Nuclear Plant Emergency Response

Basic Radiation Principles

Module 2

Objectives

- Discuss the difference between ionizing and non-ionizing radiation.
- Describe radioactive decay.
- Discuss the different types of ionizing radiation.

Radiation in Pop Culture

Different Types of Radiation

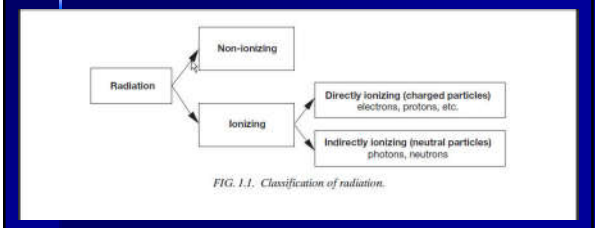
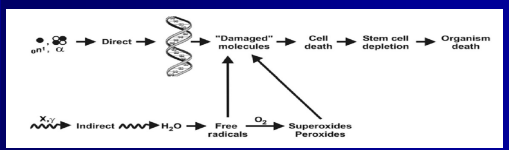
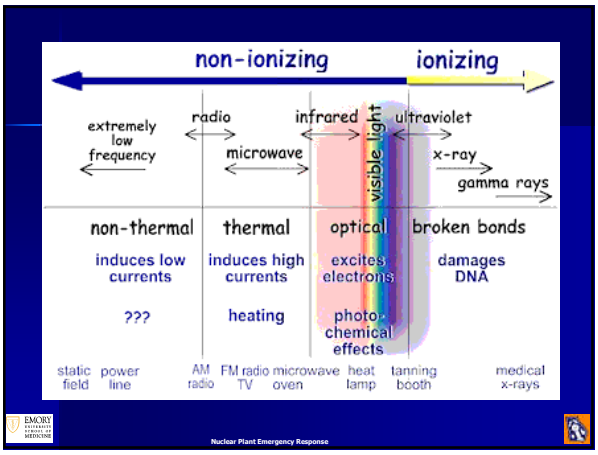


FIG. 1.1. Classification of radiation.

Ionizing Radiation

- Damages DNA.
- Produces free radicals by damaging water molecules.




non-ionizing
ionizing
extremely low frequency
radio
microwave
infrared
visible light
ultraviolet
x-ray
gamma rays
non-thermal
thermal
optical
broken bonds
induces low currents
induces high currents
excites electrons
damages DNA
???
heating
photo-chemical effects
static field
power line
AM radio
FM radio TV
microwave oven
heat lamp
tanning booth
medical x-rays
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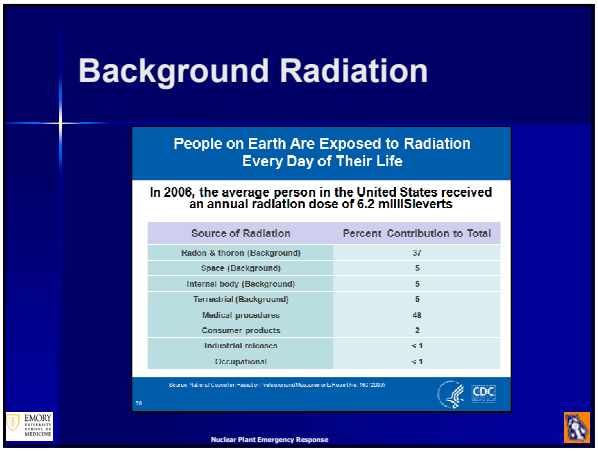
Background Radiation
People on Earth Are Exposed to Radiation Every Day of Their Life
In 2006, the average person in the United States received an annual radiation dose of 6.2 milliSieverts
Source of Radiation
Percent Contribution to Total
Radon & thoron (Background) 37
Space (Background) 5
Internal body (Background) 5
Terrestrial (Background) 6
Medical procedures 48
Consumer products 2
Industrial releases < 1
Occupational < 1
CDC
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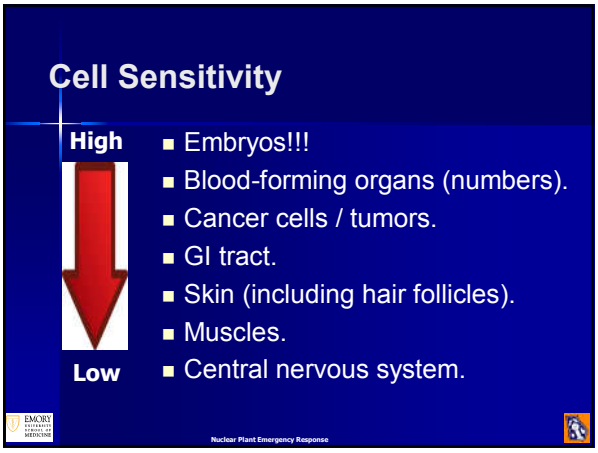
Cell Sensitivity
High
Low
Embryos!!!
Blood-forming organs (numbers).
Cancer cells / tumors.
GI tract.
Skin (including hair follicles).
Muscles.
Central nervous system.
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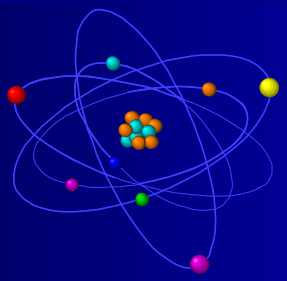
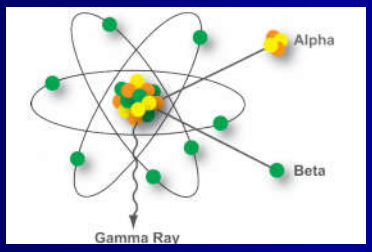
What is an Atom Composed Of?



Why do Certain Atoms Emit Radiation and are Radioactive?



Activity

- A measure of the amount of radioactive material
- Measured by the number of radioactive disintegrations per second
  - 1 Bequerel = 1 disintegration / sec
- Not related to mass or volume

*1 Curie = 37 billion disintegrations / sec

Radiation Measurement Units

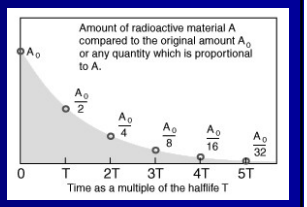
S.I.	Formula	USA
1 Becquerel (Bq)=	1 / 37 billion x	Curie (Ci)
1 Gray (Gy) =	100 x	RAD
1 Sievert (Sv) =	100 x	REM

Difference Between RAD and REM - Gray and Sievert

- RAD and Gray (Gy) express the amount of energy deposited per gram of tissue or material.
- REM and Sievert (Sv)express the health effect from the radiation deposited in a specific organ by a specific type of radiation.
- For gamma rays 1 Gy = 1 Sv

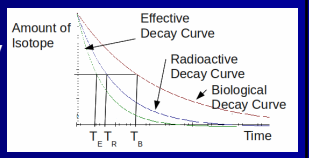
Physical Half Life

- Time required for activity to be reduced by ½
- Specific to each radionuclide
  - I-131 = 8 day
  - Cs-134 = 2 yr
  - Cs-137 = 30 yr



Biological and Effective Half-Life

- Biological: time required for body to eliminate ½ of a particular element



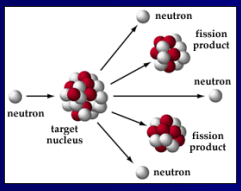
- Effective: combined effect of radioactive decay and physical elimination
- Effective half-life is ALWAYS less than physical or biological half-life

ALARA

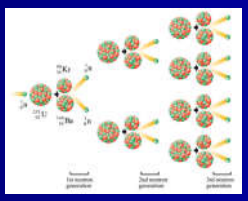
- "As Low As Reasonably Achievable"
- Work activities in radiation areas must be carefully planned to minimize radiation doses to workers
- Dose to general public kept low
- Control of releases of radioactive materials to the environment

How do Nuclear Reactors Work?

Nuclear Fission

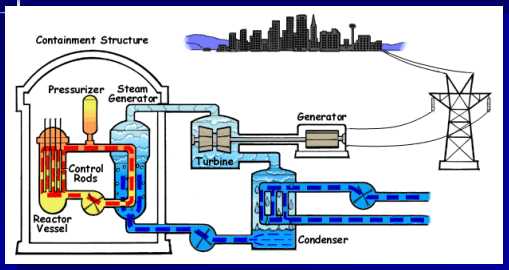


Neutrons split U-235 atoms, releasing heat and fission products

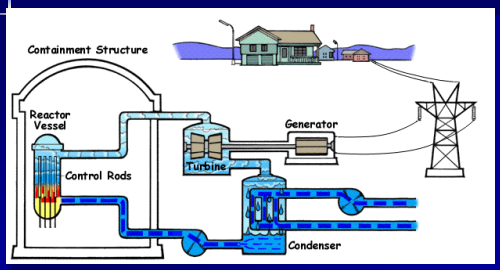


Neutron "poisons" absorb neutrons to control chain reaction

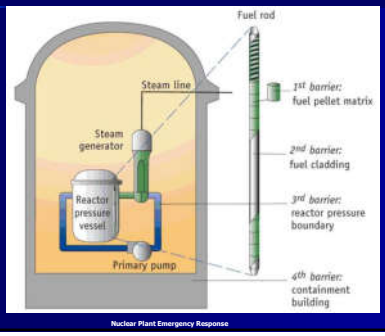
Pressurized Water Reactor



Boiling Water Reactor

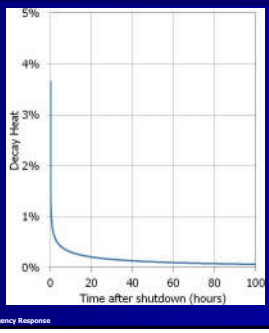


Defense in Depth -- Barriers



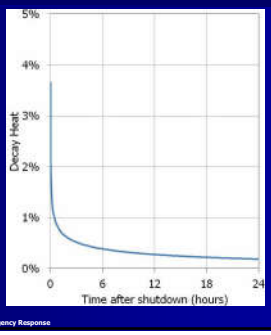
Decay Heat

- β decay of fission products
- Heat must be removed to prevent fuel damage



Decay Heat

- β decay of fission products
- Heat must be removed to prevent fuel damage
- Chemical reaction releases H_2 gas at ~1,200 ° C



Loss of Cooling Water

- Rupture of fuel cladding (small release)
  - krypton, xenon, iodine
- Zirconium oxide (H_2 and more heat)
- Melting of control rods (BWR)
- Melting of fuel (larger release)
  - iodine, cesium, strontium, etc.
- Liquification and relocation of fuel

Any Questions?

Summary Points

- Ionizing radiation damages cells and DNA.
- Ionizing radiation includes alpha particles, beta particles, gamma rays and neutrons.
- People are exposed to background radiation at all times.
- NPP accidents usually involve loss of coolant mechanisms.