Basic Radiation Safety Awareness Training

Outline

History of Radiation

Natural & Man-Made Background Sources of Radiation

Fundamentals

Exposure Limits & Regulations

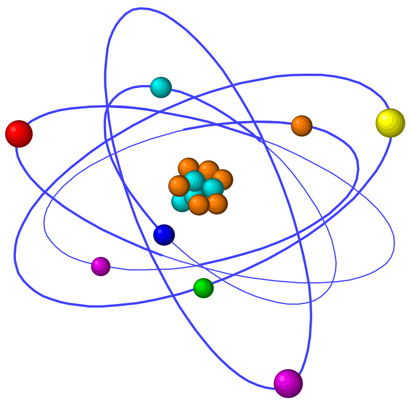
Detection of Radiation

Safe Practices with Radiation

Biological Effects of Radiation

Where to Find Further Information

What is Radiation?



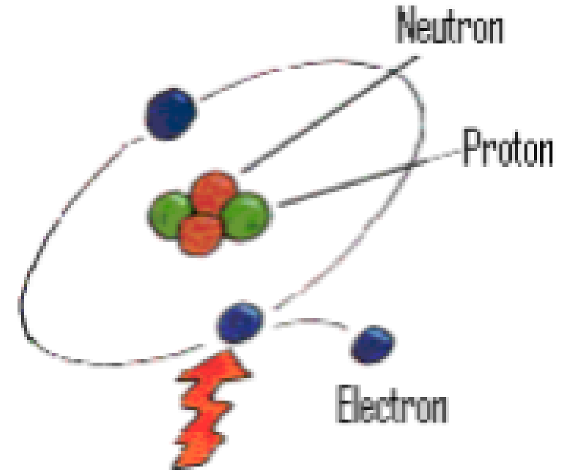
Radiation: energy in motion

Radioactivity: spontaneous emission of radiation from the nucleus of an unstable atom

Isotope: atoms with the same number of protons, but different number of neutrons

Radioisotope: unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. Approximately 5,000 natural and artificial radioisotopes have been identified

Types of Radiation



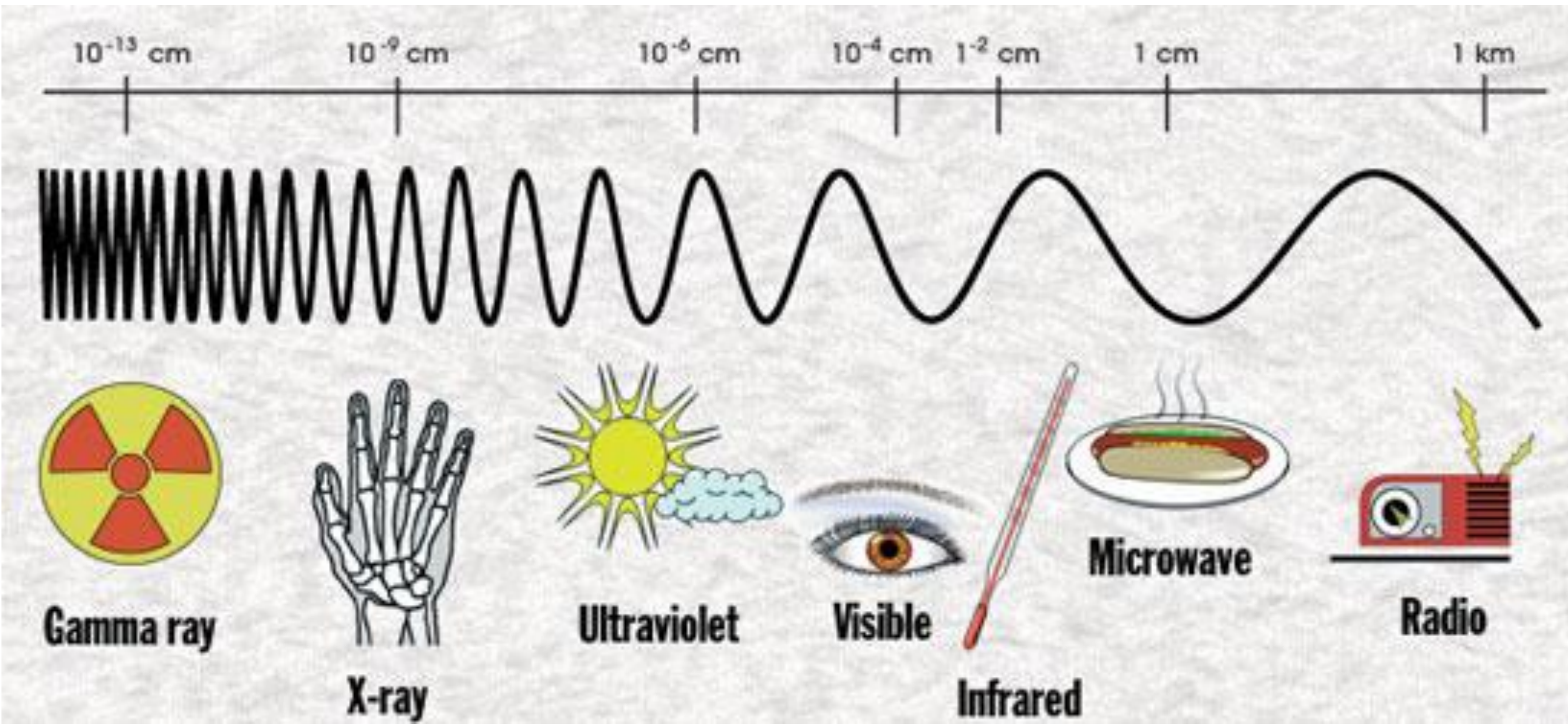
▪**<u>Non-Ionizing Radiation</u>**: Radiation that does not have sufficient energy to dislodge orbital electrons.

Examples of non-ionizing radiation: microwaves, ultraviolet light, lasers, radio waves, infrared light, and radar.

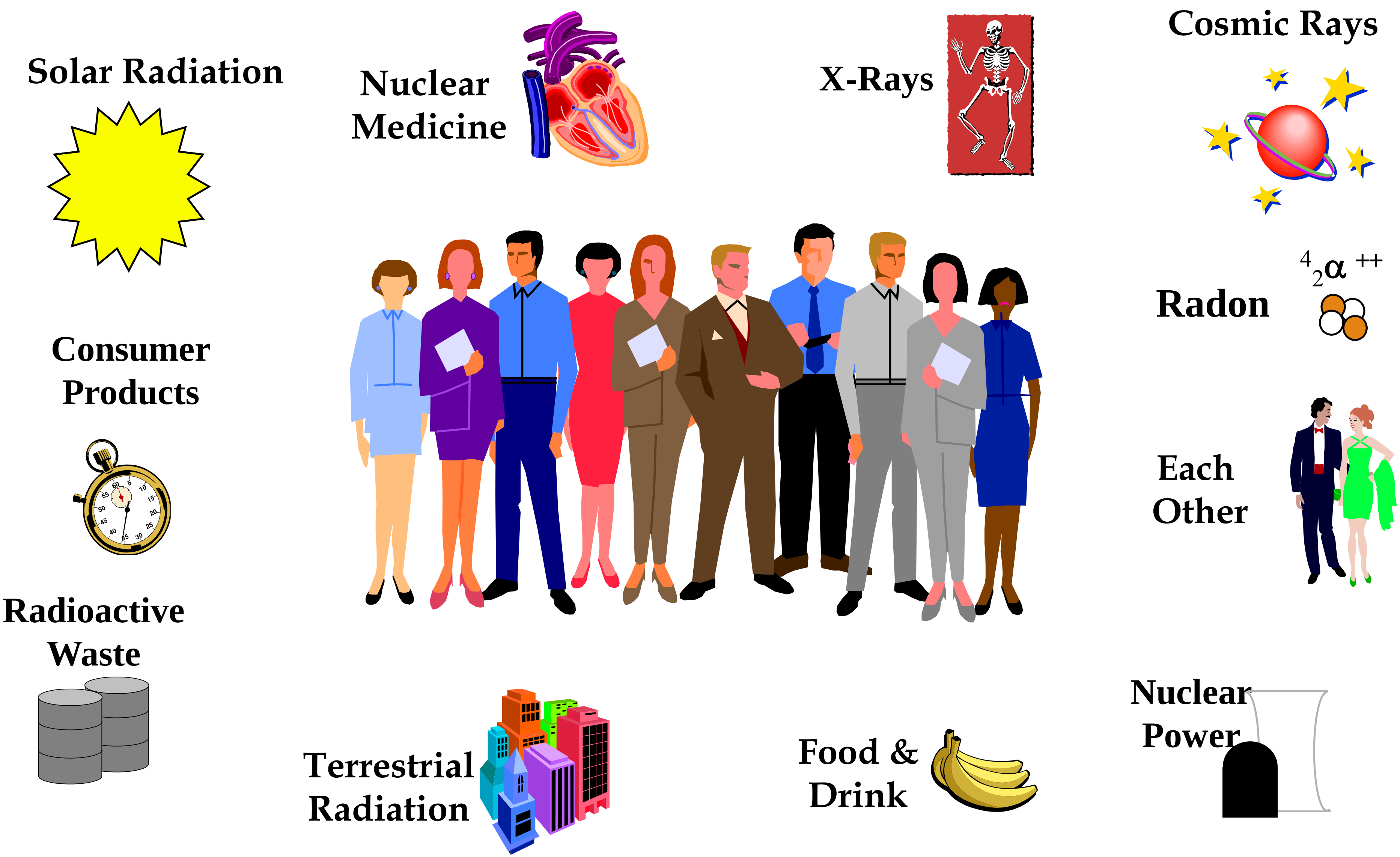
▪**<u>Ionizing Radiation</u>**: Radiation that has sufficient energy to dislodge orbital electrons.

Examples of ionizing radiation: alpha particles, beta particles, neutrons, gamma rays, and x-rays.

Radiation Spectrum



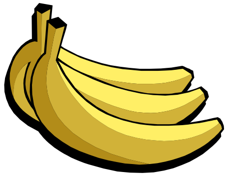
RADIOACTIVE SOURCES



Terrestrial Radiation

Terrestrial radiation comes from radioactivity emitting from *Primordial radio nuclides* - these are radio nuclides left over from when the earth was created.

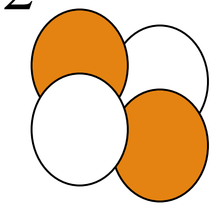
- Common radionuclides created during formation of earth:
  - Radioactive Potassium (K-40) found in bananas, throughout the human body, in plant fertilizer and anywhere else stable potassium exists.



  - Radioactive Rubidium (Rb-87) is found in brazil nuts among other things.

Terrestrial Radiation

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



Greatest contributor is ^{226}Ra (Radium) with significant levels also from ^{238}U, ^{232}Th, and ^{40}K.

- Igneous rock contains the highest concentration followed by sedimentary, sandstone and limestone.
- Fly ash from coal burning plants contains more radiation than that of nuclear or oil-fired plants.

Let's Compare Backgrounds

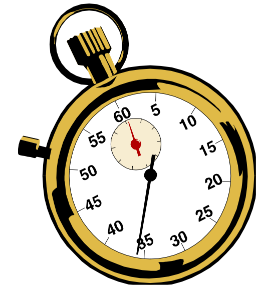
Sea level - 30 mrem/year

from cosmic radiation

10,000 ft. altitude - 140 mrem/year

from cosmic radiation

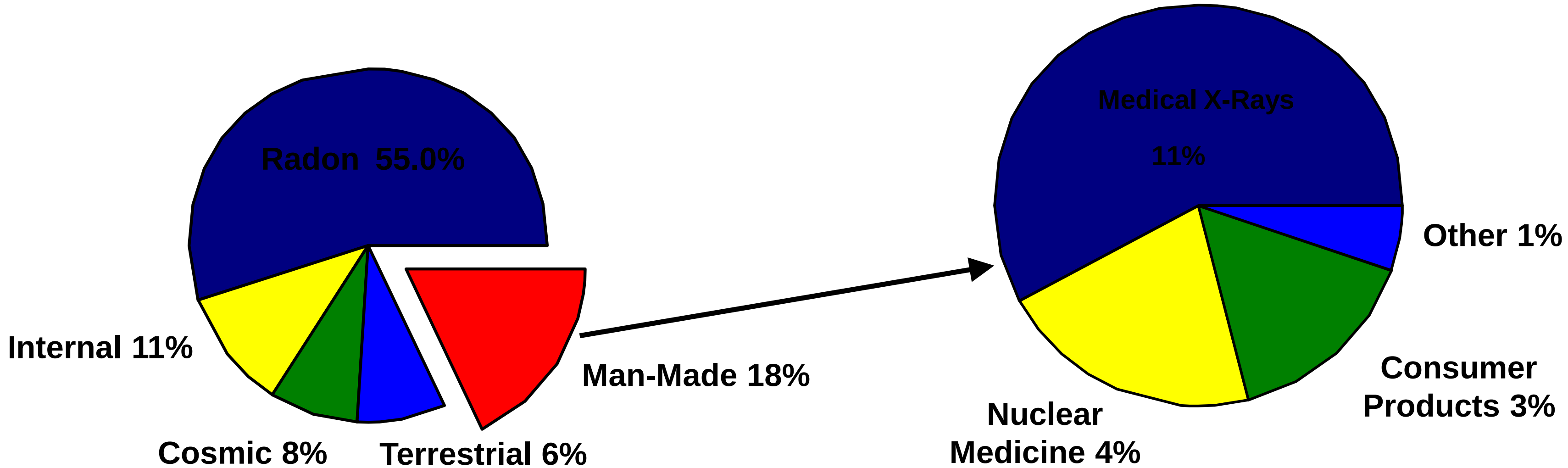
Consumer Products and Radioactive Material



- There are more sources of radiation in the consumer product category than in any other.
  - Television sets - low energy x-rays.
  - Smoke detectors
  - Some more products or services: treatment of agricultural products; long lasting light bulbs; building materials; static eliminators in manufacturing; and luminous dials of watches, clocks and compasses

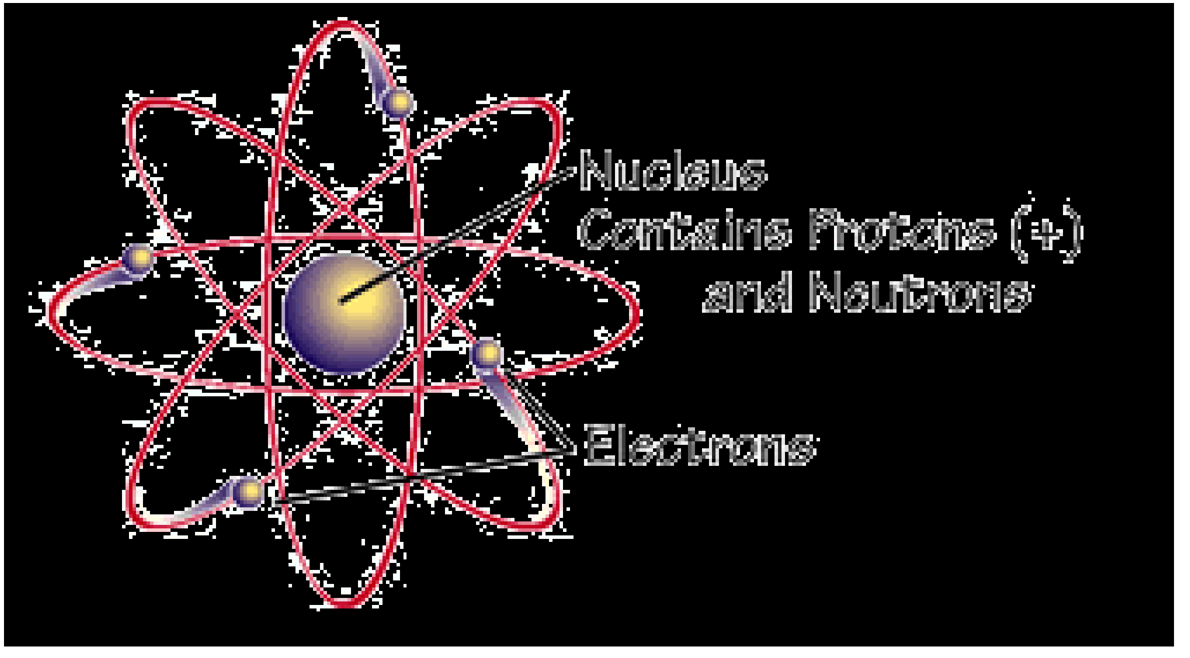
Annual Dose from Background Radiation

Total exposure / Man-made sources



Total US average dose equivalent = 360 mrem/year

The Anatomy of the Atom



Ionizing radiation

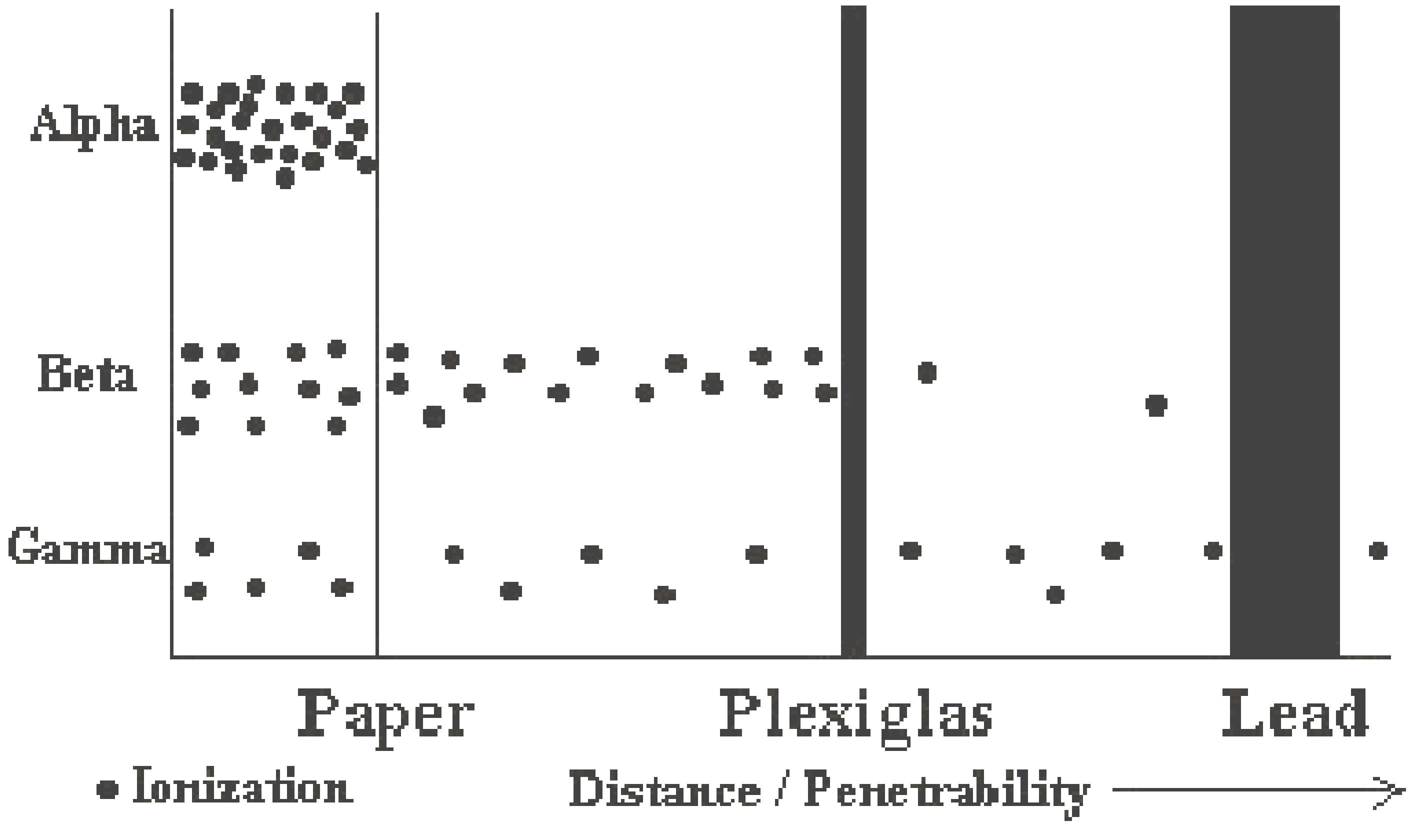
Occurs from the addition or removal of electrons from neutral atoms

Four main types of ionizing radiation

- alpha, beta, gamma and neutrons

α Alpha
β Beta
γ Gamma (X-ray)
n Neutron

Linear Energy Transfer



ALARA

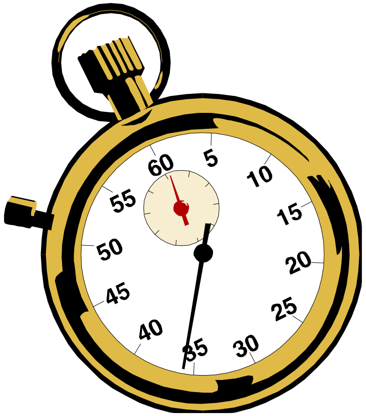
As **L**ow **A**s **R**easonably **A**chievable

How?

- Time
- Distance
- Shielding

Why?

- Minimize Dose



- Less time = Less radiation exposure
- Use RAM only when necessary
- Dry runs (without radioactive material)
  - Identify portions of the experiment that can be altered in order to decrease exposure times
- Shorten time when near RAM
- Obtaining higher doses in order to get an experiment done quicker is NOT “reasonable”!

Distance

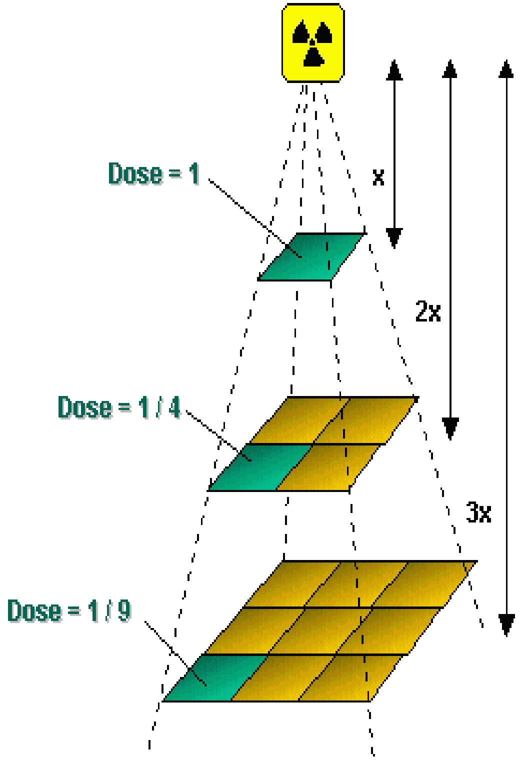
Effective & Easy

Inverse Square Law

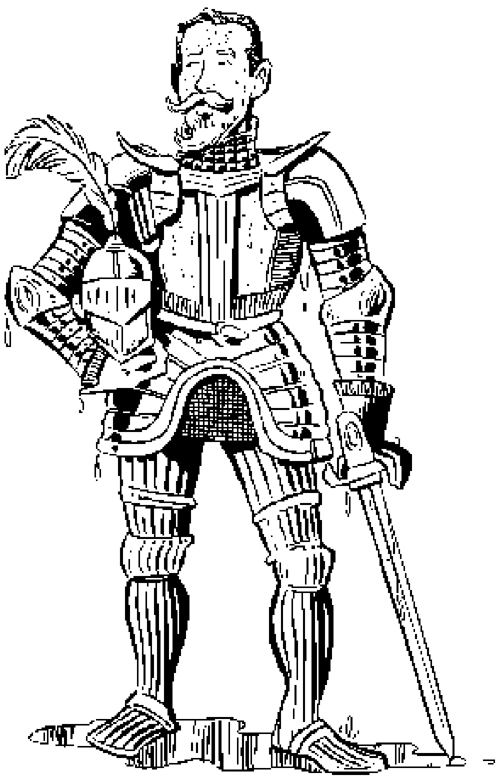
- Doubling distance from source, decreases dose by factor of four
- Tripling it decreases dose nine-fold

More Distance = Less Radiation Exposur

Tongs, Tweezers, Pipettes, Pliers



Shielding

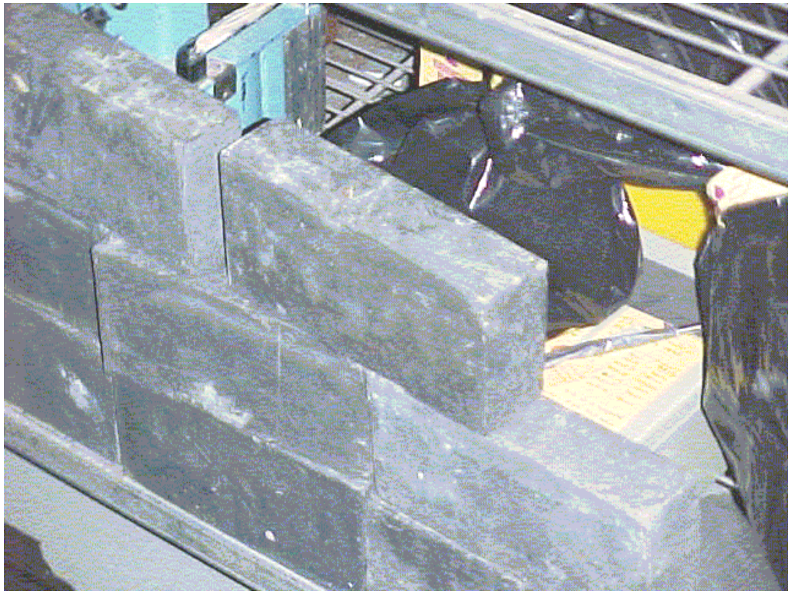


Materials “absorb” radiation

Proper shielding = Less Radiation Exposure

Plexiglass vs. Lead

Shielding Examples

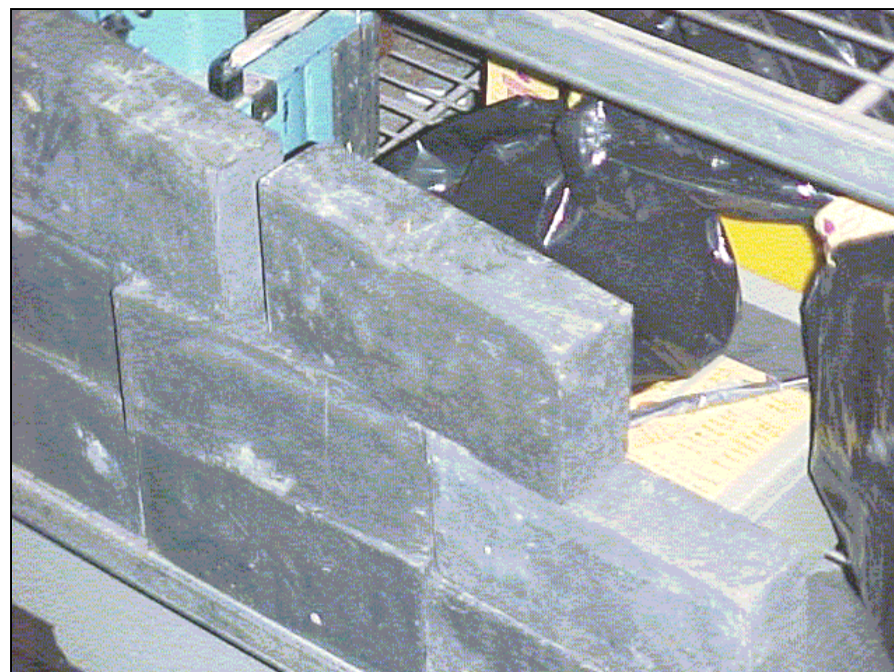


Radiation Shielding

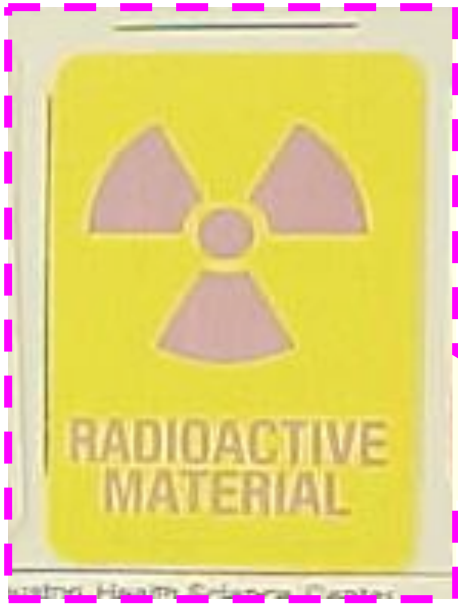
- **Shielding used where appropriate**
- **Significantly reduces radiation effects**

Plexiglas

Lead



Radiation Postings



- Radiation use will be labeled on door, work area & storage area
- Research laboratories work with very low levels of radioactive materials
- Safety can check for potential contamination prior to work in a lab that uses radioactive materials
- As a precaution: wear gloves, safety glasses and wash hands

Inappropriate Lab Attire

Appropriate Lab Attire

Lab coat

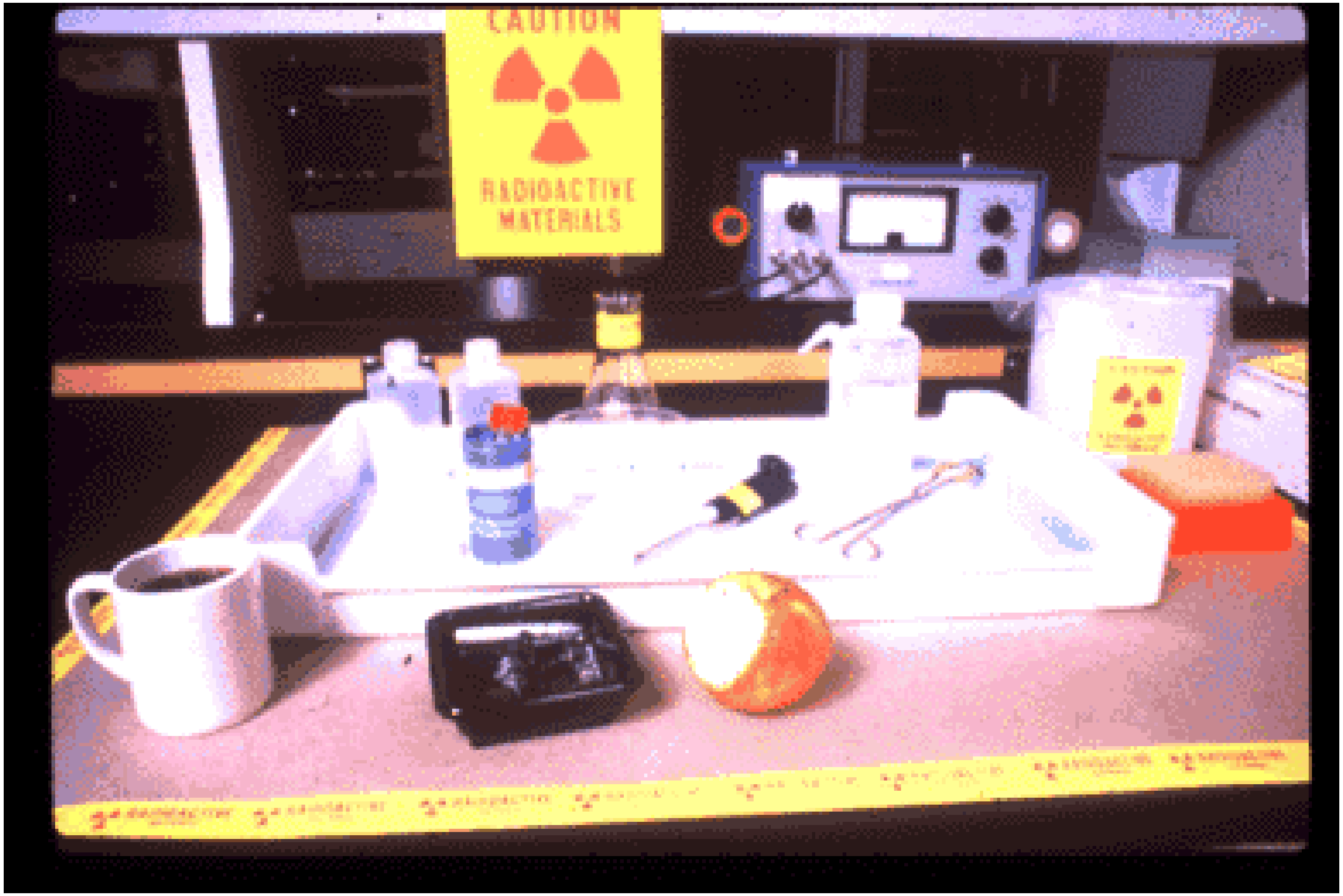
Eye protection

Closed toe shoes

Personnel monitoring

Gloves

Route of Entry for Exposure



Laboratory Wipe Tests

Fill out form RS-8

Draw map of laboratory

Take wipes of surfaces (10 cm^2) throughout lab

Run wipes monthly for possible contamination

Document all information on form and place in Radiation Safety Binder

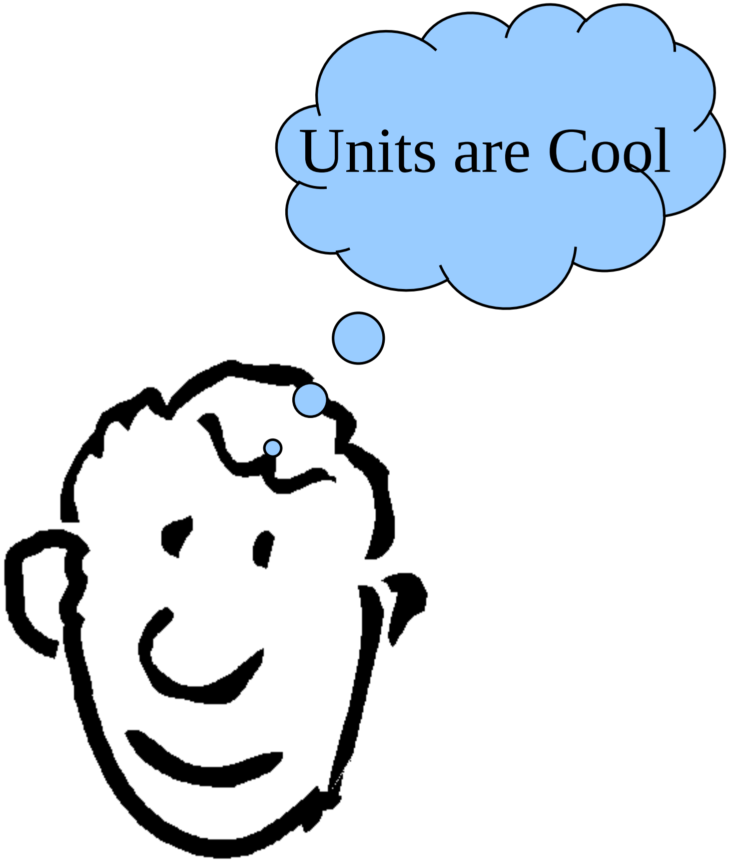
Common Units

Radioactivity

Exposure

Absorbed Dose

Dose Equivalent



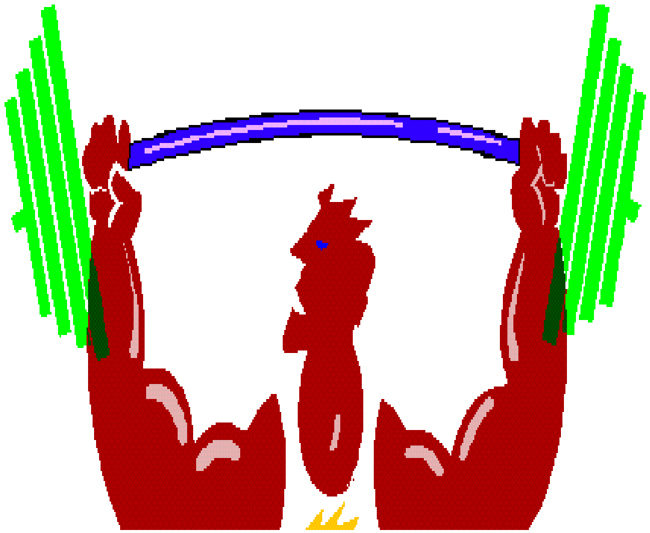
Radioactivity

Rate of Decay / Potential to Decay

"Strength"

Curie (Ci) - 1 gram of radium disintegrates

3.7×10^{10} disintegration/ (dps)



Becquerel (Bq)

= 1 disintegration/second (dps)

1 mCi = 37 MBq

Exposure

Radioactivity is measured in Roentgens (R)

Charge produced in air from ionization by gamma and x-rays

- ONLY for photons in air
- Rather infrequently used unit

A measure of what is emitted

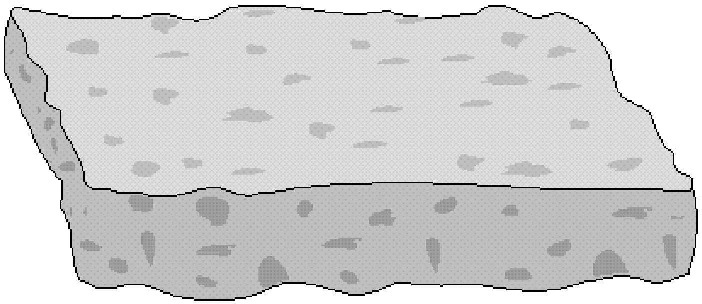
Absorbed Dose

Energy deposited by any form of ionizing radiation in a unit mass of material

Roentgen Absorbed Dose (rad)

Gray (Gy)

1 Gy = 100 rad



Dose Equivalent

Scale for equating relative hazards of various types of ionization in terms of equivalent risk

Damage in tissue measured in rem

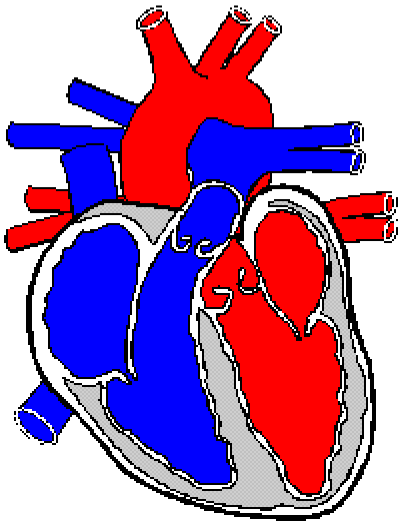
- (Roentgen Equivalent Man)

Q:risk of biological injury

rem = Q * rad

Sievert (Sv)

1 Sv = 100 rem



What do we really need to know?

$1\ R \approx 1\ rad = 1\ rem$

- For gammas & betas*

$1\ rad \neq 1\ rem$

- For alphas, neutrons & protons
- 1 rem = 1 rad * Q

And why do we want to know it?

Dosage and dosimetry are measured and reported in rems.

All the Federal and State regulations are written in rems.

The regulators must be placated with reports in rems.

Annual Radiation Exposure Limits

Occupationally Exposed Worker:

	rem	mrem
Whole body	5	5000
Eye	15	15,000
Shallow	50	50,000
Minor	0.5	500
Pregnant Worker	0.5*	500*
		*9 months

General Public: 100 mrem/year or 2mrem/hour

Why Establish Occupational Exposure Limits?

We want to eliminate ability of

non-stochastic effects (Acute) to occur

- Example: Skin Reddening

We want to reduce the probability of the occurrence of

stochastic effects (Chronic)

to same level as other occupations

- Example: Leukemia

- **Established from Accident Data**

Whole Body

Total Effective Dose Equivalent (TEDE)

TEDE = Internal + External

Assume Internal Contribution Zero

- Unless Ingestion, Absorption or Inhalation Suspected

Limit = 5 rem / yr

Ensuring Compliance to Radiation Exposure Limits

Use the established activity limit for each isotope

Compare with similar situations

Estimate with meter

Calculate

- Time, Distance, Shielding, Type, Energy, Geometry

Measure

- TLD Chip, Luxel
- Bioassay

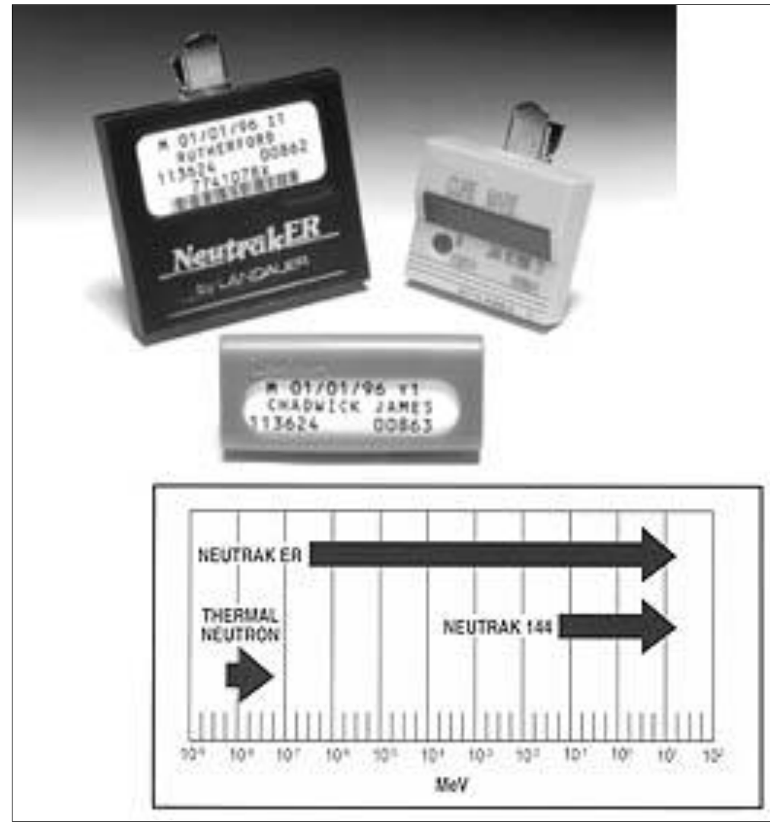
Who should wear radiation dosimeters or badges?

Those “likely” to exceed 10% of their annual limit are required

Those who would like a badge

Minors & Declared Pregnant Workers*

Types of Badges Available



Rules, Rights & Responsibilities as a Radiation Worker

Department of State Health Services

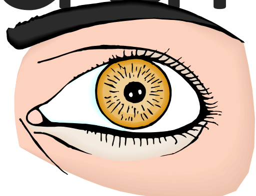
- **Radiation Control**

Texas Regulations for Control of Radiation

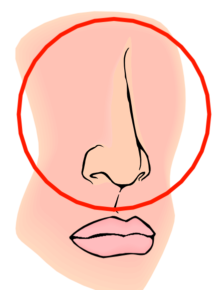
In Accordance with Texas Radiation Control Act, Health & Safety Code, Ch 401

25 TAC (Texas Administrative Code) 289

Detection of Radiation



The Human Eye

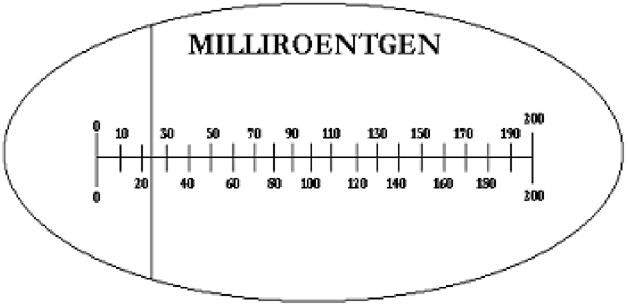


The Nose

Radiation Detectors

General Classes of Detectors

- Gas-Filled Detectors
- Solid Detectors
- Liquid Detectors



Gas-Filled Detectors

Proportional Counter

Ion Chambers

Geiger-Mueller Counters

Main Difference - Charge Multiplication

Liquid Scintillation Counter (LSC)

More Radiation Misconceptions

- Radiation does not give you *<u>super human</u>* powers

- Radiation will not make you glow in the dark

Summary of Biological Effects of Radiation

Radiation may…

- Deposit Energy in Body
- Cause DNA Damage
- Create Ionizations in Body
  - Leading to Free Radicals

Which may lead to biological damage

Radiation Effects on Cells

Radio sensitivity Theory of Bergonie & Tribondeau.

- Cell are radiosensitive if they :
  - Have a high division rate
  - Have a long dividing future
  - Are of an unspecialized type
    - These are the underlying premise for ALARA

Response to radiation depends on:

Total dose

Dose rate

Radiation quality

Stage of development at the time of exposure

Whole Body Effects

Acute or Nonstochastic

- Occur when the radiation dose is large enough to cause extensive biological damage to cells so that large numbers of cells die off.
- Evident hours to a few months after exposure (Early).

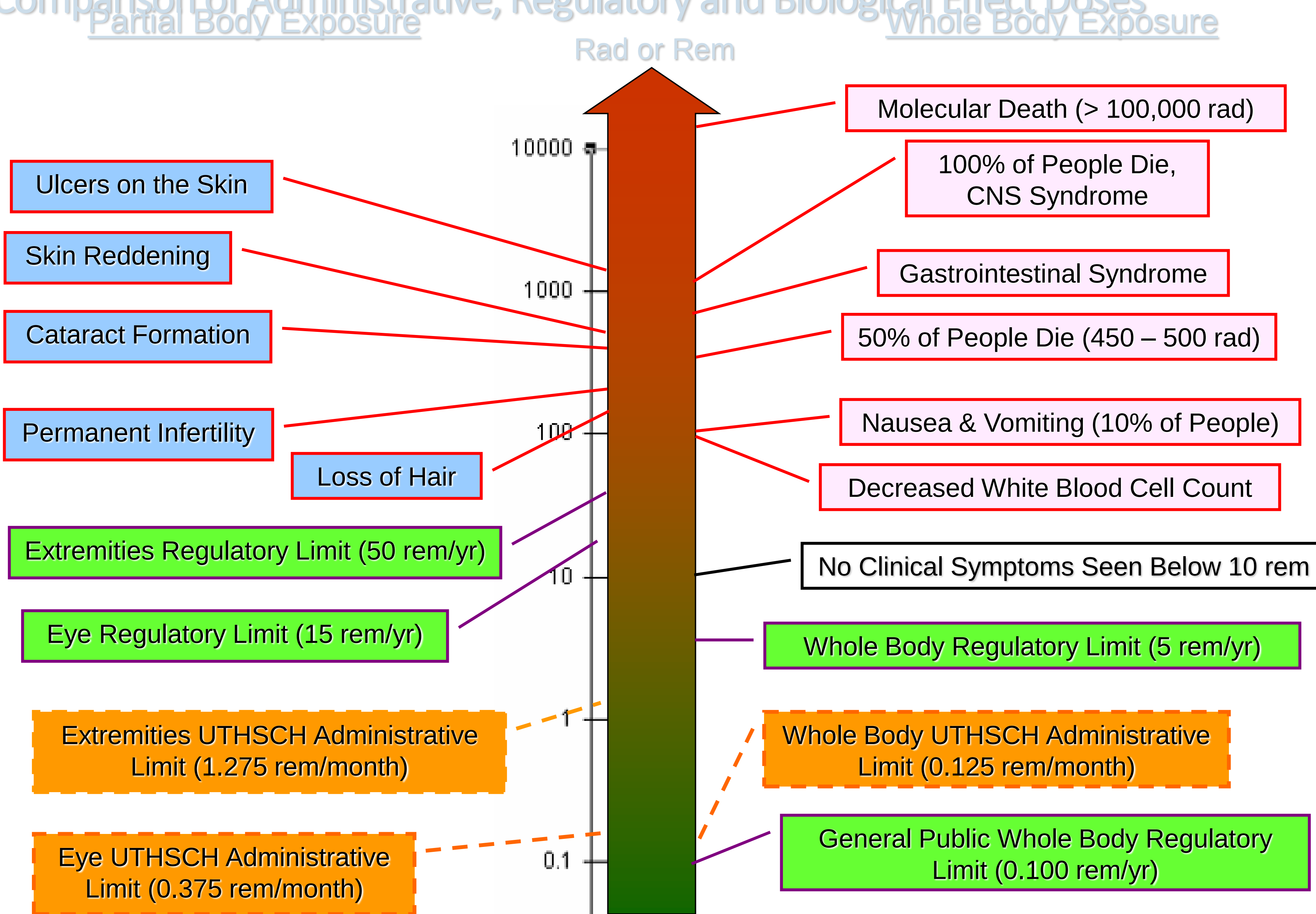
Late or Stochastic (Delayed)

- Exhibit themselves over years after acute exposure.
  - Genetic
  - Somatic
  - Teratogenic

Most and Least Radiosensitive Cells

Low Sensitivity	Mature red blood cells Muscle cells Ganglion cells Mature connective tissues
High Sensitivity	Gastric mucosa Mucous membranes Esophageal epithelium Urinary bladder epithelium
Very High Sensitivity	Primitive blood cells Intestinal epithelium Spermatogonia Ovarian follicular cells Lymphocytes

Comparison of Administrative, Regulatory and Biological Effect Doses



Medical Treatment

External Decontamination

- Mild cleaning solution applied to intact skin
  - Betadine, Soap, Rad-Con for hands
- Never use harsh abrasive or steel wool

Internal Decontamination

- Treatment which enhances excretion of radionuclides

How Often Does This Happen?

Results of reported exposure-related incidents in Texas 1956 – 2000

Source: Emery, et. al.