testicular cancer and leukemia among police officers using radar
 - Leukemia and lymphoma with radio frequency and microwave use among military personnel
- The research has been extended and results are inconclusive

More Research

- The most susceptible organs are the eyes and brain
- Some research showing increased risk of breast cancer for radio and telegraph operators
- Reproductive effects?
 - Higher miscarriages and birth defects from pregnant women using monitors 20 hours per week or longer during the first trimester
 - Some wonder if the heat from laptops will affect sperm

Protection Against ELF's

- There are no standards for exposure to radiofrequency radiation (RFR) as long as there are no thermal effects
- The U.S. FCC is monitoring thermal effects on brain, testicles, breasts, and lymph glands
- OSHA standards are 10 times higher
- The Swedish government has standards for computer monitors

Noise and Health Effects

- Unwanted sound
- Deafness, permanent and temporary hearing loss, and psychological stress
- Measurements
 - hertz (Hz) = frequency
 - amps (A) = loudness
 - decibels (Db) = intensity; also watts per centimeter squared (W/cm^2)

Temporary Hearing Loss

- The louder the noise, the more hearing loss
- When exposed to loud noise the person experiences tinnitus and temporary deafness (a.k.a. “temporary threshold shift” [TSS])
- Continued exposure damages hair cells in the organ of Corti of the cochlea of the inner ear
- The damage is irreversible

Health Effects of Ultrasonic Devices

- Used in submarines and medical imaging
- The sound wave strikes the body and reflects back to the probe
- The distance between is measures according to the “echoes” on the screen to produce a two-dimensional image
- Concerns about damage to the fetus

How to Reduce Exposure to Radioactivity

- Authorities governed by:
 - National Environmental Policy Act of 1969
 - Telecommunications Act of 1996
- The FDA and FCC recommends:
- Have the cell phone antenna mounted on the car
- Use headsets
- Have only short conversations on cell phones