Background Radiation: Man-made and Natural

ACADs (08-006) Covered

1.1.4.5	3.2.3.9	3.3.2.1	3.3.2.2
4.10.1	4.10.2	4.12.1.1	

Keywords

Natural radiation, man-made radiation, exposure, terrestrial, extraterrestrial, cosmographic, radionuclide, decay chain, x-ray, medical radiation, norm.

Description

Supporting Material

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Background Radiation

- **The Natural Radiation Environment**
- **The Man-Made Radiation Environment**
- **Radiation Exposure to People**
- **Summary**

Radiation in Life

Solar Radiation

Cosmic Rays

Nuclear Medicine

X-Rays

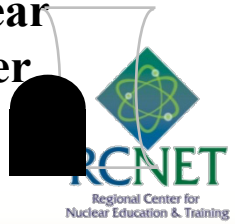
Radon $^{4}_{2}\alpha^{++}$

Consumer Products

Each Other

Radioactive Waste

Nuclear Power



Terrestrial Radiation

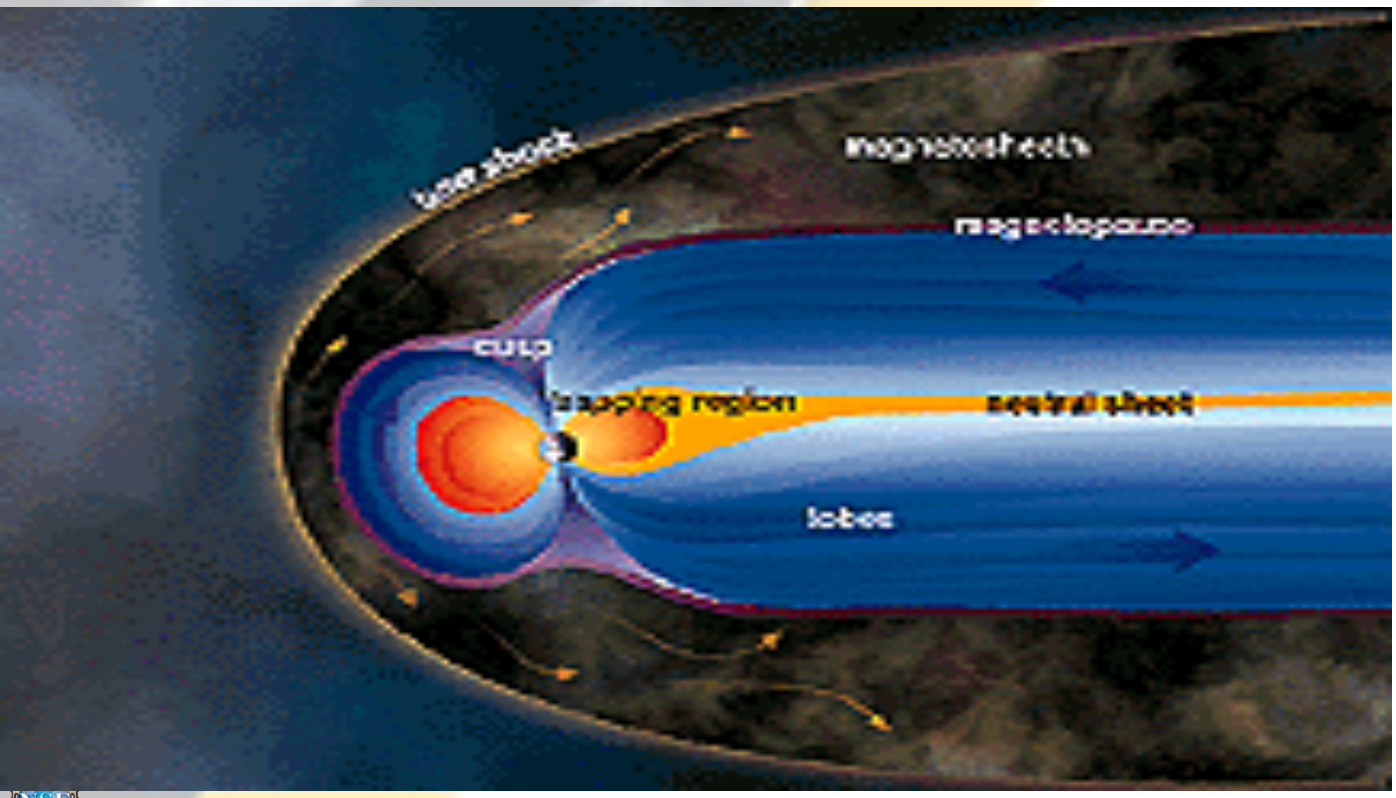
Food & Drink

Extraterrestrial Radiation

- The primary source of cosmic radiation is from outside this solar system.
- The atmosphere and the earth's magnetic field act as a shield against incoming radiation, reducing the amount of radiation that actually reaches the earth's surface.
- The higher you rise in altitude, the higher your dose from cosmic radiation. The dose rate doubles every 1500 meters

Magnetic Fields

The Magnetic Field of the Earth stop some of the particles from the Solar wind and Galactic Radiation from penetrating to the surface



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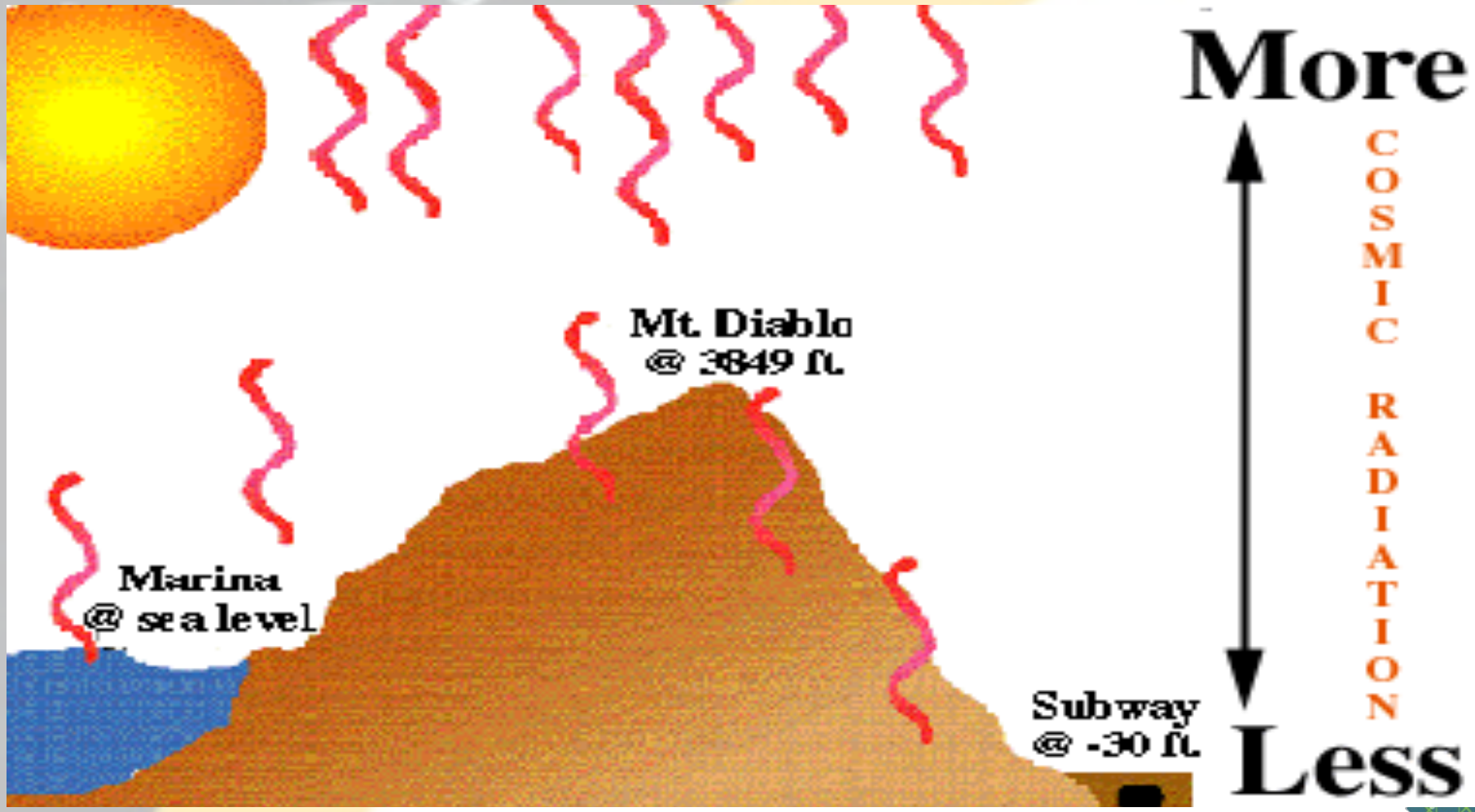
Relationship Between Altitude and Cosmic Radiation



A dose of approximately 27 millirem/year at sea level doubles for every 1500 meter increase in elevation.

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Cosmogenic radioactivity

Is radioactivity that is produced when the incoming cosmic radiation interacts with the upper atmosphere of the earth

- **The stable atoms, mostly N, in the upper atmosphere interact with cosmic radiation to produce radionuclides.**
  - **Carbon-14, essential to the carbon dating process**
  - **Hydrogen-3, or tritium, is formed when cosmic rays interact with nitrogen, oxygen, or lithium in the atmosphere.**

Terrestrial Radiation: Chains or Series

- **Radionuclide Series** - There are four different decay chains (series) of *primordial radionuclides*.
- To determine the series, divide the mass number of the parent isotope by four and there will be a constant remainder for all radionuclides in the series
- These radionuclides include U-238, Pu-241, Th-232 and U-235. These are called "chain radionuclides"

Terrestrial Radiation: Chains or Series

4n Series - Thorium (Th-232); half-life 1.39×10^{10} years

4n+1 Series - Neptunium (Pu-241); half-life 13.2 years

4n+2 Series - Uranium (U-238); half-life 4.5×10^{9} years

4n+3 Series - Actinium (U-235); half-life 7.13×10^{8} years

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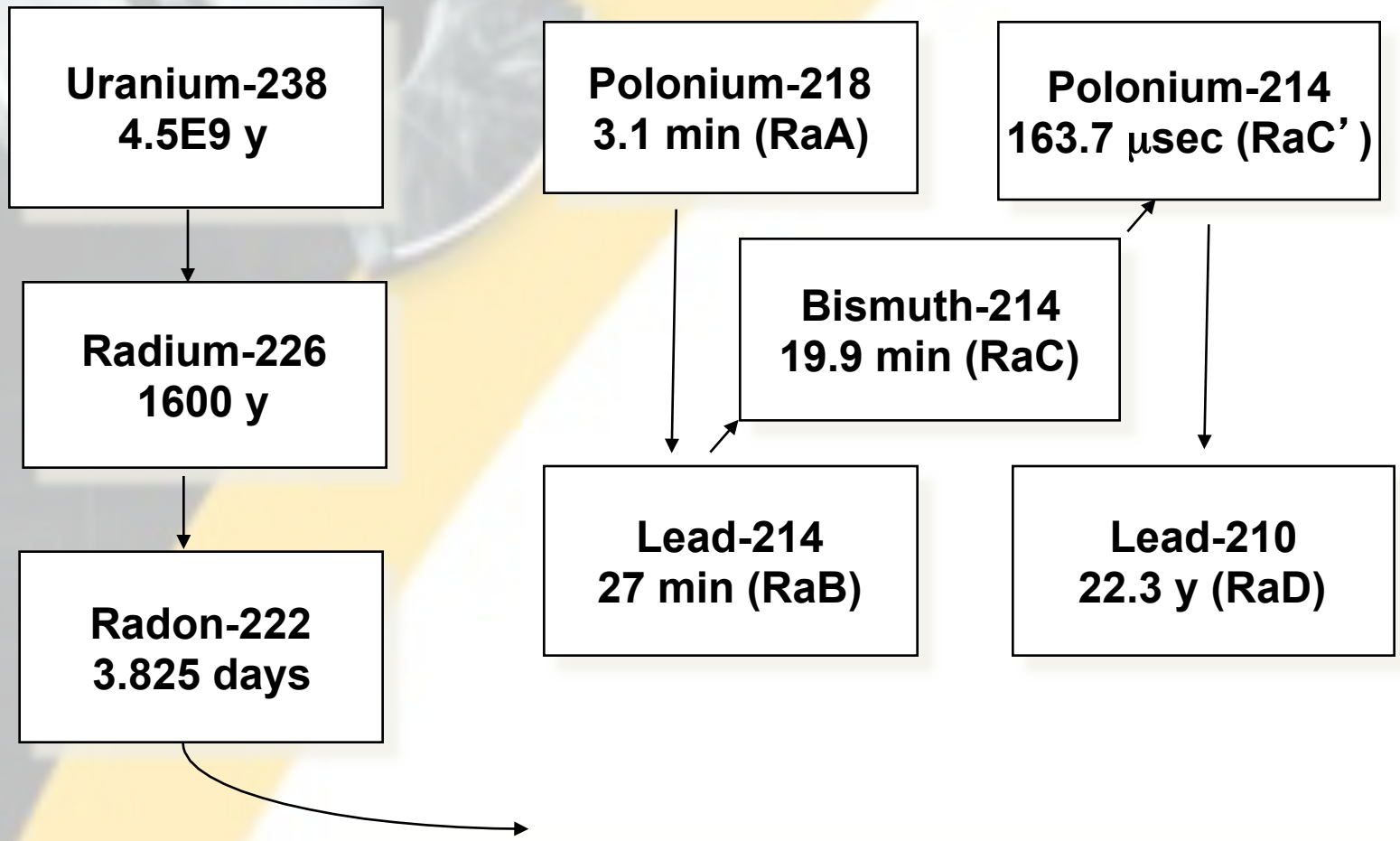
Terrestrial Radiation: Chains or Series

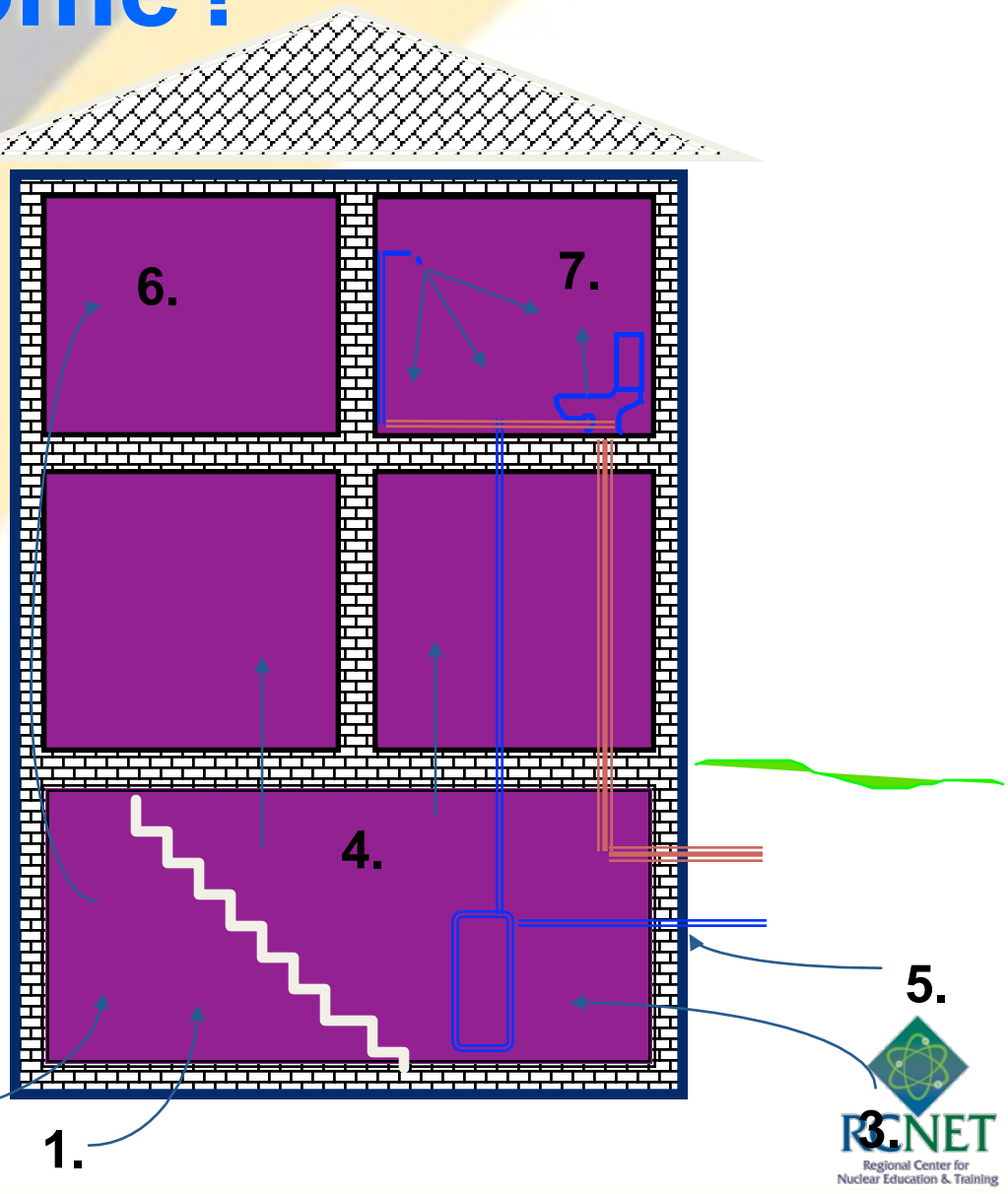
- General characteristics of radionuclide series:
  - The first parent of each series has a half-life that is typically on the order of hundreds of millions of years (i.e., the age of the Earth).
  - The final nuclide of each series is a stable isotope of lead.
  - Each series has a different isotope of the radioactive gas radon.

Radon and the Uranium Decay Series



How Does Radon Get in the Home?

1. Cracks in Solid Floors
2. Construction Joints
3. Cracks in Walls
4. Gaps in Floors
5. Gaps around Pipes
6. Cavities in Walls
7. The Water Supply



NORM

- Norm is the result of any action by people that accumulates and concentrates the naturally occurring material to a point of concern
- Oil and gas production generate lots of NORM when they bring up oil from underground
- The change in pressure and chemistry tend to have Ra plate out in tank and pipes
- Old oil drilling piping and storage tanks may have much NORM in them

Terrestrial Radiation and Radioactivity

- Some common singly-occurring radionuclides that were created during the formation of earth are the following:
  - Radioactive potassium (K-40) is found in bananas, throughout the human body, and anywhere else stable potassium exists.
  - Radioactive rubidium (Rb-87) is found in brazil nuts among other things.

Consumer Products and Radioactive Material

- There are more sources of radiation in the consumer product category than in any other.
  - Television sets accelerate electrons to make the picture on the screen and in the process produce a few low energy x-rays.
  - –Smoke detectors contain a small radioactive source and an ionization chamber
  - –Welding rods, static eliminators in manufacturing, and luminous dials

Consumer Products

- Coleman lantern mantles (if you can find them)
- Radium-painted watch and compass dials, instruments dials and markers
- Irradiation of contact solution, surgical equipment, spices, tires, make up, teflon pans
- Electron tubes, electrostatic eliminators, Exit signs

Safer Consumer Products: Food Irradiation

- Food Irradiation is a physical means of food treatment comparable to heat pasteurization, canning, or freezing.
- It does not make the product radioactive
- Food must be marked with the symbol at the right

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Safer Consumer Products: Food Irradiation

- The process involves exposing food, either packaged or in bulk, to one of three types of radiation: gamma rays, machine generated electrons, or X rays.
- Food Irradiation promises to improve our ability to preserve food longer with better retention of the original qualities of the food, while at the same time reducing the incidence of food-borne diseases and infestation problems in bulk foods.

Strawberries

Sprouting

The Nuclear Fuel Cycle

- The public is exposed to a variety of sources from the nuclear fuel cycle in air and water emissions, radioactive waste, and direct irradiation. However, the total collective doses from the nuclear fuel cycle are very small.
  - <0.03% of the total average annual effective dose to the general population of the U.S. is from nuclear power (<1 millirem/year)
  - That is considerably less than the total average annual effective dose of approximately 620 millirem/year due to all sources of radiation

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Components of the Nuclear Fuel Cycle

Specific components of the Nuclear Fuel Cycle:

- Mining of Uranium and Thorium
- Milling of Uranium and Thorium
- Enrichment and Nuclear Fuel Production
- Nuclear Power Reactors
- Fuel Reprocessing and By-Product Radioactive Waste
- High-Level Waste Storage
- Plutonium Recycling and Storage

High Grade Ores

- Contain a few percent of uranium (1-4%), in unusual cases, up to 10%
- Typically in the form of uraninite (largely UO_2), or pitchblende.
- These ores are found primarily in central Africa (Zaire) and in Canada (Big Bear Lake).

Pitchblende Sample

Medium Grade Ores

- Contain 0.1 to 1.0% uranium
- Found on the Colorado plateau region (Colorado, Utah, New Mexico and Arizona), also found in California, Nevada, Texas, and Washington
- Found in Canada, Australia, and Czechoslovakia
- Typically carnotite, thorianite, phosphates, and carbonates

Medical Uses of Radioactive Material

- **Diagnostic purposes** - Radionuclides can be used to provide an image of an internal structure in the human body, or they can allow doctors to visualize various stages in the function of an organ.
- Radiation from X rays also fall into the diagnostic category.

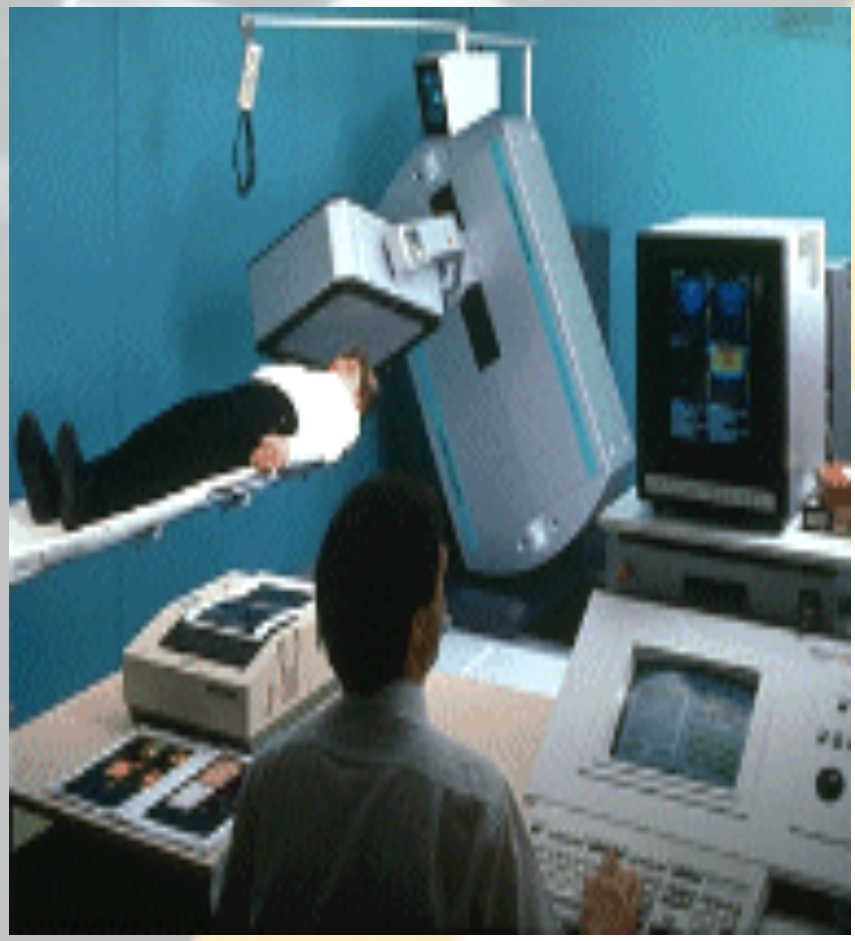
Medical Uses of Radioactive Material

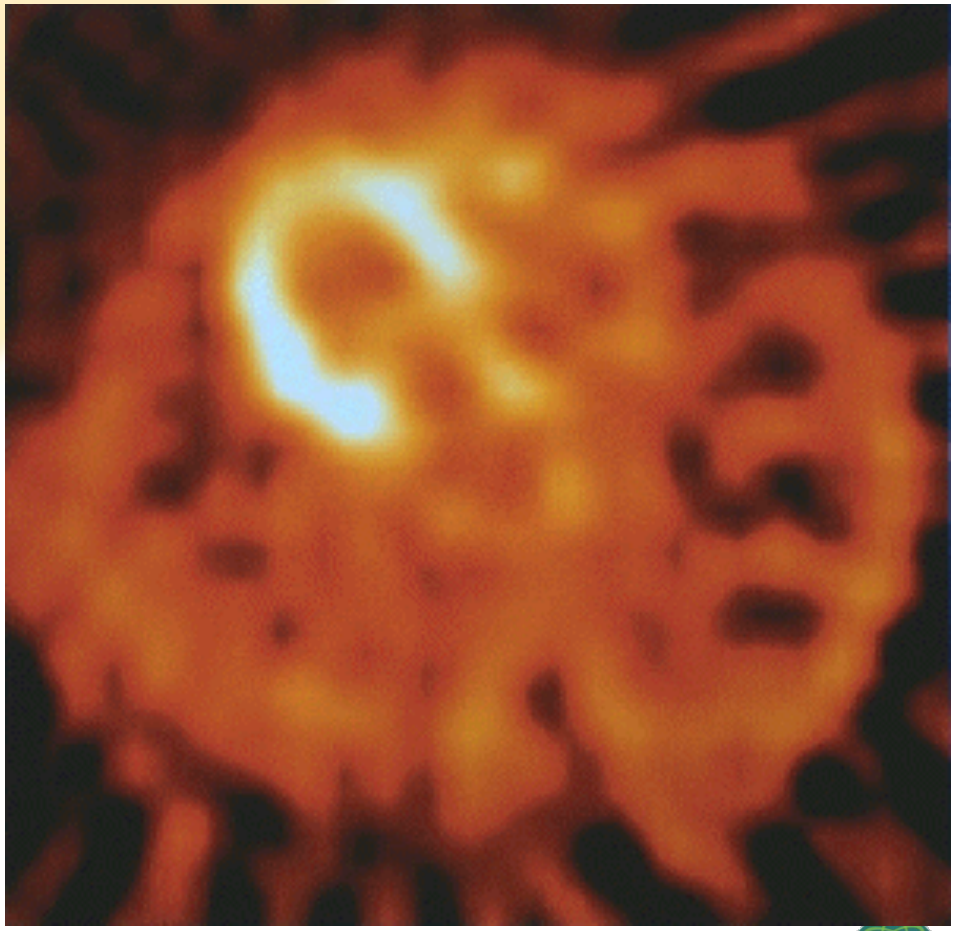
- **Therapeutic purposes - Radiation and radionuclides can be used to damage or destroy abnormal or diseased cells.**
- **Therapeutic uses include treatment of cancer and other diseases with ionizing radiation.**

Characteristics of Diagnostic Medical Uses

- Radionuclides should have certain characteristics:
  - short half-life
  - cannot emit alpha or beta radiation
  - must emit gammas with sufficient energy
  - highest possible specific activity
- Technetium-99m is used in more than 80% of the cases.

Medical Uses: Diagnostic Purposes

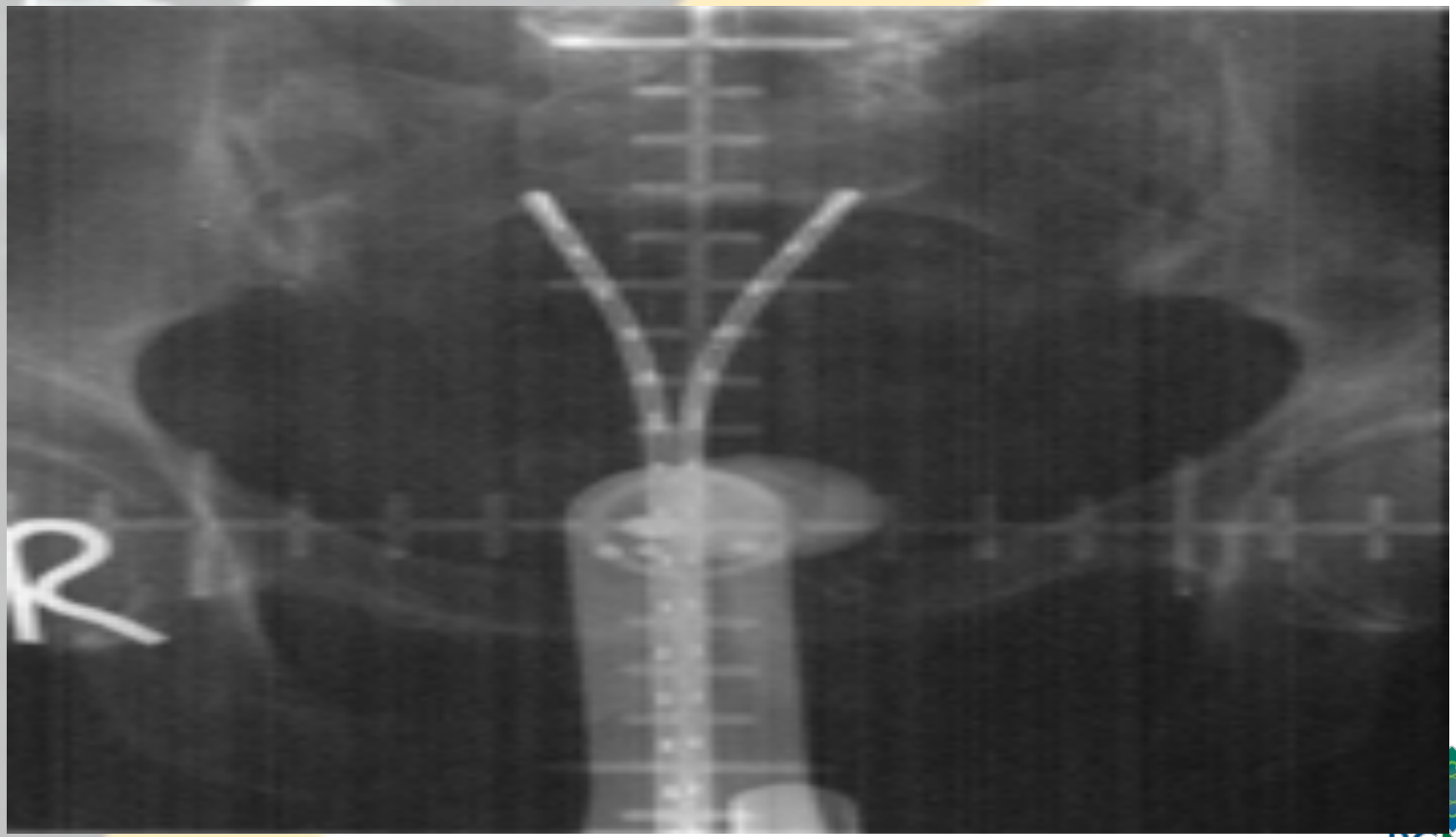




Characteristics of Therapeutic Medical Uses

- Criteria for internally deposited radionuclides:
  - the half-life should not cause an extended stay in the hospital
  - radionuclide should emit particulate radiation (alphas or betas)
  - radionuclide should also emit gamma rays to determine that the appropriate region has been targeted

Medical Uses: Therapeutic Purposes



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Machine Sources of Radiation

- X-ray Generators: Consists of a x-ray tube, a source of high voltage, tube filament current, and radiation shielding to shape the beam
  - Principle types of diagnostic X rays - radiographic, fluoroscopic, and photo-fluorographic
  - Therapeutic X rays - superficial x ray for skin cancer, orthovoltage x ray generators for deeper lying tumors
  - Industrial X rays - nondestructive examination of metal parts and tires

Machine Sources of Radiation

- **Nuclear Particle Accelerators: Objective is to produce a high energy stream of ions, directed along some path**
  - **Linear accelerator or Linacs (industrial and medical uses)**
  - **Cyclotron (also includes betatrons and synchrotrons)**
  - **Van de Graaff accelerator**

Fallout from Nuclear Explosions

- The dose to the living organism from a nuclear explosion is due mostly to released fission products, with some contribution from unused fuel, neutron activation products, and nuclides produced by nuclear reactions.
- <0.03% of the total average annual effective dose to the general population in the U.S. is from fallout from weapons testing (<1millirem/year).

Ionizing Radiation: Activities and Effects

- Food Irradiation: 100,000 rad
- Cancer Radiation Therapy: 6,000 rad
- Lethal WB Dose to 50% of Population: 350 rad
- Increase risk of cancer by 1% 12.5 rem
- Maximum Annual Occupational Dose: 5 rem
- Average Annual U.S. Population Dose: 620 mrem
- Average Dose from Radon per year: 200 mrem
- Annual Dose Limit for General Population: 100 mrem
- Dose from a skull x-ray: 8 mrem
- Dose from round-trip flight LA to NY: 2 mrem

Sources of Radiation Exposure to the U.S. Population – 1990

Total Average Annual Dose = 360 mrem (3.6 mSv)

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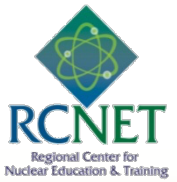
A New Evaluation of Radiation Exposure of the U.S. Public Has Been Released by the NCRP



2006 Population Dose

- Sources of exposure include:
  - Natural radiation exposure
  - Medical uses of radiation and radioactivity
  - Consumer products
  - Industrial uses
  - Occupational exposure
- Average effective dose to each individual is 620 mrem/y (6.2 mSv/y) – **not quite double!**

What is the largest contributor to the radiation exposure of the U. S. Population?

- **Medical uses** 48%
- Radon 37%
- Natural background 13%
- Others 2%

2006 Population Exposure

- **Computed tomography** **24%**
- **Nuclear medicine** **12%**
- **Interventional medicine** **7%**
- **Radiographic/Fluoroscopic** **5%**
- **Radon** **37%**
- Terrestrial 3%
- Internal (ingestion) 5%
- Space radiation (external) 5%
- Consumer products 2%
- Industrial <0.1%
- Occupational <0.1%

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Questions

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