RADIATION SAFETY TRAINING

Presented By:

RADIATION SOLUTIONS

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raddisposal.com

An introduction to

Atomic Structure, Terminology, Types of Radiation and Units of Measure

Three Parts to an Atom Structure

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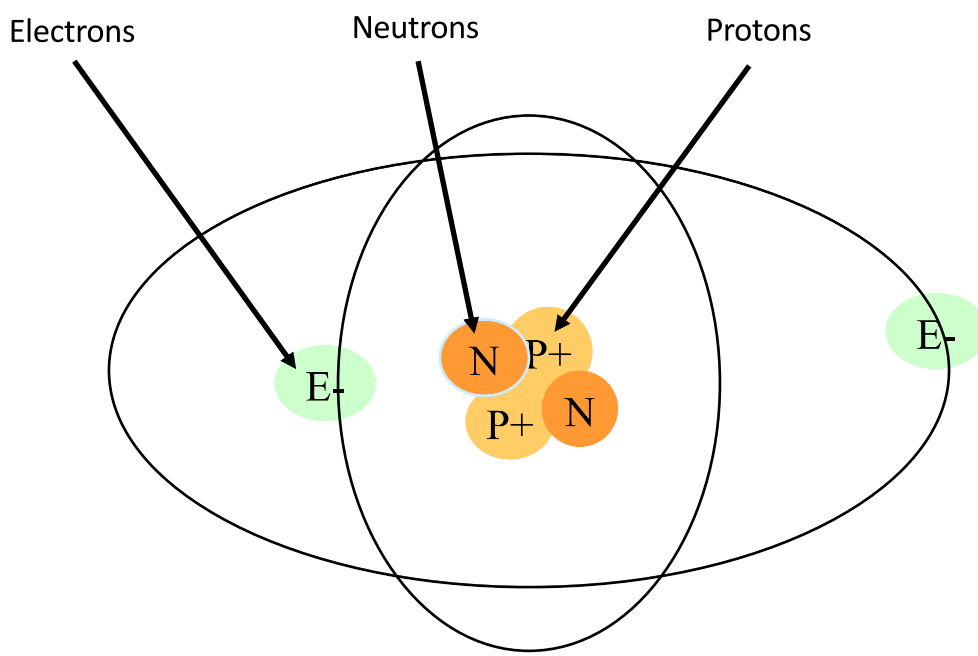
All matter is made up of atoms

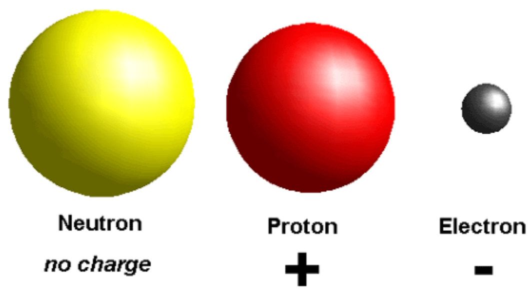


This is the structure of a Helium Atom – 2 Protons, 2 Neutrons, 2 Electrons

Protons & Electrons

Protons

- Located in the nucleus of the atom
- They have a positive (+) charge
- The number of protons in the nucleus determines the element
- If the number of protons in an atom change, the element changes

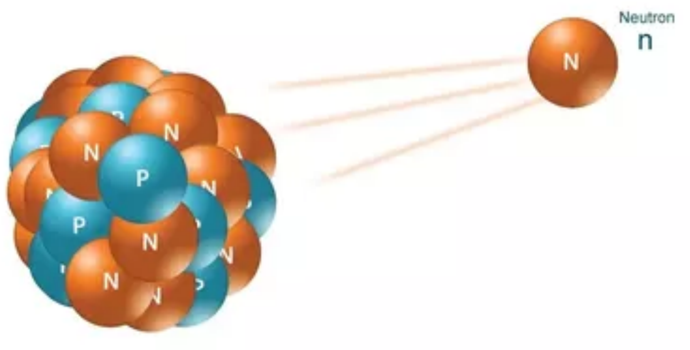


Electrons

- They have a negative (-) charge
- Located in electron clouds that orbit the nucleus
- The electron configuration determines the chemical properties of an atom
- Equal to the number of protons in the atom's nucleus
- Determines the chemical properties of the atom

Neutrons

Neutrons

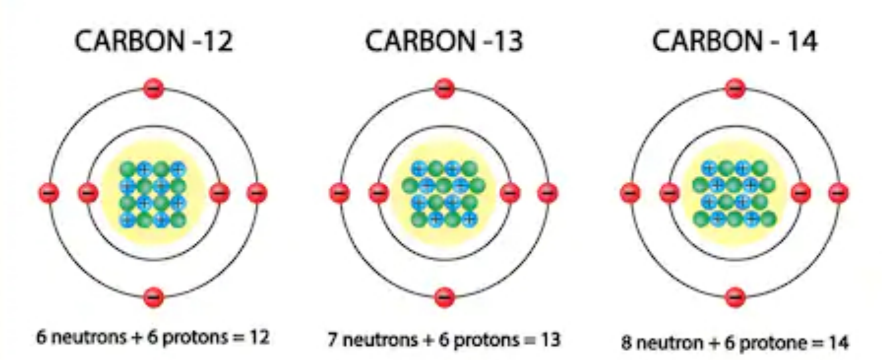


- Located in the nucleus
  of an atom
- They have no electrical
  charge (neutral)
- Changing the number of neutrons does not change the atom’s identity. (the element stays the same)
- When loose they are fast and travel long distances in the air
- They can be stopped or slowed down by water or polyethylene
- Effectively equal in weight to a proton in size

Isotopes

- Atoms of the same element (i.e. Cesium, Carbon) that have the same number of protons, but a different number of neutrons are called **ISOTOPES.**
- They have the same chemical properties, but have different nuclear properties.
- Number of neutrons can vary for a given element (i.e. Cs-130… Cs-148) → Balance between protons and neutrons determine nuclear stability.

Different Isotopes of Carbon



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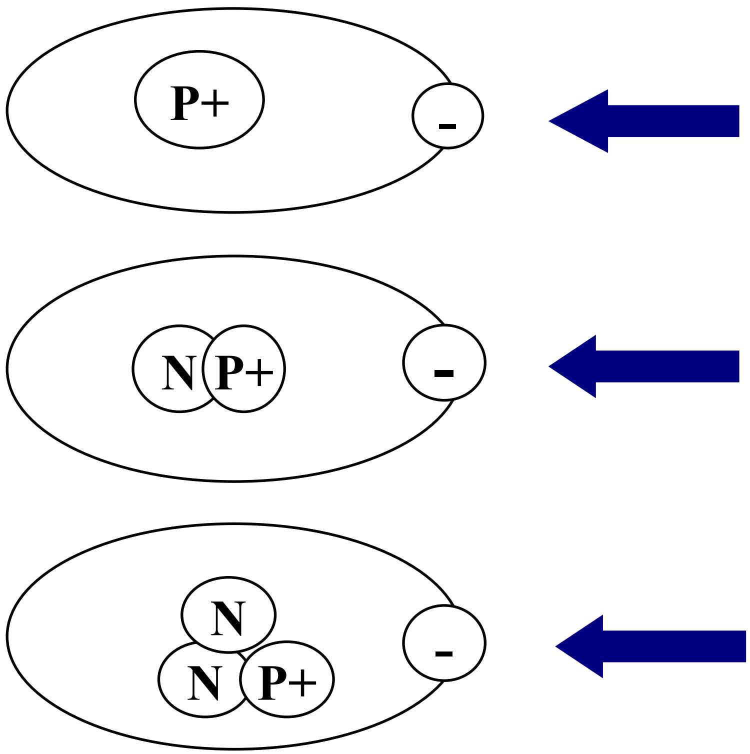
Isotopes of Hydrogen

This example shows how the number of neutrons can change the isotope.
Remember the protons stay the same.



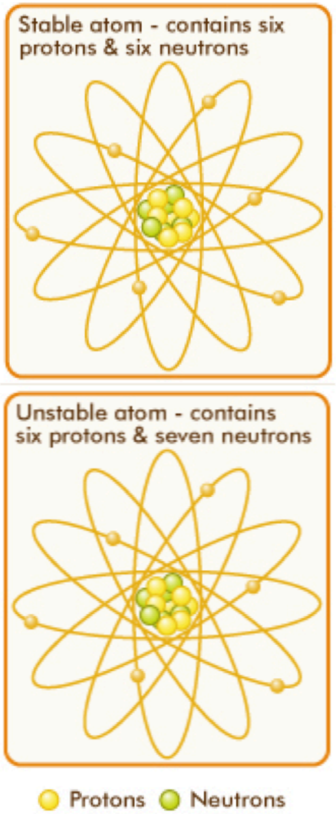
H_1 Hydrogen

H_2 Deuterium

H_3 Tritium

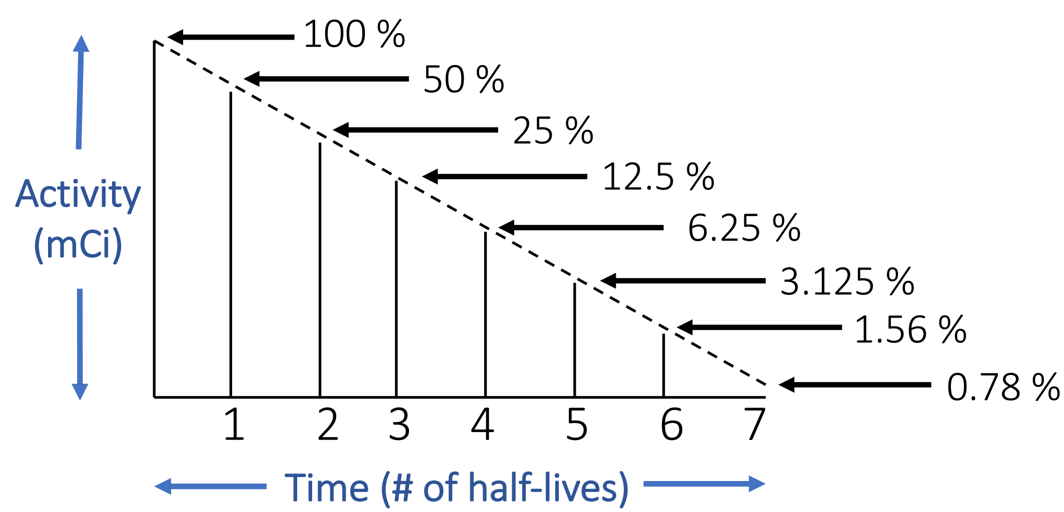
Unstable Atoms Emit Radiation

- Too many or too few neutrons to protons in a nucleus will cause the atom to be unstable.
- An unstable atom will automatically try to become stable by giving off its excess energy in the form of particles or waves. This is called radiation.
- Throwing off excess energy will effect other atoms by “stripping the electrons off the other atoms”. This action is referred to as Ionizing Radiation.
- Stripping of electrons from other atoms creates an “ion pair”.



Seeking Stability - Radioactive Half-Life

- The time it takes for ½ of an unstable atom to disintegrate to half of its original activity.
- After 7 half lives, the isotope is 1% of its original activity.



Imbalance Between the Protons and Neutrons

Cs-137

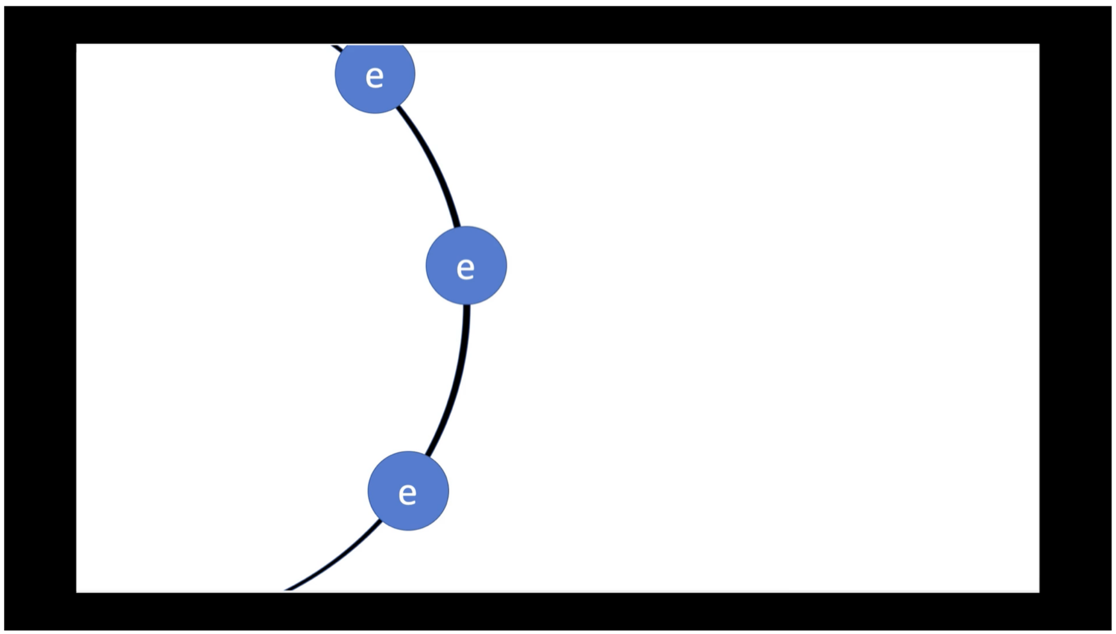
- 55 Protons and 82 Neutrons
- Because of the unequal amount of protons to neutrons, we get an unstable (radioactive) isotope called Cesium 137
- Beta and gamma emitter
- 0.661 Mega Electron Volt (MeV) of energy
- Half-life of 30 years

Am-241

- 95 Protons & 146 Neutrons
- Because of the unequal amount of protons to neutrons, we get an unstable (radioactive) isotope called Americium 241
- alpha emitter
- 5.6 MeV Energy
- Half-life of 433 years

Your Concern: Ionizing Radiation

Ionizing radiation is radiation traveling as a particle or electromagnetic wave, that carries sufficient energy to detach electrons from atoms or molecules, thereby ionizing them.



(click on picture to see ionizing radiation interaction with atom)

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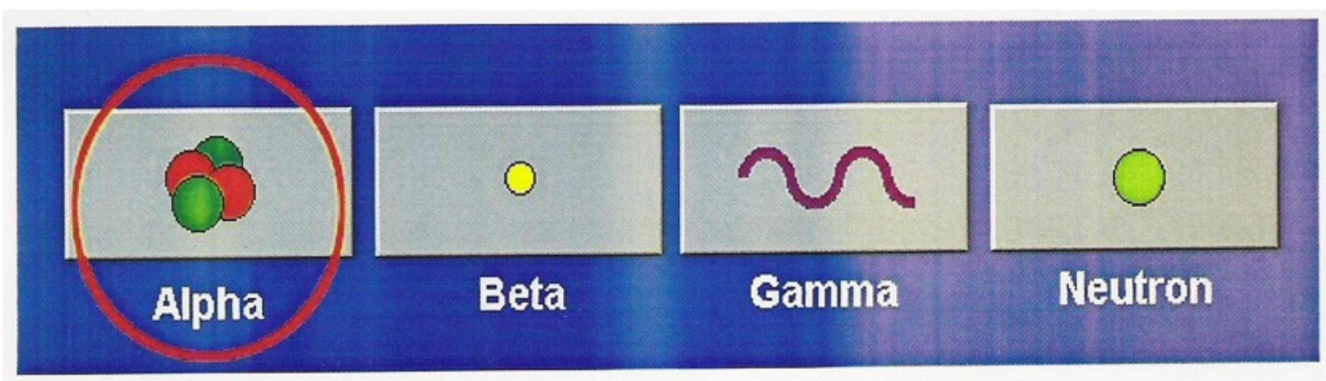
Four Basic Types of Ionizing Radiation

- ALPHA
- BETA
- NEUTRON

PARTICLES

- GAMMA

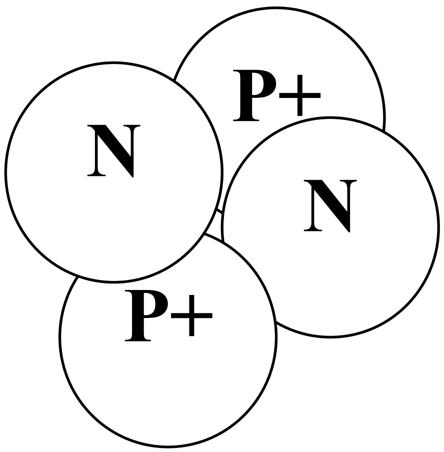
ELECTROMAGNETIC WAVES



Alpha Particles

Particle Type Radiation

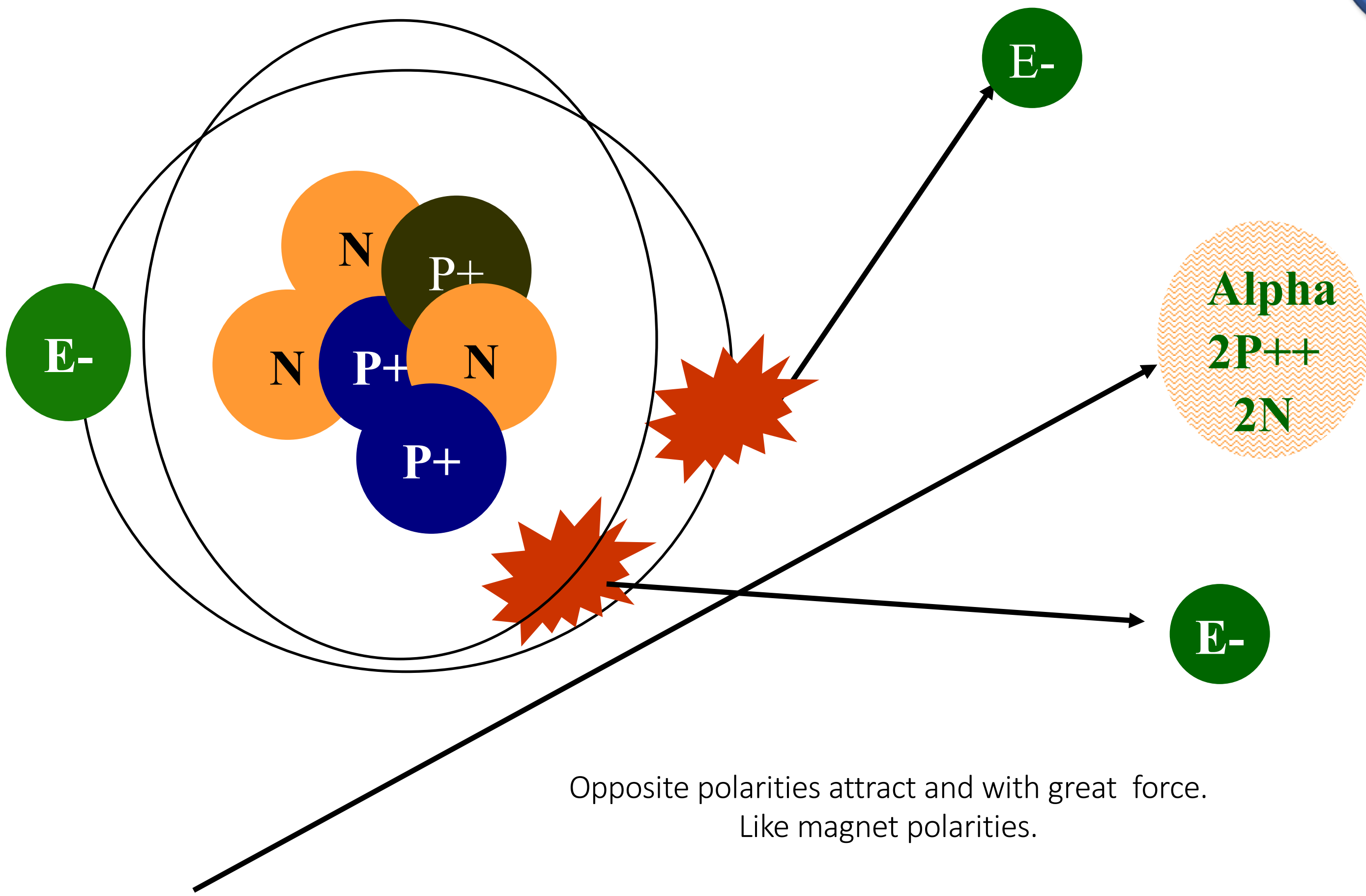
α



- Originate in the nucleus
- Consists of 2 protons & 2 neutrons
- Large heavy mass & high energy
- Shielded by paper
- Short range in air (1-2 inches)
- Large positive charge
- Biological hazard if ingested, inhaled, or injected (wound)
- Am-241 is an Alpha emitter, but not a concern unless source is breached

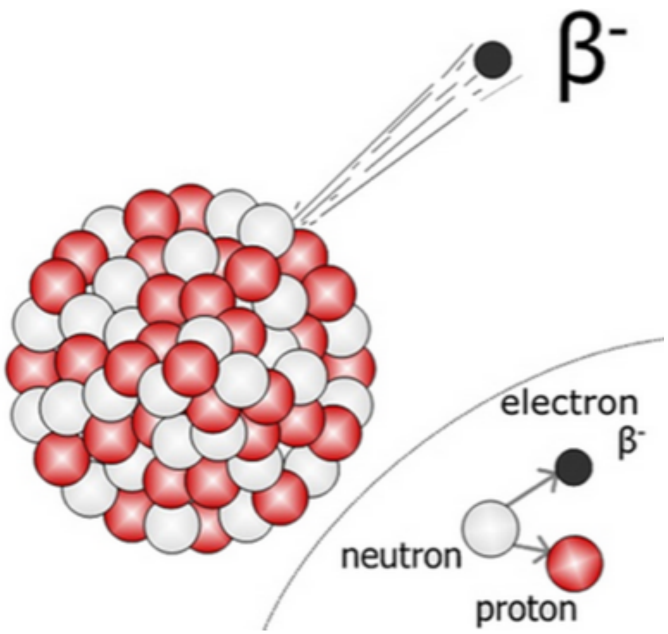
Alpha Ionization

Particle Type Radiation



Opposite polarities attract and with great force.
Like magnet polarities.

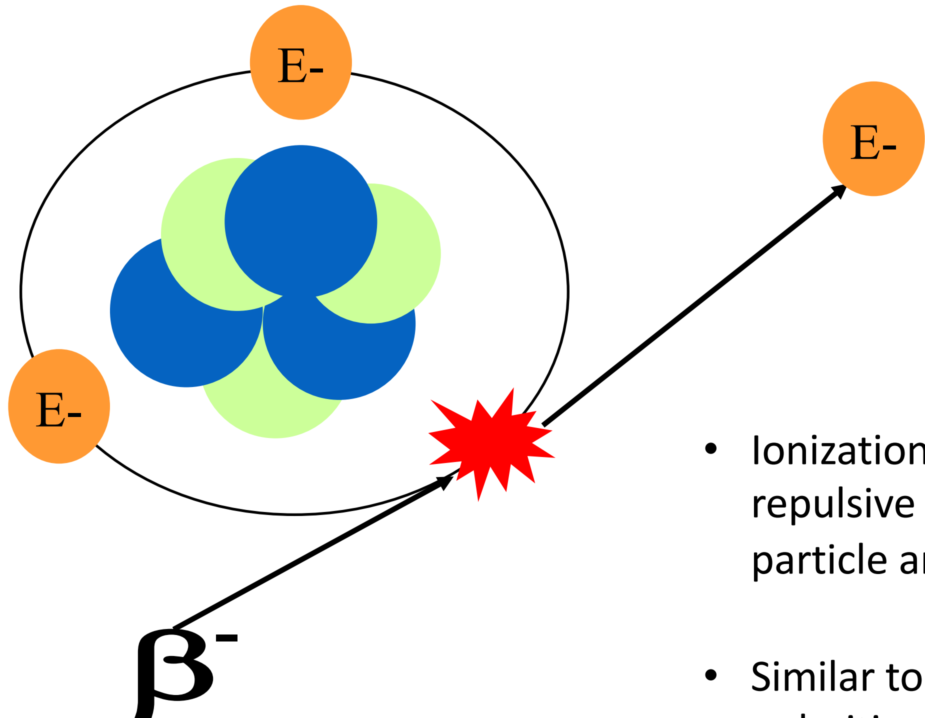
Beta Particles



- Emitted from nucleus
- Negative (-) charge
- Range in air is a few feet to a few tens of feet
- Shielded by plastic, glass, or foil
- Internal and external biological hazard
- Not a major concern in a nuclear gauge unless the Cs-137 source (a gamma & beta emitter) capsule is breached

Beta Ionization

Particle Type Radiation



- Ionization occurs due to the repulsive force between the beta particle and orbital electrons

- Similar to how the same magnetic polarities repel each other with force

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Neutron Particles

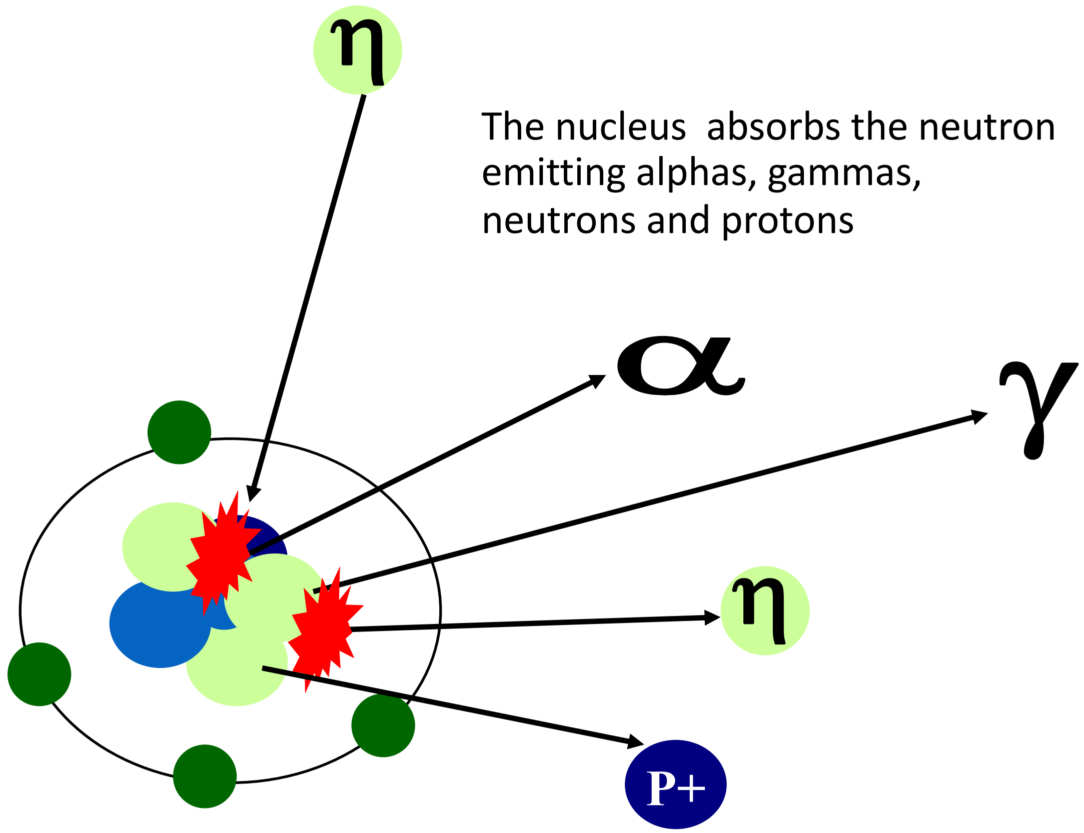
Particle Type Radiation

- Emitted from nucleus of an unstable atom
- Has no electrical charge
- Interacts with matter directly through collisions or indirectly when absorbed by another nucleus
- Range in air is VERY far – can be hundreds to thousands of feet
- Unique characteristic – Light density materials containing hydrogen or hydrogenous atoms (i.e. water, oil, polyethylene, etc.) are the only effective shielding because of high linear energy transfer (LET)
- Neutrons penetrate human tissue & bone – cause significant damage due to high LET. Primary radiological concern w/ gauges

Neutron Ionization

Particle Type Radiation

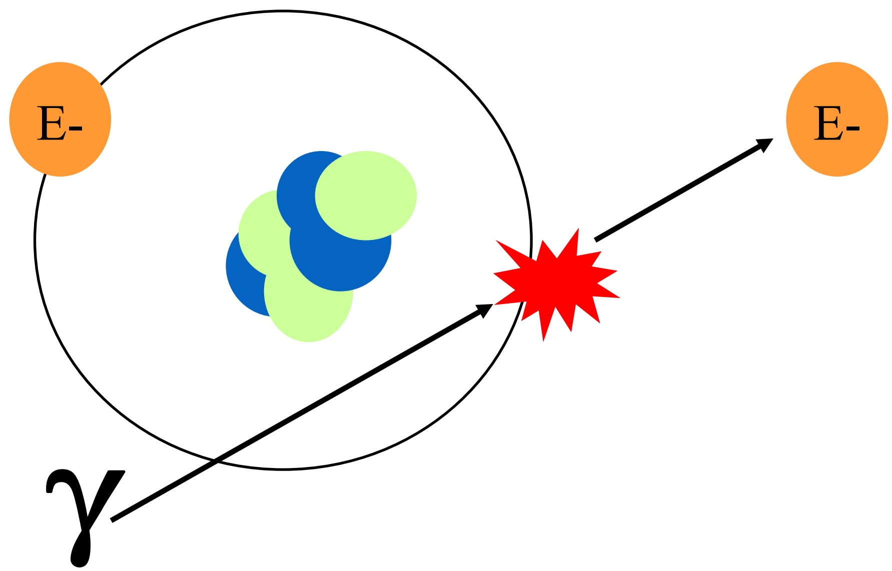
The nucleus absorbs the neutron emitting alphas, gammas, neutrons and protons



Gamma Ionization

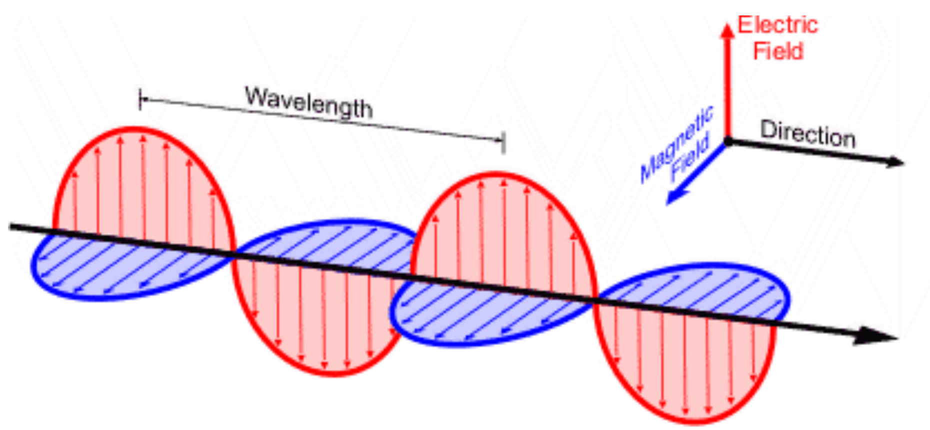
Electro-Magnetic Wave

- Electromagnetic waves or energy
- Has no electrical charge
- Originates in the nucleus as released energy
- Travels long distances in the air (1,000’s of feet in seconds)
- Shielded by dense materials (lead, concrete, steel, etc.)
- Penetrates tissue/bone – primary radiological concern w/ gauges



What is Electromagnetic Radiation?

- "Bundles" of electro-magnetic energy are known as photons, x-rays and/or gamma rays
- The energy of a given Photon is an expression of its frequency, amplitude, and wavelength
- Examples:
  - Visible light
  - Infra-red
  - Microwaves
  - Radio
  - TV
  - X-rays
  - Gamma rays



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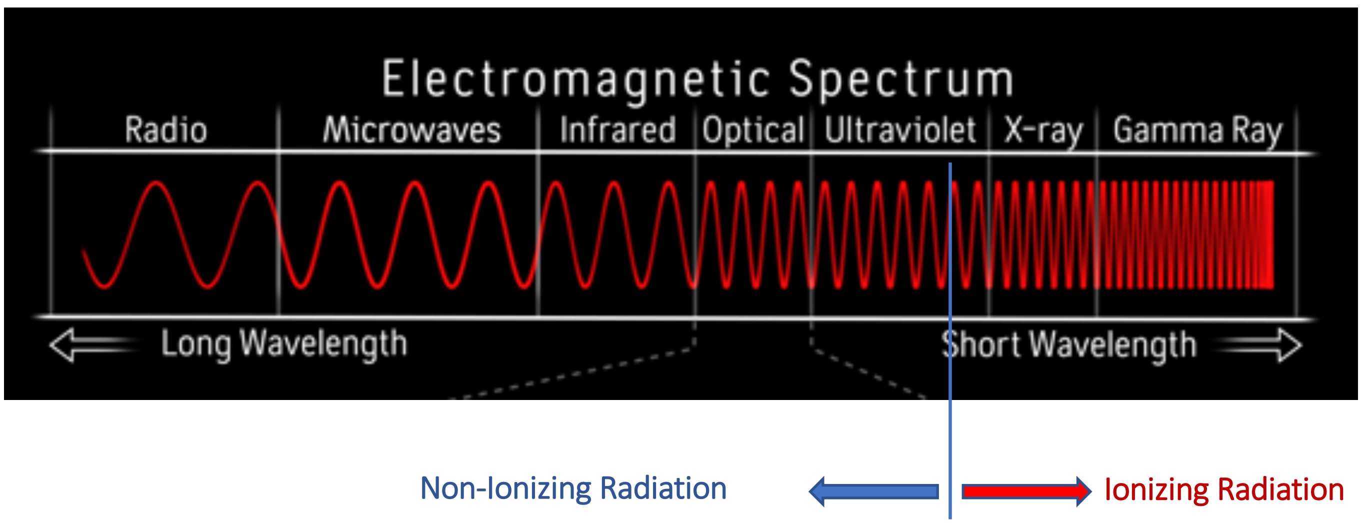
Electromagnetic Radiation

Electromagnetic Radiation (gamma) can be harmless or detrimental to your health depending on its wave length, frequency and amplitude



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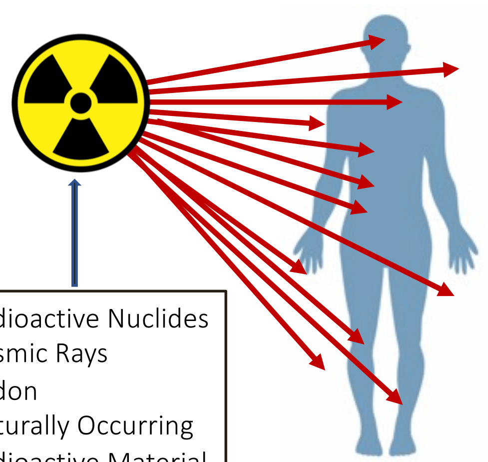
Radioactive Exposure vs. Contamination

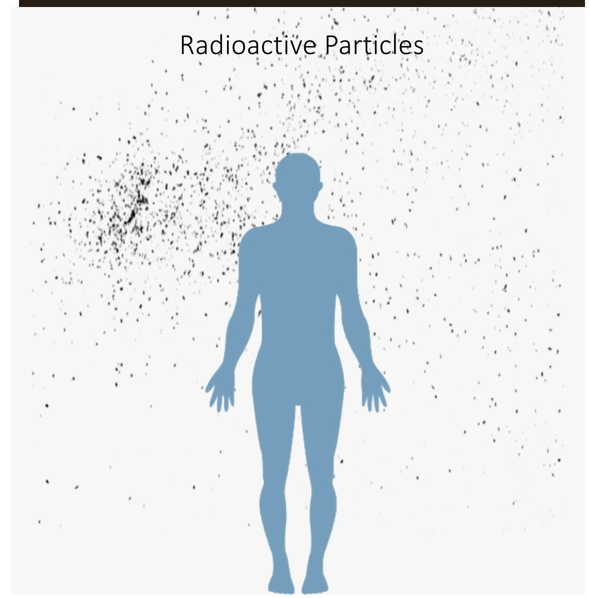
Radiation Exposure

Gamma & X-Rays



- Radioactive Nuclides
- Cosmic Rays
- Radon
- Naturally Occurring Radioactive Material
- X-Rays

Radiation Contamination



- Airborne radioactive particles
- Land on hair, skin, clothing
- Breathed into lungs
- Enter exposed wounds

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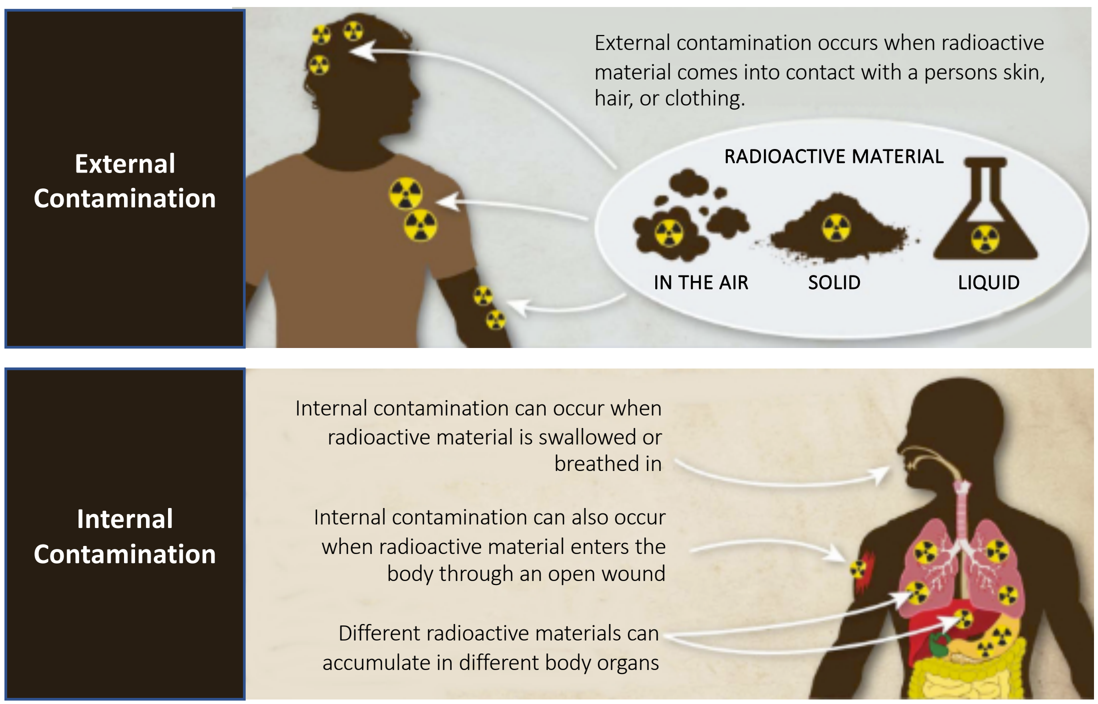
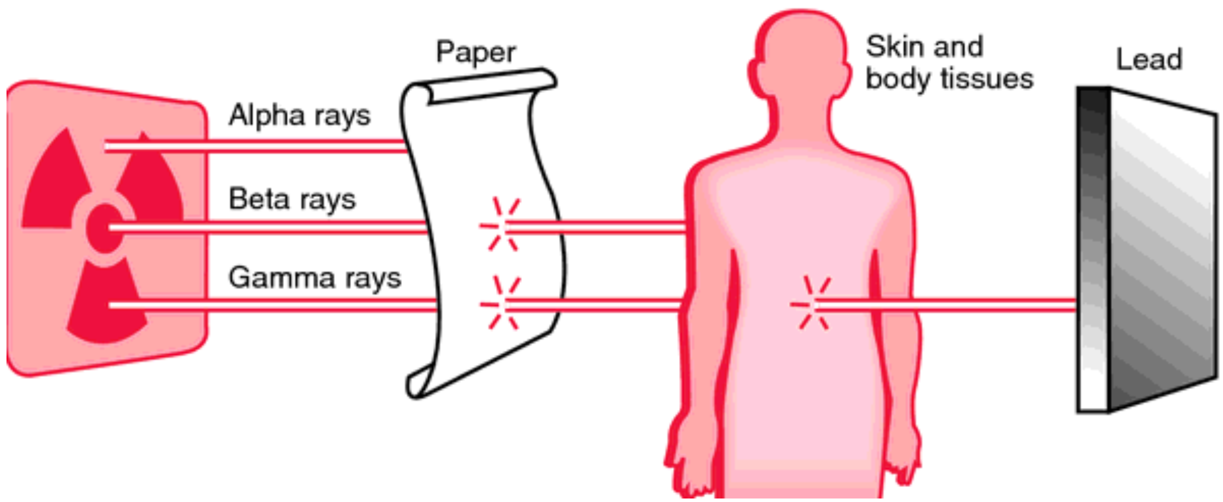
Radioactive Contamination

This occurs if the sealed source capsule is breached that contain radioactive isotopes in powder form. When the powder becomes airborne or attaches itself to other materials it becomes a radiological contamination hazard.



Radiation Penetrating Power

Below are the particles and waves that would be airborne and their penetrating power



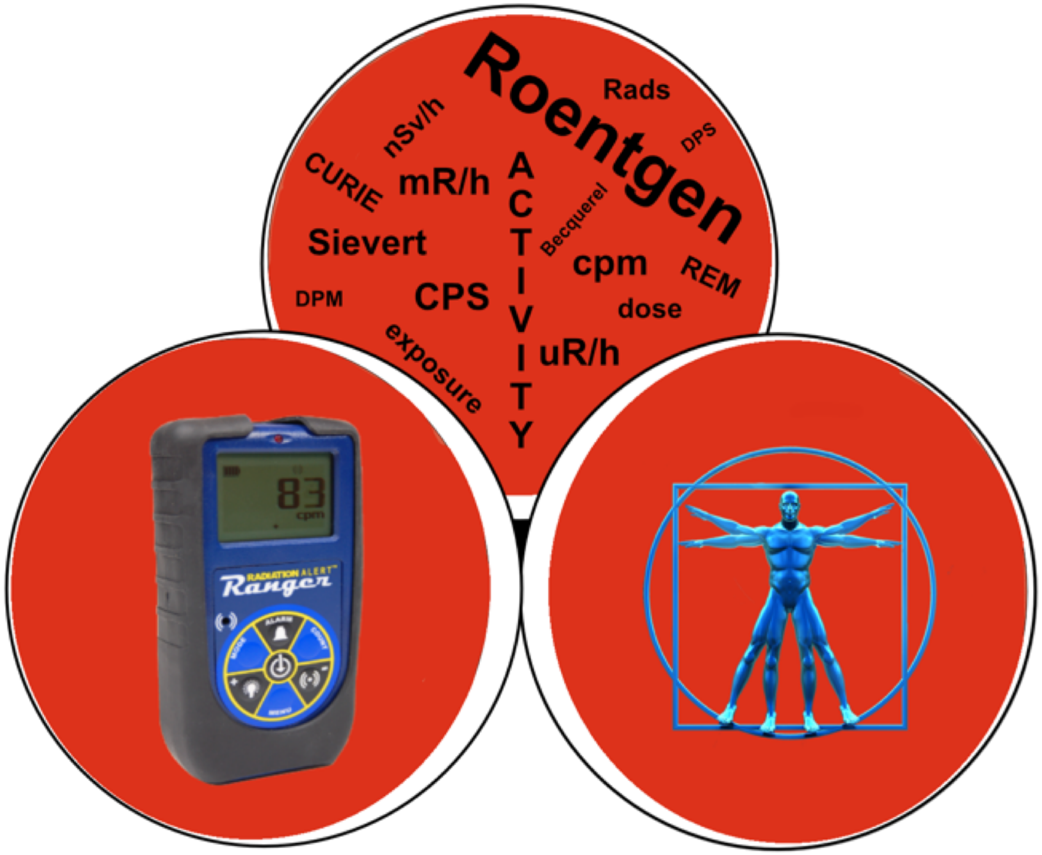
Definitions

- **Radiation:** An unstable atom seeks stability by spontaneously giving off excess energy in the form of a wave or particle. This wave or particle is radiation.
- **Ionization:** The process of removing electrons from a neutral or stable atom. This removal may produce sufficient energy (radiation) to ionize other atoms. If enough energy is produced to remove electrons from another atom, the remaining atom has a positive (+) charge. Not all radiation is ionizing radiation.
- **Non-Ionizing Radiation:** Radiation that does not have the energy needed to ionize another atom. Examples of non-ionizing radiation are radio waves, microwaves, visible light and ultraviolet.
- **Radioactive Contamination:** Loose radioactive material in an unwanted place. Example would be a sealed source that has been broken and the radioactive material (RAM) is loose and spreading.

Definitions

- **Radioactive Material:** Material that contains unstable atoms emitting energized particles and/or waves.
- **Radioactivity:** Quantity of random disintegration (decay) of a unstable nucleus expressed in units of Becquerels and Curies.
- **Radioactive Decay:** The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission of radiation.
- **Radioactive Half-Life:** The time it takes for an unstable atom to reduce its activity by 1/2 .
- **Radiation Energy:** Energy comes in two forms; Particles (Alpha, Beta, and Neutron) and Waves (Gamma).

RADIATION UNITS OF MEASUREMENT



Radiation Units of Measurement

	Direct Reading	Calculated		
MEASUREMENT TYPE	**Exposure Rate**	**Absorbed Dose**	**Equivalent Dose**	**Effective Dose**

CALCULATION	Exposure Rate (read from meter)	Exposure Rate x Duration	Absorbed Dose x Radiation Quality Factor	Equivalent Dose x Tissue Weighting Factor
MULTIPLIERS & FACTORS			Beta, Gamma, X-Ray = x 1 Alpha = x 20 Neutrons = complex energy functions	Skin: 0.01 Thyroid: 0.05 Lungs: 0.12 Gonads: 0.20
RADIATION UNITS OF MEASUREMENT	ROENTGEN/HR	RAD GRAY	REM SIEVERTS	REM SIEVERTS

International System of Units (SI)

Old Units	SI Units
Curie (Ci)	Becquerel (Bq)
Roentgen	Couloumb/kilogram
RAD	GRAY (Gy)
REM	Sievert (Sv)

The Roentgen (R)

- The quantity of Gamma radiation that will produce 2 Billion ion pairs in one cubic centimeter of air at Standard Temperature and Pressure (STP)

- Old term - limited use in modern Radiation Protection

Named in honor of Wilhelm Roentgen who discovered x-rays in 1895

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Radiation Absorbed Dose (RAD)

- A measure of the amount of **any type** of ionizing radiation that will deposit 100 Ergs in **any medium**
  - 1 Rad = 100 Ergs/g from ionization
  - 1 Rad = 2 billion ion pairs/cm^3

(Used to represent energy deposited in non-living matter)

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Roentgen Equivalent Man (REM)

- The quantity of any radiation which produces the same biological damage resulting from the absorption of 1 RAD of Gamma radiation in human body tissue.

  REM = Measures dose to the human body

- When calculating total biological dose, all RAD measurements are converted to REM by the use of a quality factor.

The REM – Dose Equivalence

- The REM takes into account the ways different types of radiation effect us. It does that by multiplying RADs of radiation received by a quality factor.

RAD X QUALITY FACTOR = REM

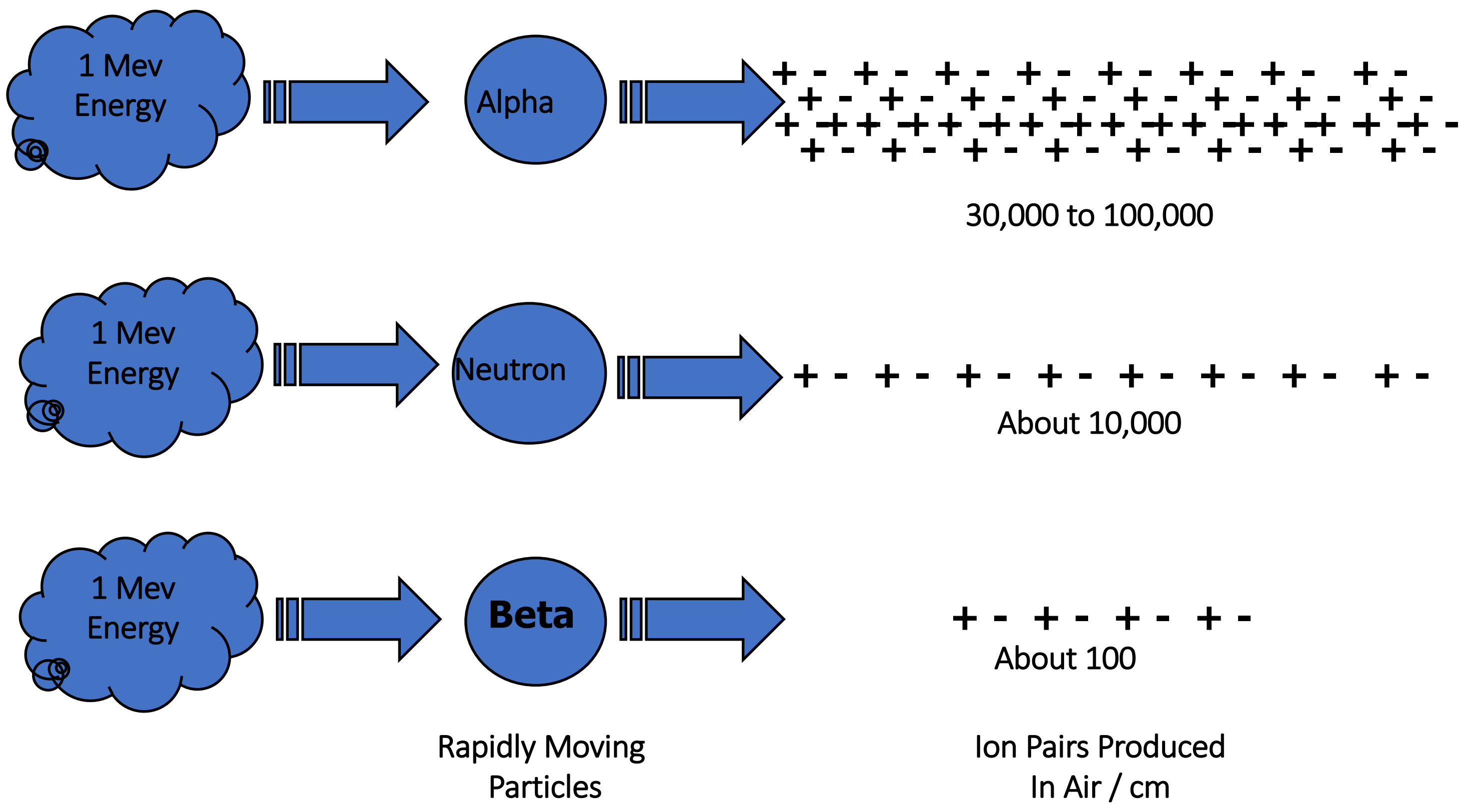
- The quality factor reflects the relative biological effectiveness of a particular type of radiation to produce biological damage.

Quality Factors

A numerical value is given for each type of radiation based on its potential to produce biological damage.

Type of Radiation	Quality Factor
Beta, gamma	1
Slow Neutrons	3
Fast Neutrons	10
Alpha	20

Specific Ionization – Basis for QF



Converting Units – rem to mrem

- Radiation dose is most often expressed in thousandths of a rem (mrem).
- 1 rem = 1000 mrem
- 1.35 rem = 1,350.0 mrem

Example mrem to rem using 250 mrem:

250 mrem x 1 rem ÷ 1000 mrem = 0.25 rem

Radiation Dose (Exposure)

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The amount of radiation a person receives (rem)

- Damage to the human body is relative to the location where the dose was deposited. A dose that would be lethal to the whole body can be safely administered to a small area.
- Parts of the body have higher dose limits than the body as a whole.

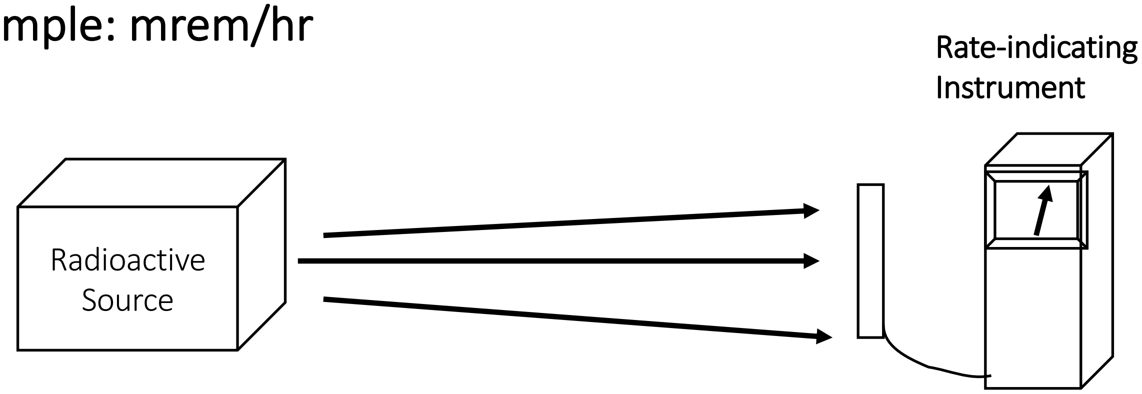
Examples of allowable annual radiation dose limits from the NRC

- **Organs 50 rem/yr**
- **Skin 50 rem/yr**
- **Extremities 50 rem/yr**
- **lens of eye 15 rem/yr**
- **whole body 5 rem/yr**

Radiation Dose Rate

- The amount of radiation dose that would be received over time
- Many radiation instruments report dose rate

Example: mrem/hr



Dose RATE	X	TIME	=	DOSE
100 mrem/hr	X	1hr	=	100 mrem

Dose Rate X Time = Dose

(Examples)

0.5 mrem/hr X 8 hrs. = 4 mrem

50 mrem/hr X ½ hr. = 25 mrem

1000 rem/hr X 1 hr = 1000 rem

Dose Problem

If an individual enters and remains in a radiation field of 0.5 mrem/hr, what will his/her dose be after 8 hours?

a) 4 rem
b) 40 mrem
c) 4 mrem
d) 400 mrem

Radioactivity Measured in Curie (Ci)

- A curie of radioactivity is defined as a particular number of disintegrations (decays) that radioactive material undergoes in a certain period of time. The time is usually in seconds.
- 3.7×10^{10} dps = 1 Curie or 37,000,000,000 dps
  - That's 37 billion disintegrations per second
- 1 dps = 1 disintegration per second (dps)
- 1 dpm = 1 disintegration per minute (dpm)
- 1 dpm = 60 dps
- 1000 mCi = 1 Ci

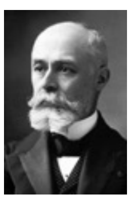
NOTE: Usually all of your sealed sources or radioactive material that you will be exposed to is measured in milli-curies (mCi)

Named in honor of Marie Curie who discovered Radium and Polonium

Becquerel

The Becquerel (Bq) is required in transportation of radioactive material

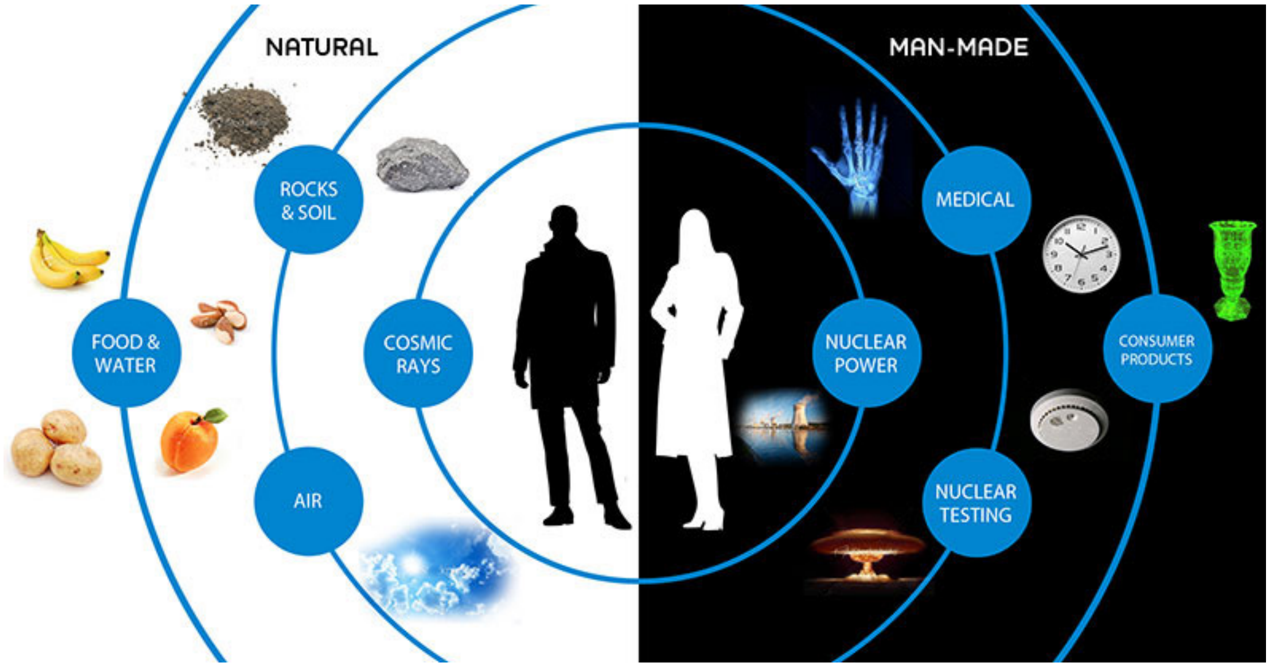
- Represents the number of disintegrations (decays) per unit time
  - 1 dps = 1 Becquerel (Bq)
  - 3.7×10^{10} Becquerels = 1 Curie
- Often expressed as activity (MBq)



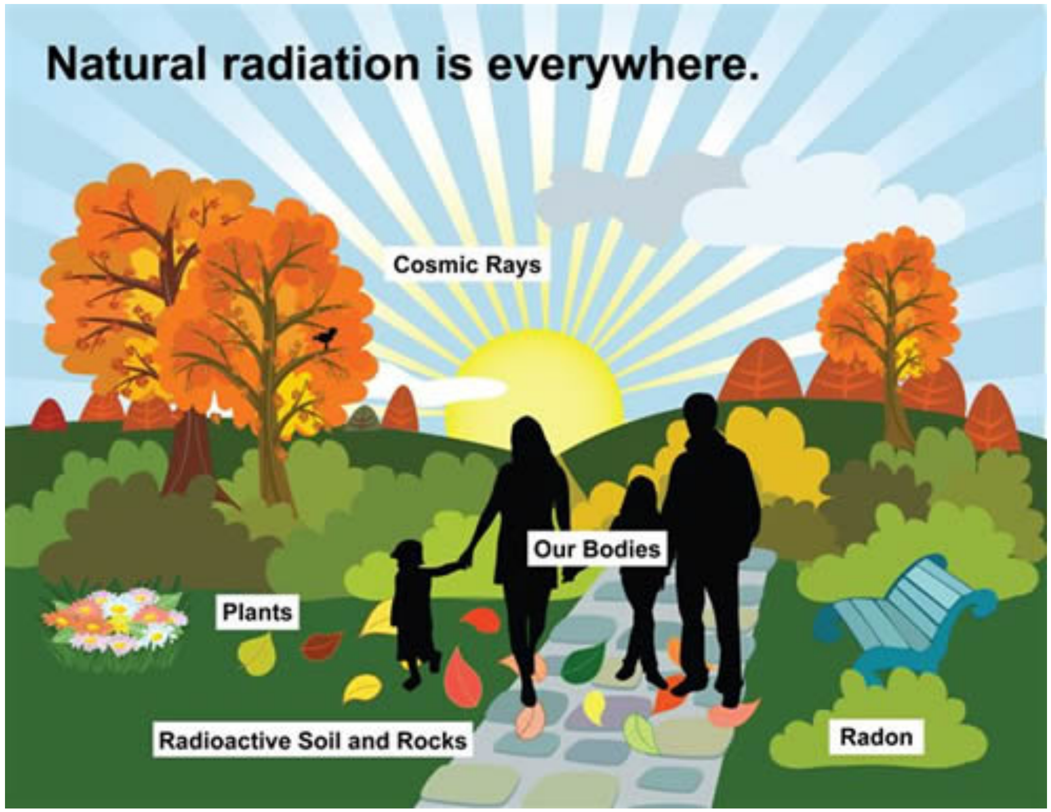
Named in honor of Henri Becquerel who discovered spontaneous radioactivity

dps = disintegrations per second
MBq= Mega Becquerels (1,000,000 Bq)

RADIATION SOURCES



Natural Background Radiation Sources



Our bodies are constantly exposed to naturally occurring radiations

Cosmic Sources of Radiation

Protons, neutrons, betas and a variety of heavy particles plus gamma rays, x-rays & other electromagnetic radiation

Average Dose = 30 mrem/year

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Terrestrial Sources

Granite, Soil, Minerals, Ground Water, Air, Mine Tailings, Natural Gas, etc.

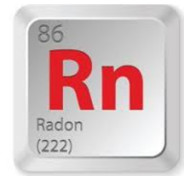
- ^{3}H Helium
- ^{14}C Carbon
- ^{40}K Potassium
- ^{226}Ra Radium
- ^{232}Th Thorium
- ^{238}U Uranium
- ^{222}Rn Radon

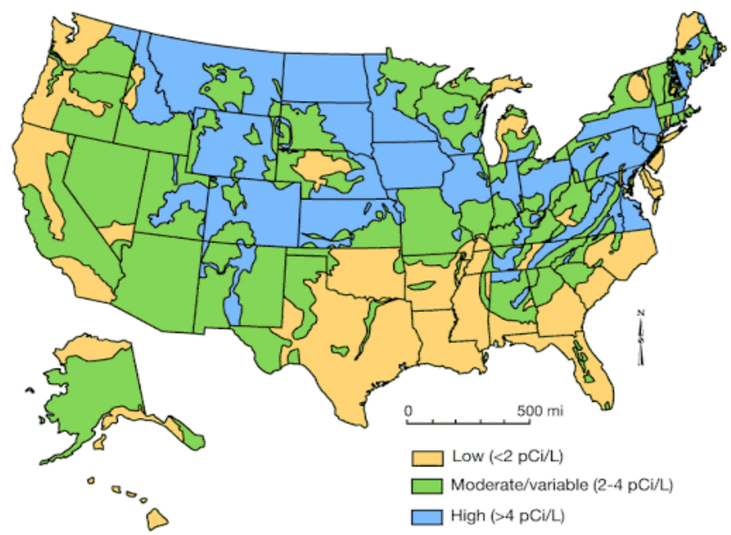
Average Dose = 30 mrem/year

Radon

- From decay of Radium and Uranium
- Naturally occurring in soil and rock formations
- Usually present in basements, mines, well water, granite and slag used in building materials, etc.
- Calculated to be the 2^{nd} leading cause of lung cancer in the U.S.

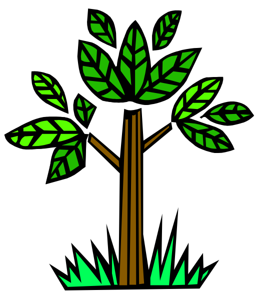
Average Dose = 200 mrem/year





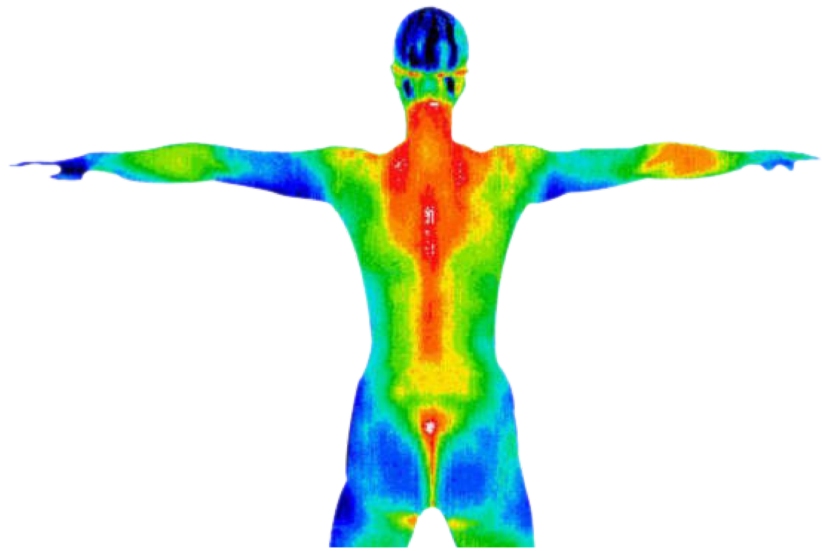
Levels vary by region and fluctuate with changes in atmospheric pressure

Internal Sources



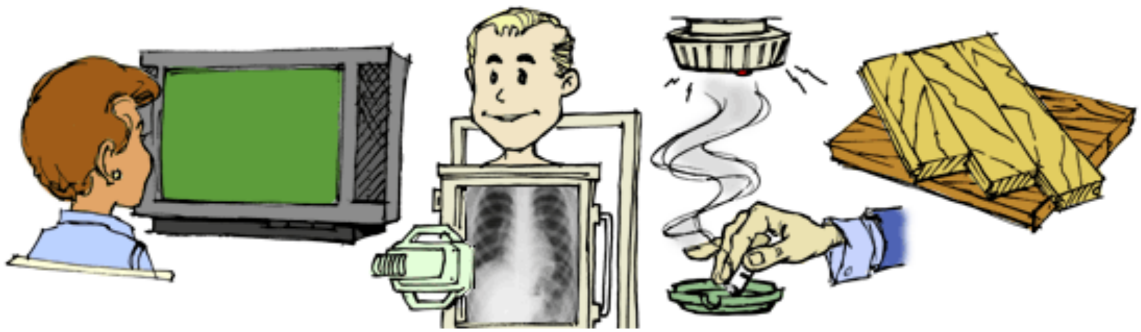
^{14}C, ^{40}K, ^{226}Ra

Bananas, Tobacco, Root Crops, Milk, etc.



Average Dose = 40 mrem/year

Man Made Radiation Sources



An average person being exposed to a man made sources will receive: **Approximately 330 mrem/yr**

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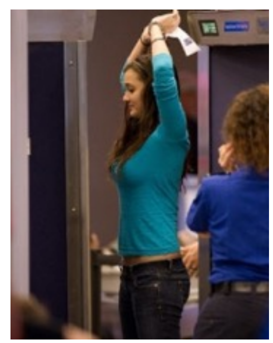
Consumer Products - Man Made Sources

- CT SCANS **(x-ray)**
- PET SCANS (short lived radionuclides)
- TV SETS **(bremsstrahlung)**
- NATURAL GAS **(radon)**
- AIRPORT X-RAYS
- SMOKE DETECTORS **(Am-241)**
- INCANDESCENT MANTLES **(Thorium-230)**
- FOOD/TOBACCO PRODUCTS **(K40, C14)**



Tc-99 Isotope Tracer for Medical Diagnosis

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RADIATION EXPOSURE & DOSE

From Natural Background Radiation

COSMIC	30 mrem/year
TERRESTRIAL	30 mrem/year
INTERNAL	40 mrem/year
RADON GAS	200 mrem/year

Each person will receive approximately

an **AVERAGE => 300 mrem/year**

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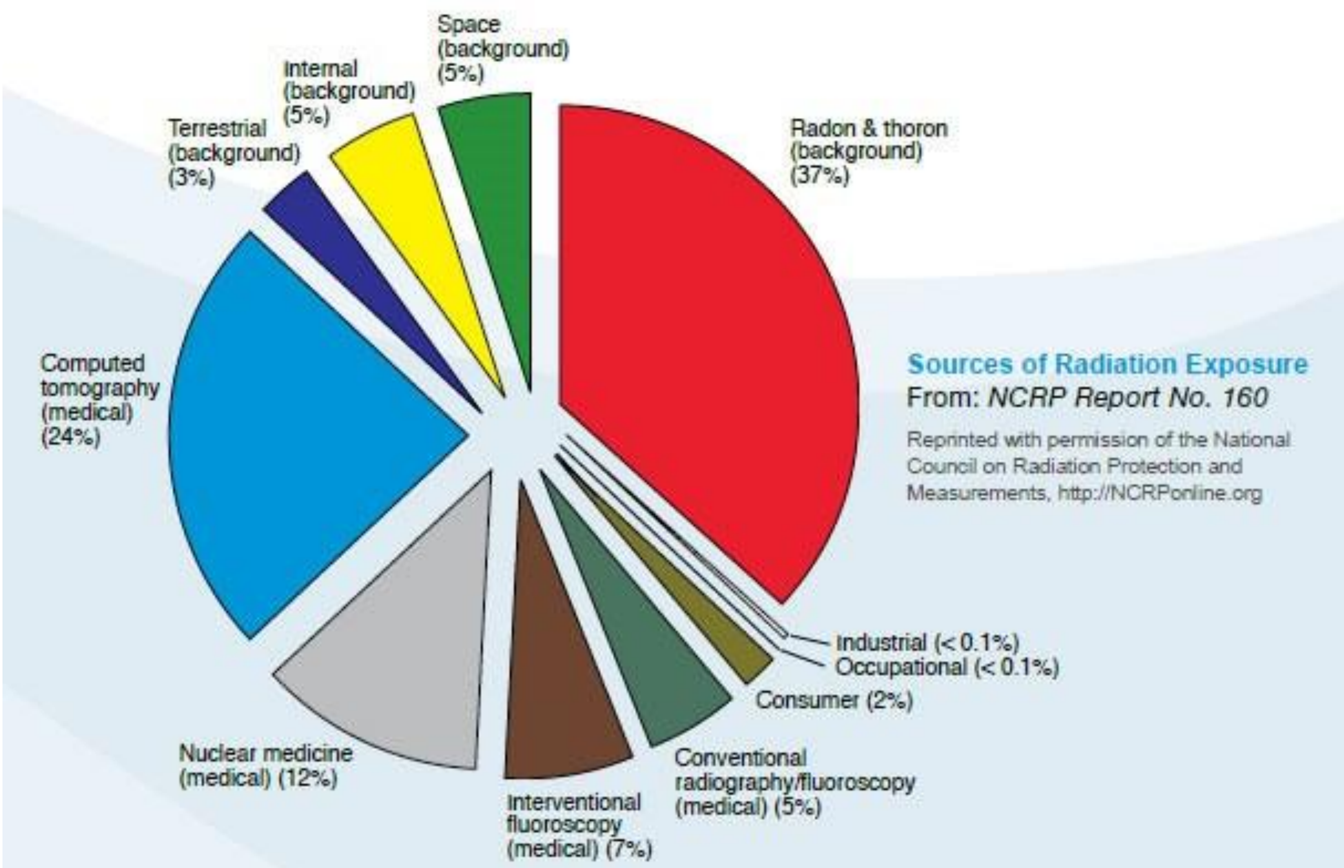
General U.S. Population Dose

NATURAL BACKGROUND
~ 300 mrem/year

MAN MADE SOURCES
~ 330 mrem/year

630 mrem/year is expected to be the average radiation dose a person will receive in a year just by going about everyday life.

Radiation Exposure In Daily Life



Maximum Possible Exposure an "Authorized User" Could Receive In a Year

Average Human receives	630 mrem
NRC Unmonitored =<	500 mrem
Total Possible	1130 mrem

NRC Requirements for whole body radiation worker before noticeable effects is 5 rem or 5000 mrem.

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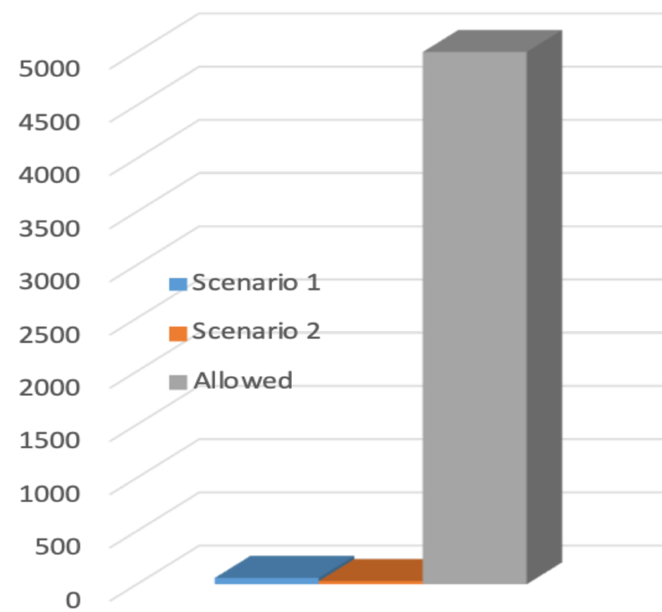
Annual Occupational Exposure Compared to Average Background Exposure

If an "Authorized User" is trained properly and:

Scenario #1:
If exposed twice/week for 16 hours X 50 weeks the result be an approximate annual dose of 50-60 mrem

Scenario #2:
If exposed once a month for 8 hours the result would be an approximate annual dose of 10-20 mrem



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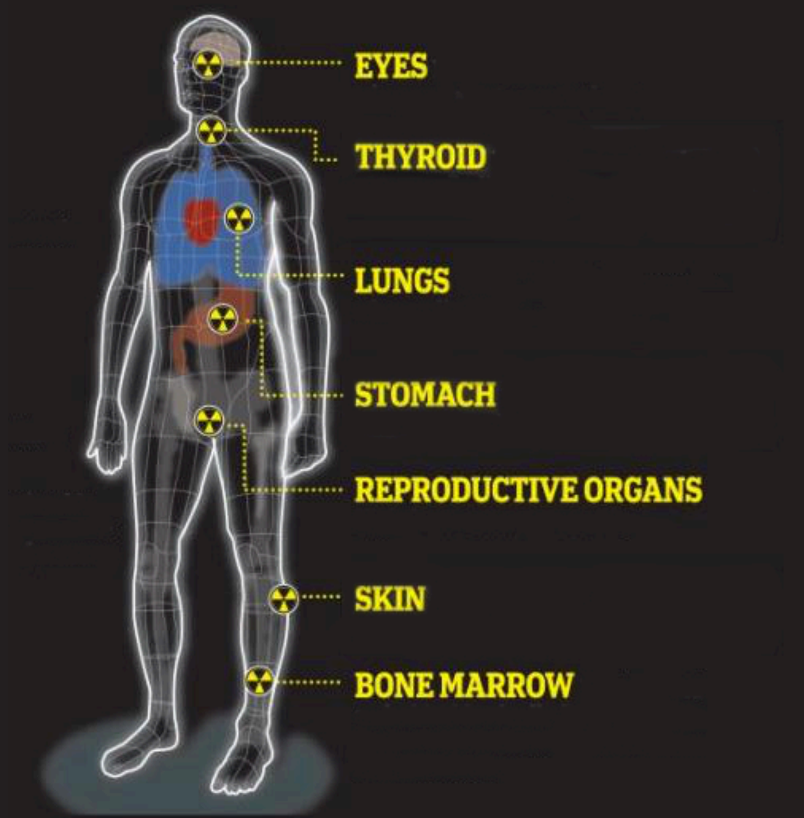
BIOLOGICAL EFFECTS & RISK

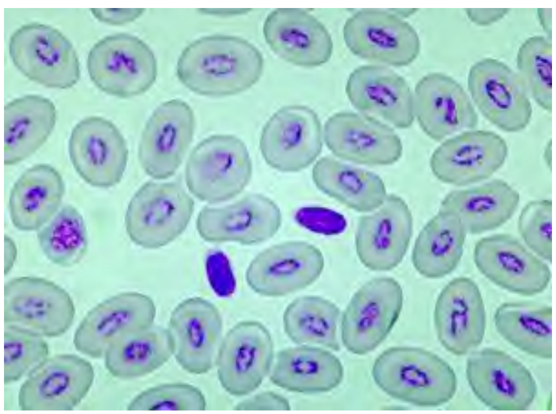


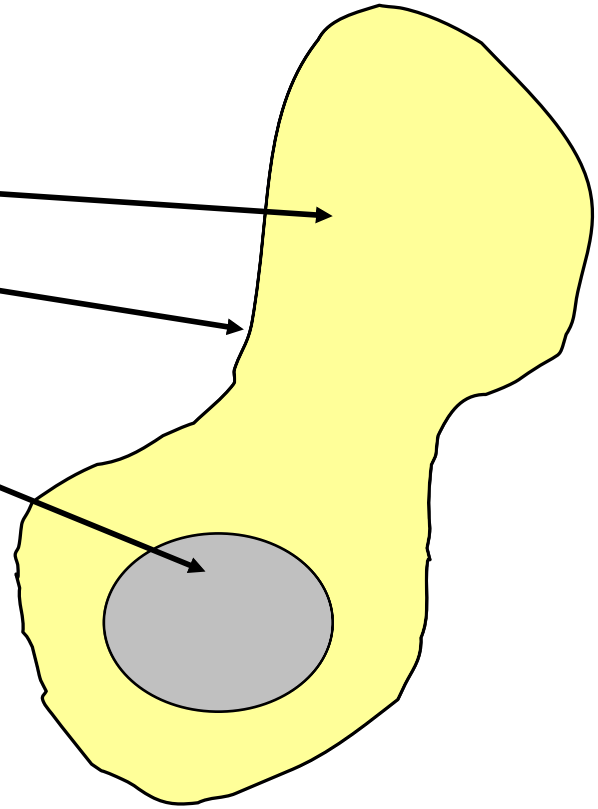
Biological Effects

- Historical study groups have learned from the following:
  - Early scientists and workers
  - 100,000 Survivors of Hiroshima and Nagasaki
  - U.S. Military experiments
  - Chernobyl survivors
  - Patients receiving therapeutic and diagnostic treatment

Radiation-Induced Cell Damage

- Protoplasm
- Cell Membrane
- Nucleus

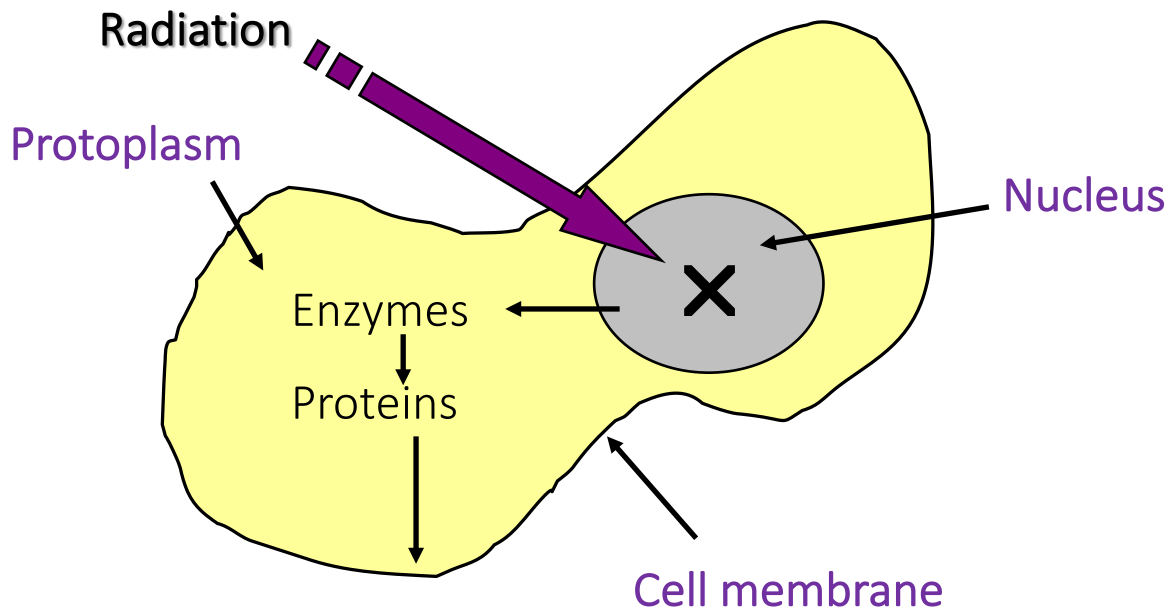




Radiation-Induced Cell Damage

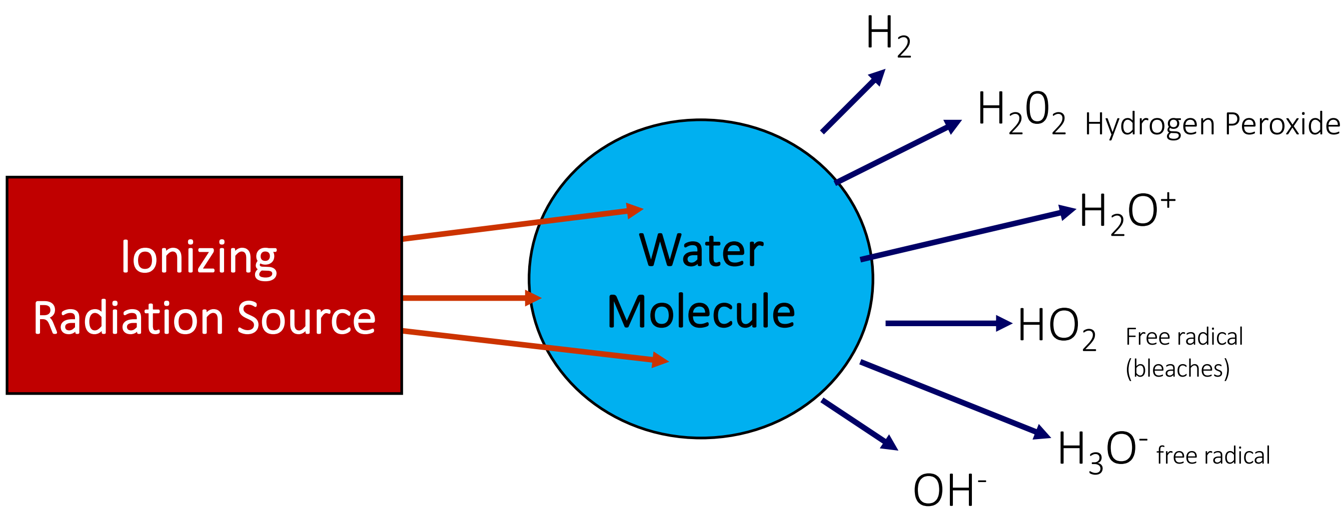
Damage severity depends on whether the radiation strikes a vital (nucleus) or non-vital (protoplasm) part of the cell.

Note: Three main parts of the cell: nucleus, protoplasm and the cell membrane



Radiation-Induced Cell Damage

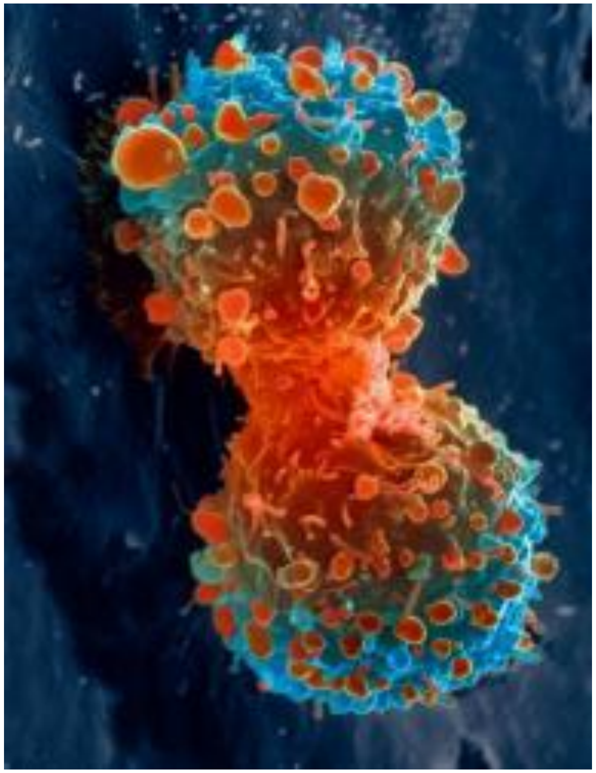
- H_2O molecules make up human cells. Indirect radiation damage caused by ionization of chemicals in these molecules which may kill or damage the host cell. Damaged cells die when chemical properties are changed from water to a bleach or peroxide by free radicals.



RADIATION SOLUTIONS

Cell Sensitivity to Radiation

- Rapidly dividing cells or active cells are more sensitive to radiation damage.
  - Examples of these cells are blood forming cells, intestinal tract lining cells, hair follicles, and reproductive cells.
  - Fetus to young adults of 18 yrs.
- Cells that divide slowly are more specialized and not as sensitive to radiation damage (i.e. brain or muscle cells).



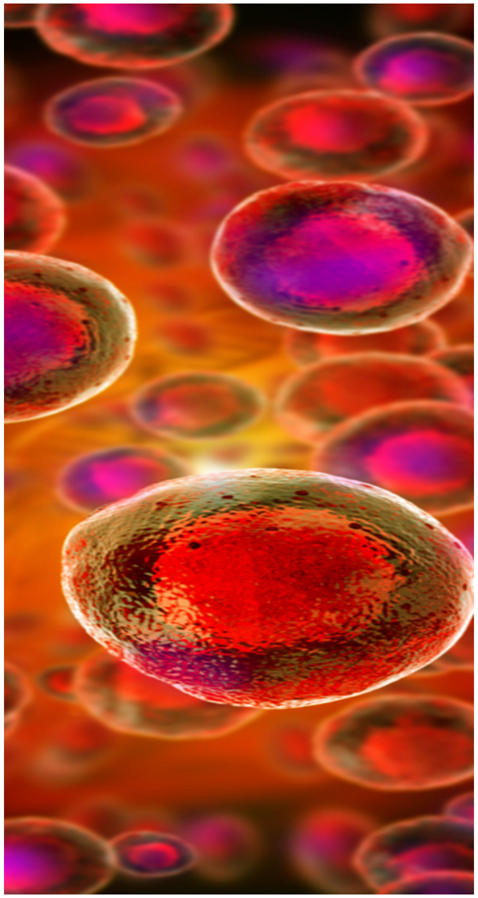
Possible Effects of Radiation on Cells

Ionizing radiation may have four possible effects on human cells

1. No damage produced
2. Cells are damaged, but repair themselves
3. Cells are damaged, improperly replicate (i.e. cancer)
4. Cells die as a result of damage

The extent of biological damage is dependent on:

1. Type of radiation
2. Acute or chronic dose
3. Radiosensitivity of the exposed tissue



Acute vs. Chronic Radiation Dose

RADIATION SOLUTIONS

The manner in which radiation exposure occurs determines the extent of cell damage.

- **Chronic Exposure:** low levels of radiation exposure over long periods
- **Acute Exposure:** high levels of radiation exposure in short periods of time

Acute Radiation Exposure

- Not a problem when large doses are localized and controlled

  (used to treat tumors, skin cancer, etc.)
- Acute whole body exposures can be serious and lethal
  - Causes massive cell damage
  - Body can't repair damaged cells
  - Physical effects such as reduced blood count and hair loss may occur

Effects of Acute Exposure

REM	Effects
0-5	No Detectable Effect
5-50	Slight Blood Changes
50-100	Blood Changes, Nausea
100-200	Blood Changes, Nausea, Vomiting
200-450	Hair Loss, Severe Blood Changes, Some Deaths
450-700	Lethal to 50% within 1 Month
700-1000	Probable 100% Death Within 1 Month
5000	Immediate Incapacity, Death Within 1 Week

Probability of an Acute Dose from Gauges

- Low risk ***if proper procedures are followed*** using ALARA principles

- NDG and IPG example:
  10 mCi Cs-137 source: You will have a dose rate of approximately **32.6 rem/hr** at near-contact **(i.e. 6")** from the source during routine maintenance, shutter checks and inventory.

- The dose would be localized

Radiation Risk

- On average, 25% of the general population will have cancer at some time during their lifetime

- Risk calculations have been derived from individuals who were exposed to **high levels** of radiation

- 1 Rem (1000 mrem) of radiation increases the risk of cancer by just 0.03%

There is no direct evidence of increased risks from exposure to low levels of radiation

Comparative Risks

Health Risk	Est. life expectancy lost
Smoking 20 cigs a day	6 years
Overweight (15%)	2 years
Alcohol (US Ave)	1 year
All Accidents	207 days
All Natural Hazards	7 days
Occupational dose (300 mrem/yr)	15 days
Occupational dose (1 rem/yr)	51 days

Industry type	Est. life expectancy lost
All Industries	60 days
Agriculture	320 days
Construction	227 days
Mining and quarrying	167 days
Manufacturing	40 days
Occupational dose (300 mrem/yr)	15 days
Occupational dose (1 rem/yr)	51 days

These are estimates taken from the NRC Draft guide DG-8012 and were adapted from B.L Cohen and I.S. Lee, "Catalogue of Risks Extended and Updates", Health Physics, Vol. 61, September 1991.

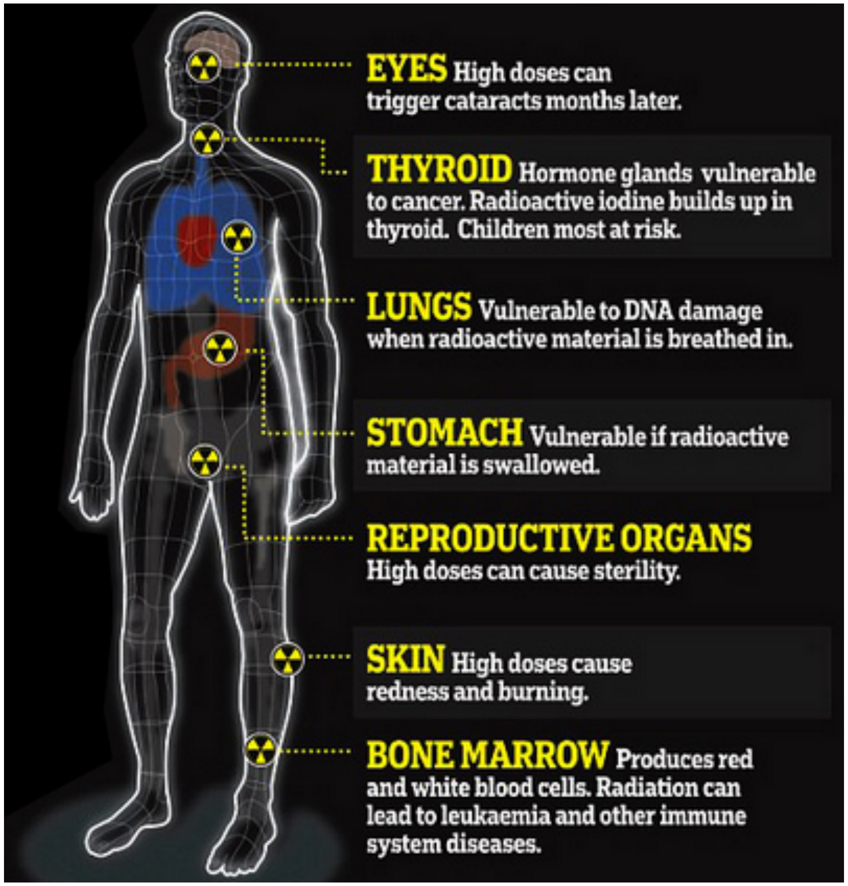
RADIATION SOLUTIONS

Exposure (Dose) Limits

Dose Limits are Set by NRC 10 CFR 20.1201

• Whole Body	5 rem/yr
• Extremities	50 rem/yr
• (Specific) Organ/Tissue	50 rem/yr
• Lens of Eye	15 rem/yr
• Pregnant Worker	500 mrem/gestation
• Visitors/Public	0.1 rem/yr. or 100 mrem

Whole Body Sensitivity Areas



RADIATION SOLUTIONS

Prenatal Radiation Exposure

- Developing embryo/fetal cells are rapidly dividing and very sensitive to radiation or other environmental factors (cigarettes, alcohol, drugs, etc.)

- Children in Japan who were exposed to radiation before birth showed birth defects:
  - 10% lower birth weight
  - 10% lower IQ

- To be prudent, strict limits are set for pregnant females – however, the risk from radiation effects is minimal when compared to the normal risk of pregnancy.

RADIATION SOLUTIONS

Declared Pregnant Worker

- Worker must be **informed** of their right to DECLARE pregnancy & must **DECLARE** pregnancy in order to invoke exposure limits for the embryo/fetus

- 500 mrem for entire pregnancy (gestation period)

- The RSO must keep separate records for the embryo/fetus – “ Unborn child of…..”

Visitors and Members of the Public

- Includes any individual who has not been trained in Radiation Safety
- Limits are set at 100 mrem/year (dose) and at < 2 mrem in any 1 hr (dose)
- Any individuals 18 years or younger, allowed 10% of the limits as per 10 CFR 20.1207

As Low As Reasonably Achievable

"ALARA"

Requirement

- It is each individual's responsibility to ensure that their exposure is minimized
- Employer/management also have responsibility to ensure that an ALARA program is in place

RADIATION SOLUTIONS

Three Ways We Keep Dose Low

ALARA

Time

Distance

Shielding

RADIATION SOLUTIONS

Minimize Time

Dose Rate X **Time** = Dose

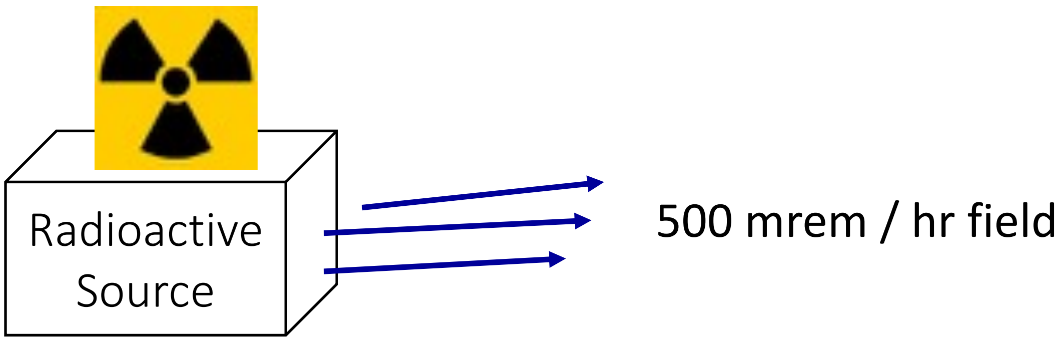
Less exposure time equals less dose

Methods for Minimizing TIME

- Reducing the amount of time in a field of radiation will lower the dose received by the workers
  - Pre-plan tasks thoroughly prior to working. Identify the hazards and mitigations.
  - Use only the number of workers actually required to do the job.
  - When transporting the gauge, take the most direct route to the job site.
  - Never loiter in any radiological areas (including around the gauges).
  - Work efficiently and swiftly.
  - Do the job right the first time.
  - Perform as much of the preparation work as possible prior to using the gauge

RADIATION SOLUTIONS

Minimize Time



- In a 500 mrem/hr field a person would receive a dose of:
  - 500 mrem/hr X .25hr (15 min.) = 125 mrem
  - 500 mrem/hr X 0.5 hr (30 min.) = 250 mrem
  - 500 mrem/hr X 2.0 hrs = 1000 mrem (1 rem)

RADIATION SOLUTIONS

Methods for Maintaining DISTANCE from Sources of Radiation

- The worker should stay as far away as possible from the gauge during measurements.

- As a general guideline for work with the nuclear gauges, if you double your distance, the dose rate falls by approximately ¼ of the original dose.

- Be familiar with the radiological dose rates in the area where the nuclear gauges are operated or stored.

- During work delays, either move the gauges away from you or relocate yourself away from the gauges to lower dose rates.

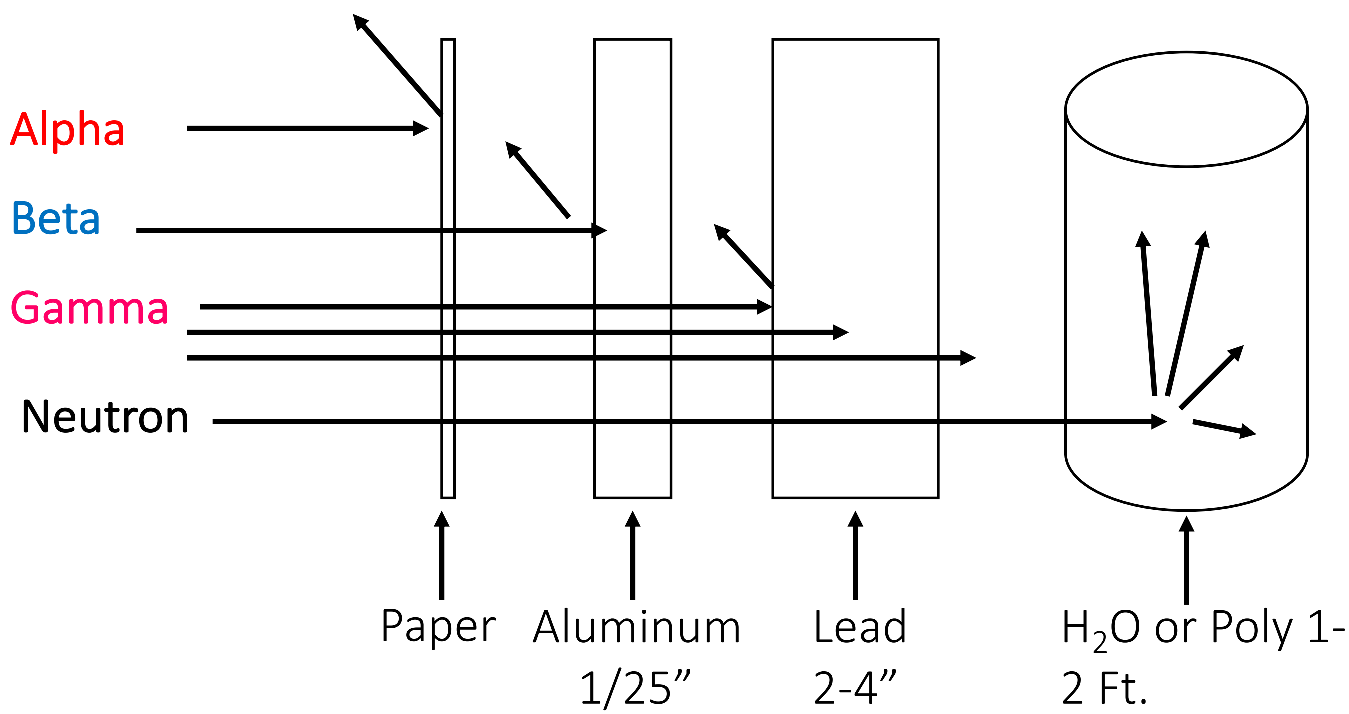
RADIATION SOLUTIONS

Methods for Maintaining Shielding

- Although NDGs are lightly shielded while in the **"safe"** position (source rod all the way up), they still emit significant radiation at close distances. Typical dose rates are 1-5 millirem at 1 ft. If there is any available shielding place yourself or the gauge behind a concrete wall, heavy equipment, etc.

- Temporary shielding (i.e. lead or concrete blocks) may be used to reduce dose rates during **"temporary"** storage or field use conditions

Relative Penetrating Power of Radiation and Types of Shielding



RADIATION SOLUTIONS

Radiation Monitoring & Dosimetry

RADIATION SOLUTIONS

Who Should Be Monitored?

Any individual member of the public who has the potential to receive >100 mrem/yr. OR > 2 mrem in any one hour needs to have a minimum of radiation awareness training

AND

Any radiation worker who has the potential to receive > 500 mrem/yr. is required to have dosimetry

RADIATION SOLUTIONS

No-Dosimetry

- If you choose not to use a dosimeter to monitor authorized users (Radiation Workers) you will need proof of dose calculations.

INSTEAD…

- RSO's will use and document historical dose rate measurements and time study calculations to demonstrate that an individual *Radiation Worker* will not exceed 500 mrem/yr (10% of 10 CFR 20 limit of 5 rem (5000 mrem or 5 rem)

- If not, they are required to have dosimetry

Personnel Dosimetry – TLD

Thermo-Luminescent Dosimeters (TLD)

- Crystalline materials with impurities that capture deposited energy from radiation
- When processed, they give accurate indication of the radiation dose received
- Sensitive to Beta, Gamma and Neutron

Personnel Dosimetry – Film Badge

- Use photographic film encased in a badge
- Film is darkened by radiation
- Darkening of the film is proportional to radiation received
- Sensitive to Beta and Gamma

Not the most effective measurement as they are sensitive to light and requires quarterly interval read outs.

Digital Dosimeters (self reading)

- It is a battery-powered, direct-reading dosimeter
- By pushing a button, the dosimeter reads out exposure in mrem
- It also gives an audible “chirp” when exposure is high
- It measures radiation dose in real time. Know it now.
- Can be set to alarm at a specific dose rate or when stay time limit is reached
- Can be set to “chirp” at a specified dose accumulation (i.e. every 1 mrem received)
- Relatively expensive

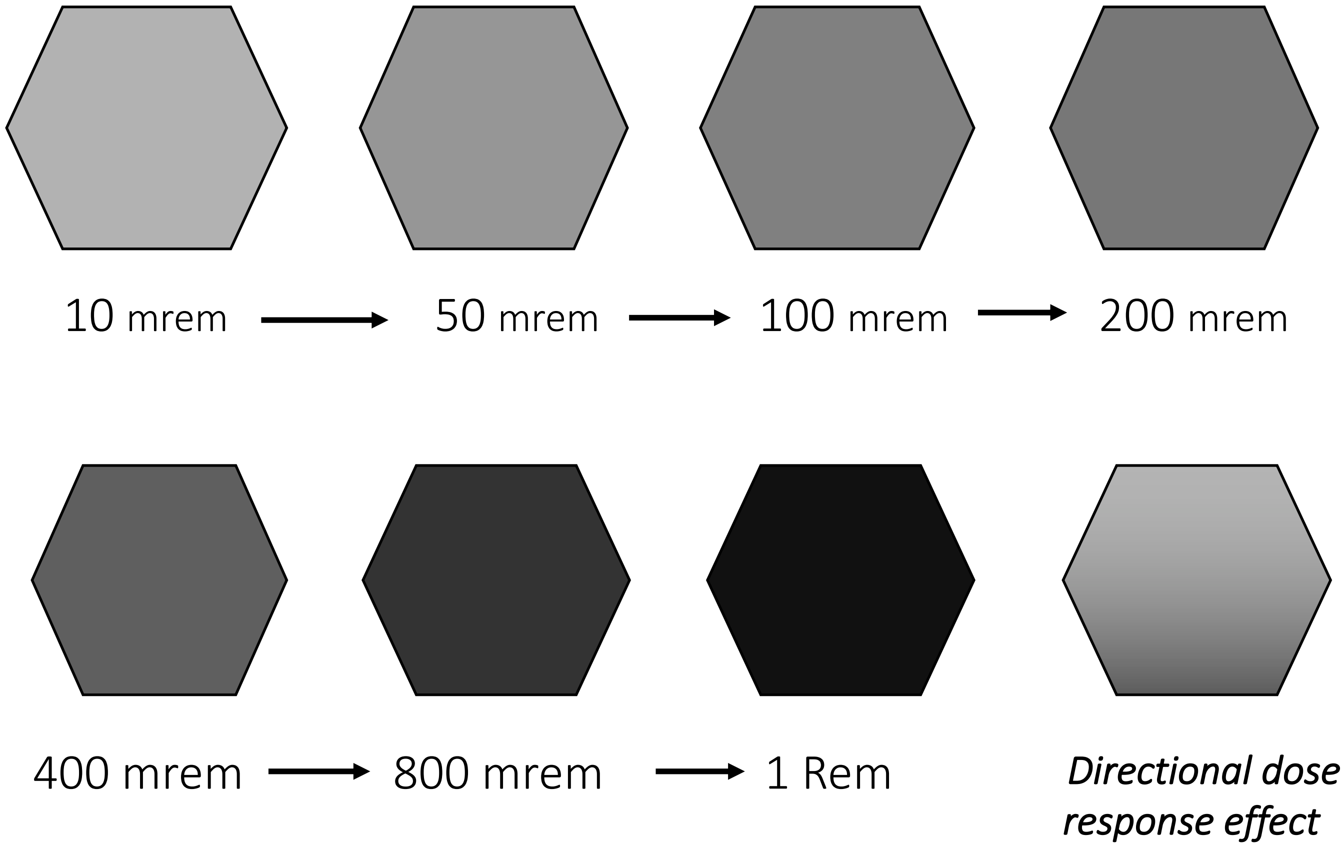
Note: This is the preferred type of dosimeter. It gives you immediate information, is not easily influenced by light, and only needs to be calibrated once a year.

Dosimetry – Do's and Don'ts

- **DO** - Wear dosimeter face out between belt and neck on front of body
- **DO** - Store away from radiation
- **DO** - Handle with care: no excessive heat, washing, or opening case
- **DO** - Report missing or damaged dosimeters to RSO immediately
- **DON'T** - EVER wear another person's dosimeter

RADIATION SOLUTIONS

Film Badge Darkening Effect



RADIATION SOLUTIONS

Radiation Detection Instruments

- Radiation detection instruments provide a critical protective means to determine radiation dose and dose rates in the performance of work activities and for safe transport and storage of radioactive material.
- Federal & State regulations require that the Licensee **"have available"** adequate radiation monitoring instruments suitable for the type and activity of radiation to be monitored.
- Instruments must be maintained in good working condition and periodically (usually every 12 months) calibrated.

RADIATION SOLUTIONS

Radiation Detection Instruments

RADIATION DOSE RATE METERS
(mRem/hr)

CONTAMINATION SURVEY METERS
(CPM)

Whole Body Counter (Internal Monitoring)

Reports total radioactivity of the body and presents a complete breakdown of all detected nuclides and their activities.

RADIATION SOLUTIONS

Contamination Monitoring Leak Tests

Leak Test Requirements

- Check for leakage (contamination) from a sealed source
- Usually required every 3 to 6 months (portable gauges)
- 36 months for fixed gauges
- RSO or service provider must be approved in the license to do tests
- Counting equipment must have detection capability of < 0.005 of a microcurie

- Should be identified in the license
- Test frequency is dependent on the license condition or the Sealed Source Device Registration

RADIATION SOLUTIONS

Radiation Dose Records

CODE OF FEDERAL REGULATIONS

- 10 CFR Part 20 requires that individual occupational dose records OR dose estimates be maintained by the employer for each worker including:
  - Previous, external, and internal dose
  - Dose assessment/reconstruction reports

SAFETY RESPONSIBILITY

Worker's Responsibilities

- Be aware of POSTINGS and the external radiation fields to which they and members of the public could be exposed

- Be aware of and take the corrective action required to minimize risk of contamination from radioactive materials and sources

RADIATION SOLUTIONS

Worker's Responsibilities

- Know and be prepared to take emergency control measures in the event of damage or malfunction of the gauge.
- Take measures to minimize dose in accordance with ALARA principles.
- Report other occupational and/or medical radiation exposure to your employer/RSO.
  - Necessary in order for dose evaluations & estimates to be accurate and complete
  - Radiation exposure from medical applications are exempt from occupational dose limits but the RSO may need to take this into consideration for ALARA purposes

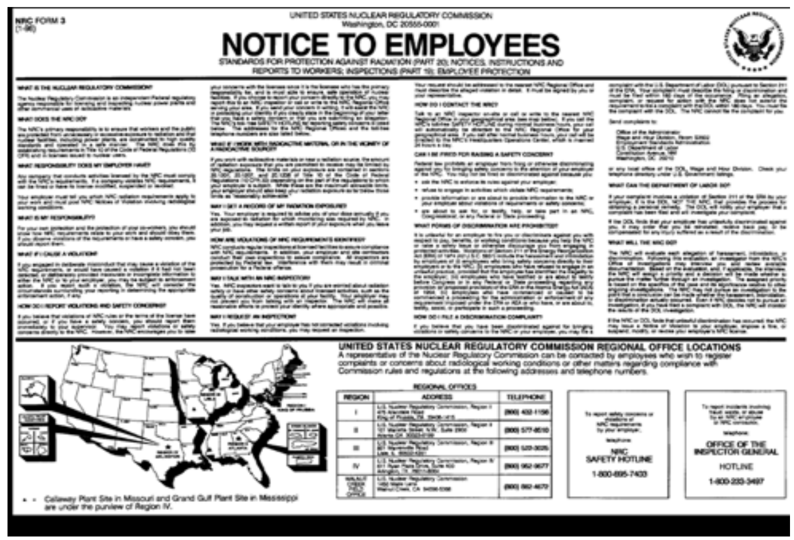
Management's Responsibilities

- Maintain dose records for each monitored worker OR approved dose estimates for unmonitored workers
- Must provide the necessary support, training, resources, recognition, and authority to RSO and workers
- Must provide timely response to, and implementation of, corrective actions to deficiencies, incidents, and/or audit findings.

Whistleblower Protection

- Management is required to support the RSO and workers in correcting legitimate radiation safety concerns and cannot implement illegal retaliatory actions such as job termination, reassignment, wage reductions, or similar actions to suppress or hide compliance to NRC or Agreement State requirements

Detailed rights are provided on the "Notice To Employees" posting


NRC FORM 3

UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, DC 20555-0001

NOTICE TO EMPLOYEES

STANDARDS FOR PROTECTION AGAINST RADIATION (PART 20); NOTICES, INSTRUCTIONS AND REPORTS TO WORKERS; INSPECTIONS (PART 19); EMPLOYEE PROTECTION

UNITED STATES NUCLEAR REGULATORY COMMISSION REGIONAL OFFICE LOCATIONS

RSO Responsibilities

- The Radiation Safety Officer (RSO) is required to:
  - Have required training and experience and ability to safely manage and control the radioactive material the company is licensed to possess
  - Ensure that procedures, training and audits are performed in a compliant manner for the Radiation Safety Program
  - Responsible for all records and documentation pertaining to radiation equipment and radiation workers
  - Have primary oversight of ensuring compliance with the radioactive materials license conditions
  - Have Primary reporting responsibilities to Federal/State for any incidents involving the licensed material

Summary

It is the mutual responsibility of management, the trained and authorized individual worker, and the RSO to ensure that appropriate radiation safety and compliance to license conditions are maintained in the workplace.

RADIATION SOLUTIONS

THE END

You are now required to take the exam and pass with an 80% or better score.