Radiation Protection Introduction

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MI Program
MI 120

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Introduction to Radiation Protection

- Effective measures to safeguard from unnecessary exposures from ionizing radiation
  - Patients
  - Personnel
  - General Public

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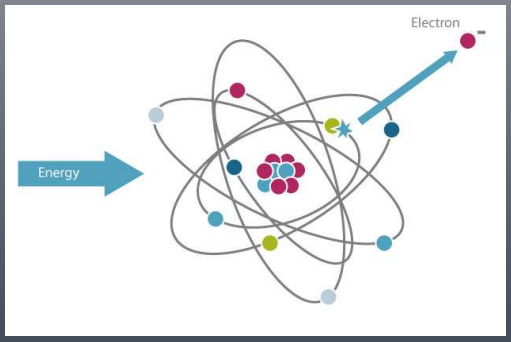
IONIZING RADIATION DEFINITION:

- Radiation that produces (+) and (–) charged particles when it passes through matter



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UNNECESSARY EXPOSURE DEFINITION:

- Exposure that does not benefit a person in terms of:
  - Diagnostic information
  - Enhancing the quality of the study

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How to Minimize Exposures:

- Proper techniques (appropriate kVp/ mAs)
  - Technique books
  - Proper measuring of body part
- Procedural factors
  - Immobilizations
  - Proper image receptor
  - Positioning around the patient's limitations
- Human determinants
  - Pathological conditions
  - Body habitus
  - Movement
- Environmental determinants
  - Humidity with film/ screen
  - 3rd world countries (heat and contaminated water)

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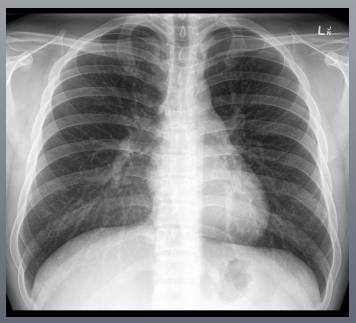
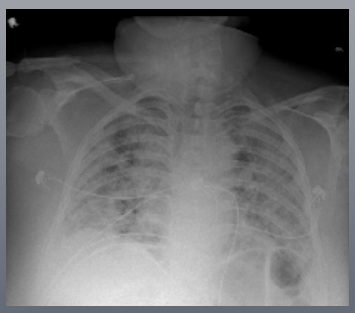
Normal CXR vs COVID CXR





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Justification of Radiation Exposures

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Voluntary Assumptions of Risks

- Weigh the positive vs negative
- Good voluntary risk is imaging for
  - Screening purposes:
    - mammogram (most effective tool for breast cancer diagnosis)
  - Injury
  - Illness

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Diagnostic Efficacy

- Provides the basis for the justification of procedures
- The degree to which a study reveals the presence or absence of a disease while following radiation safety guidelines

BOX 1-2 Achievement of Diagnostic Efficacy

Imaging procedure or practice justified by referring physician → Minimal radiation exposure → Optimal image(s) produced

→ Presence or absence of disease revealed = Diagnostic efficacy

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As a technologist you must take responsibility for the welfare of your patients

- Quality patient care
- Quality images

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Technologist's Job

- Legally part of the Standard of Practice for the profession

- Code of Ethics (ASRT)
  - #5- Acting in best interest of patient
  - #7- Accepts standard of practice, limits exposure to self, patient and others

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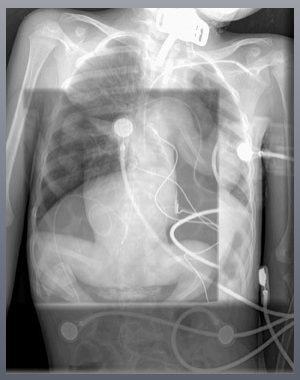
Technologist's Responsibility:

DIRTFT

- Keep radiation level at lowest level
  - Techniques- use smallest amount of exposure to produce a good, diagnostic image
  - ALARA
  - Minimize repeats- optimal image the 1st time
    - Repeats cause increased exposures to patient and technologist
  - Proper shielding (if utilized)
    - Reduces exposures
      - 50% for females
      - 90-95% for males
  - Be aware of rules of your department- follow protocols
  - Be educated in safe operations



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Radiologist/Physician Responsibilities

- Consulting
- Do not order unnecessary exams
- Radiologists- utilize same safe practices as the technologist when performing studies

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Employer Responsibilities

- Implement and maintain a radiation safety program
- Supply the necessary resources
- Written policy describing ALARA and the commitment of managing it
- Exposure audit

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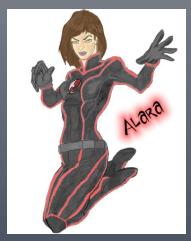
ALARA

- Keep radiation "as low as reasonably achievable" for patients and personnel (1954 NCRP)
- ORP- optimization for radiation protection (ICRP)
- Radiation induced cancers do not have a threshold (linear, non-threshold)



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PATIENT EDUCATION

- Explain procedure and what cooperation is needed to complete the study
- Explain what, if anything, needs to be done as a follow up to the exam
- Make your patient an active participant in their health care
- Answer questions about the potential risks of the radiation to reduce fears and anxiety

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BERT (Background Equivalent Radiation Time)

- Compares amount of radiation received during a specific procedure to the amount of natural background radiation over a certain period of time
- Can be referenced to explain exposure levels to patients
- Helps educate and reduces anxiety

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TABLE 1-1 Typical Adult Patient Effective Dose (EfD) and Background Equivalent Radiation Time (BERT) Values

Radiologic Procedure	EfD (mSv)	BERT (Amount of Time to Receive the Same EfD from Nature)
Dental, intraoral	0.06	1 wk
Chest radiograph	0.08	10 days
Cervical spine	0.1	2 wk
Thoracic spine	1.5	6 mo
Lumbar spine	3.0	1 yr
Upper GI series	4.5	1.5 yr
Lower GI series	6.0	2 yr
Skull	0.07	11 day
Hip	0.3	7 wk
Pelvis	0.7	4 mo
Abdomen	0.7	4 mo
Limbs and joints (except hip)	<0.01	<1.5 days
CT brain	2.0	1 yr
CT chest	8.0	3.6 yr
CT abdomen/pelvis	10.0	4.5 yr

Adapted from BF Wall: *Patient dosimetry techniques in diagnostic radiology*, York, UK, 1988, Institute of Physics and Engineering in Medicine, pp 53, 117; Cameron JR: *Med Phys World*, 15:20, 1999; Stabin MG: *Radiation protection and dosimetry: an introduction to health physics*, New York, 2008, Springer.
CT, Computed tomography; *GI*, gastrointestinal; *mSv*, millisievert.

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TRACE Program

- Tools for Radiation Awareness and Community Education- making the patient more active role
- Established by Toshiba American Medical Systems- 2010
- Radiation dose awareness and reduction program
  - Posters, brochures, websites, wallet size cards (patients)
  - In-services, emails (technologists)
  - Awareness of doses, informing of doses, establish goals (radiologists)
  - Dose reduction technologies, reporting doses

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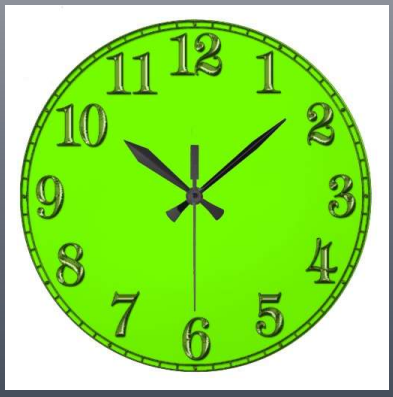
Standard Dose Reporting

- Dictating dose exposures and/or fluoro time into radiology reports



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http://www.radiologyinfo.org/en/safety/index.cfm?pg=sfty_xray

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Radiation

- Kinetic energy that passes from one location to another
- Types
  - Mechanical vibration- which causes sound (Ultrasound)
  - Electromagnetic wave-radio, microwaves, visible light, x-rays

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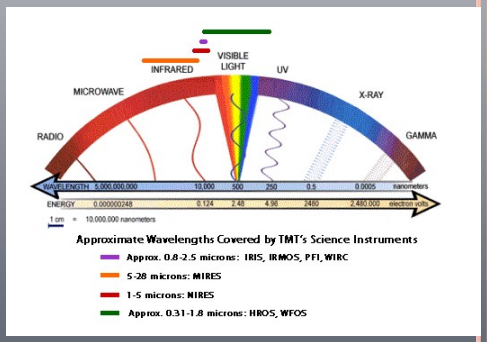
Electromagnetic Spectrum

- Frequencies and wavelengths of electromagnetic waves
- Divided into 2 parts for radiation protection purposes
  - Ionizing
  - Nonionizing



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Electromagnetic Spectrum

- Ionizing
  - X-rays and gamma rays
  - High energy, high frequency, short wavelength that transfers energy that can remove an electron from an atom that it was attached to
  - Foundation of x-rays and human tissue interactions
  - Valuable to produce images but has potential to produce biological damage
- Nonionizing
  - Ultraviolet radiation, visible light, infrared rays, microwaves, radio waves
  - Lower energy, lower frequency, longer wavelength
  - Does not have enough kinetic energy to eject electrons from an atom

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Particulate Radiation

- Another category of ionizing radiation that has high speeds
  - Alpha- from radioactive decay; emitted from elements such as uranium and plutonium
  - Beta- from radioactive decay; emitted from the nuclei of radioactive atoms (example potassium 40)
  - Neutrons- neutral components that originates from an atom's nucleus
  - Protons- positive charged components of an atom

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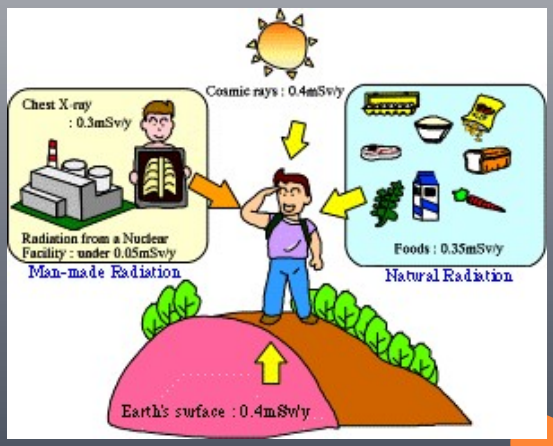
Sources of Radiation

- Natural
- Man-made



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Natural Radiation or Background ~50%

- Types
  - Terrestrial radiation
  - Cosmic radiation
  - Internal from radionuclides
- Average worldwide exposure is a total of 200-300mR (depending on radon exposure levels)

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Terrestrial Radiation (3%)

- From radioactive material in the crust of the earth
- Levels depend on the composition of the soil or rocks (mountainous areas are higher)
  - Examples
    - Uranium
    - Radium
    - Thorium
    - Radon/Thoron*

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RADON- 37% of natural exposure

- Colorless, odorless, radioactive gas that is always present in some degree in the air
- Higher levels in soil that contains granite, shale, phosphate, and pitchblende
- Enters buildings through cracks or holes in the framework
- Present in building materials like bricks, concrete and gypsum wallboard
- Usually higher in the cooler months

**Average worldwide exposure is 2mSv

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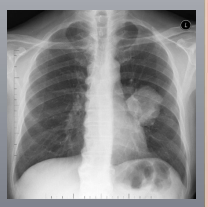
RADON

- High concentrations have potential to cause serious health hazards
  - Emits alpha radiation
- 2nd leading cause of lung cancer
- Causes 20,000 deaths per year in the US
- EPA recommends homes to have annually levels no greater than 4 pico curies per liter of air
  - EPA 1991 study- average indoor radon level is 1.3 pico curies per liter of air
  - USA Today 2014- 1 in 15 homes in US is above limits



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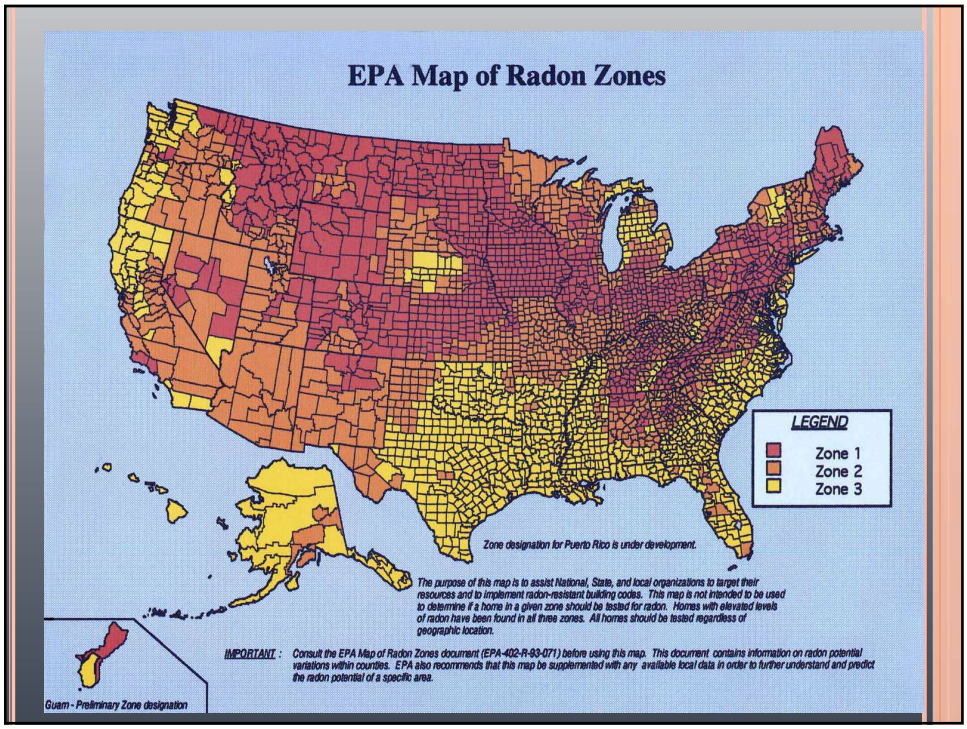

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Cosmic Radiation (5%)

- Nuclear interactions caused by the:
  - Sun (solar)
  - Beyond solar system (galactic)

Greatest intensity (exposures) occurs at high altitudes

Lowest intensity (exposures) occurs at sea level

**Denver receives 0.7 mSv per year more than those at sea level

**Average worldwide exposure is 0.33 mSv

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Internal Radiation (5%)

- Part of the human metabolism
- Radioactive atoms that make up small percentage of the body tissue
  - Ingested
  - Inhaled

Includes: Potassium-40, Carbon-14, Hydrogen-3, and Strontium-90 that exist in small quantities in the body

**Average worldwide exposure is 0.4 mSv

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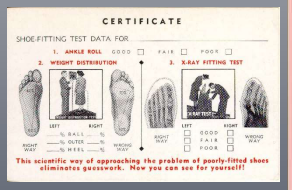
Man-made (Artificial) Radiation- ~50%

- Consumer products
  - Early tvs, airport surveillance, ionizing smoke detectors, some timepieces with luminous dials, video display terminals, shoe fitting fluoroscopes, dentures
- Air travel
- Nuclear fuel for generation power
- Atmospheric fallout from weapon testing
- Nuclear power plant accidents
  - TMI- 1979
  - Chernobyl- 1986
    - Main effect is thyroid cancer of children and adolescents
    - Increase seen in breast cancer
  - Fukushima- 2011
- Medical radiation
  - Diagnostic machines
  - Radiopharmaceuticals/ radioisotopes



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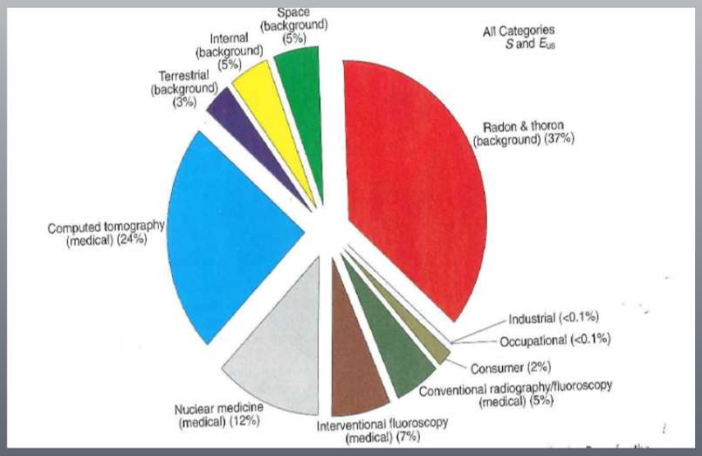

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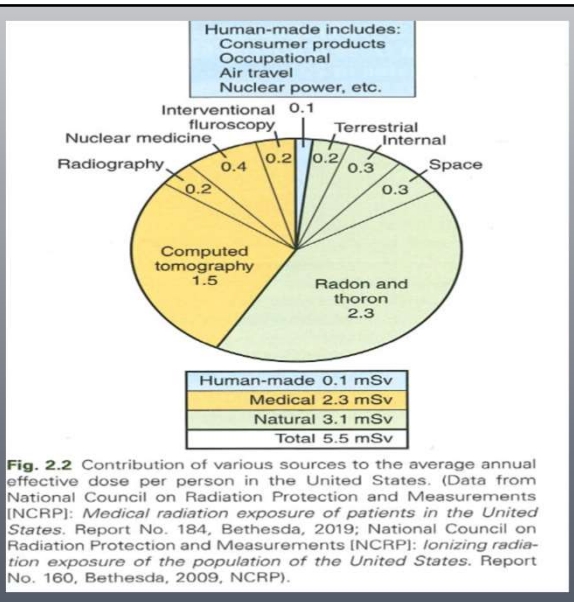

Fig. 2.2 Contribution of various sources to the average annual effective dose per person in the United States. (Data from National Council on Radiation Protection and Measurements [NCRP]: *Medical radiation exposure of patients in the United States*. Report No. 184, Bethesda, 2019; National Council on Radiation Protection and Measurements [NCRP]: *Ionizing radiation exposure of the population of the United States*. Report No. 160, Bethesda, 2009, NCRP).

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