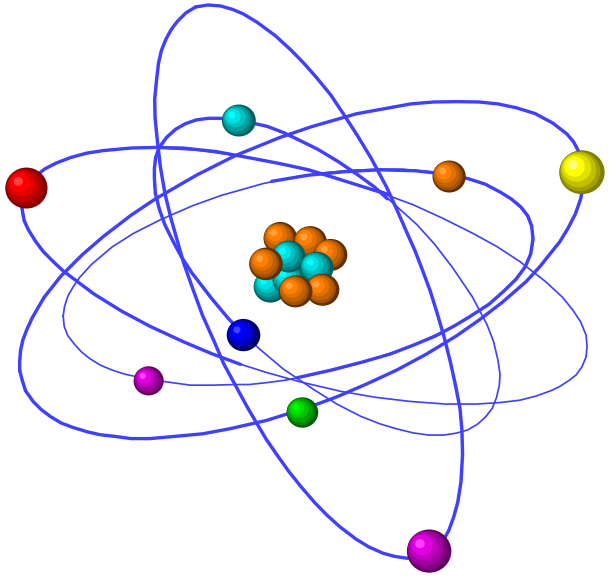
Radiation

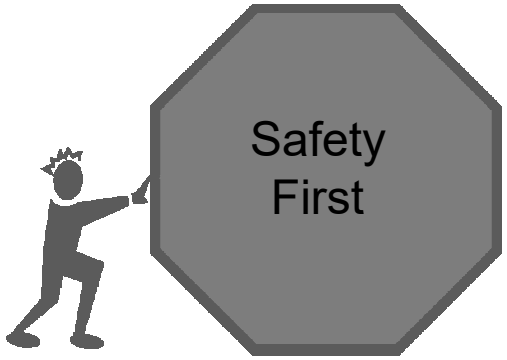


Learning Objectives

1. Define radiation
2. Describe sources of radiation
3. Describe types of radiation
4. Enumerate units
5. Describe biological effects of radiation
6. Describe protective measures

Historical Awareness

- **1895 - Wilhem Conrad Roentgen discovered X-rays and in 1901 he received the first Nobel Prize for physics.**
- **1903 - Marie Curie and Pierre Curie, along with Henri Becquerel were awarded the Nobel Prize in physics for their contributions to understanding radioactivity, including the properties of uranium.**
- **1942 - Enrico Fermi and others started the first sustained nuclear chain reaction in a laboratory beneath the University of Chicago football stadium.**
- **1945 – Nuclear bombs dropped on Japan.**



Radiological Hazards

- Detection of radiation is solely dependent on monitoring by instrument.
- In order to avoid exposure, it is important that worker realize the precautions that must be taken when dealing with radiological waste or sources.

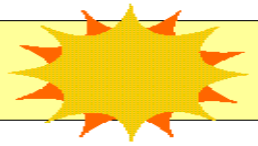
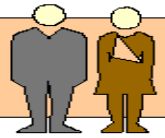
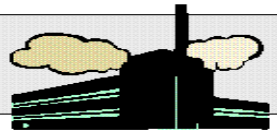
- Radiation: Energy in the form of particles or electromagnetic waves

- Radioactivity: The process by which unstable atoms spontaneously transform to new atoms and in the process emit radiation.

Sources of Radiation exposure

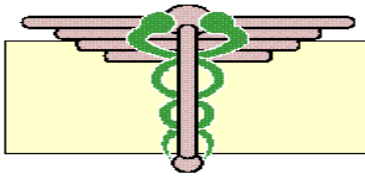
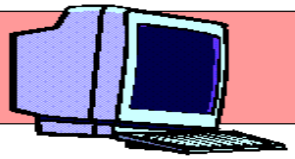
Natural	Man-Made
1. Cosmic Rays	1. Medical and Dental: X Rays, Radio isotops
2. Environmental: Terrestrial and Atmospheric	2. Occupational Exposure: Nuclear Power Plants
3. Internal: Potassium-40 Carbon -14	3. Miscellaneous: TV, Radio, Mobile, Watch dials, Luminous markers

Radiation from Natural Sources

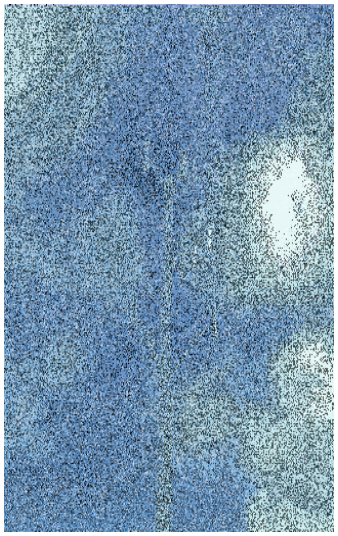
	Source	mrem/year
	Cosmic rays	28
	The earth	26
	Radon	200
	The human body	25
	Building materials	4

Transparency 4-1

Radiation from Manmade Sources

	Source	mrem/year
	Medical	90
	Fallout	5
	Consumer products	1
	Nuclear power	0.3

Other Manmade Sources of Non-Ionizing Radiation



Types of radiation

- **Ionizing radiation**: radiation which has ability to penetrate tissues and deposit its energy within them
- **Non-ionizing radiation**: these are forms of electromagnetic radiations, the wavelengths of which are more than those of ionizing radiation

Ionizing Radiation

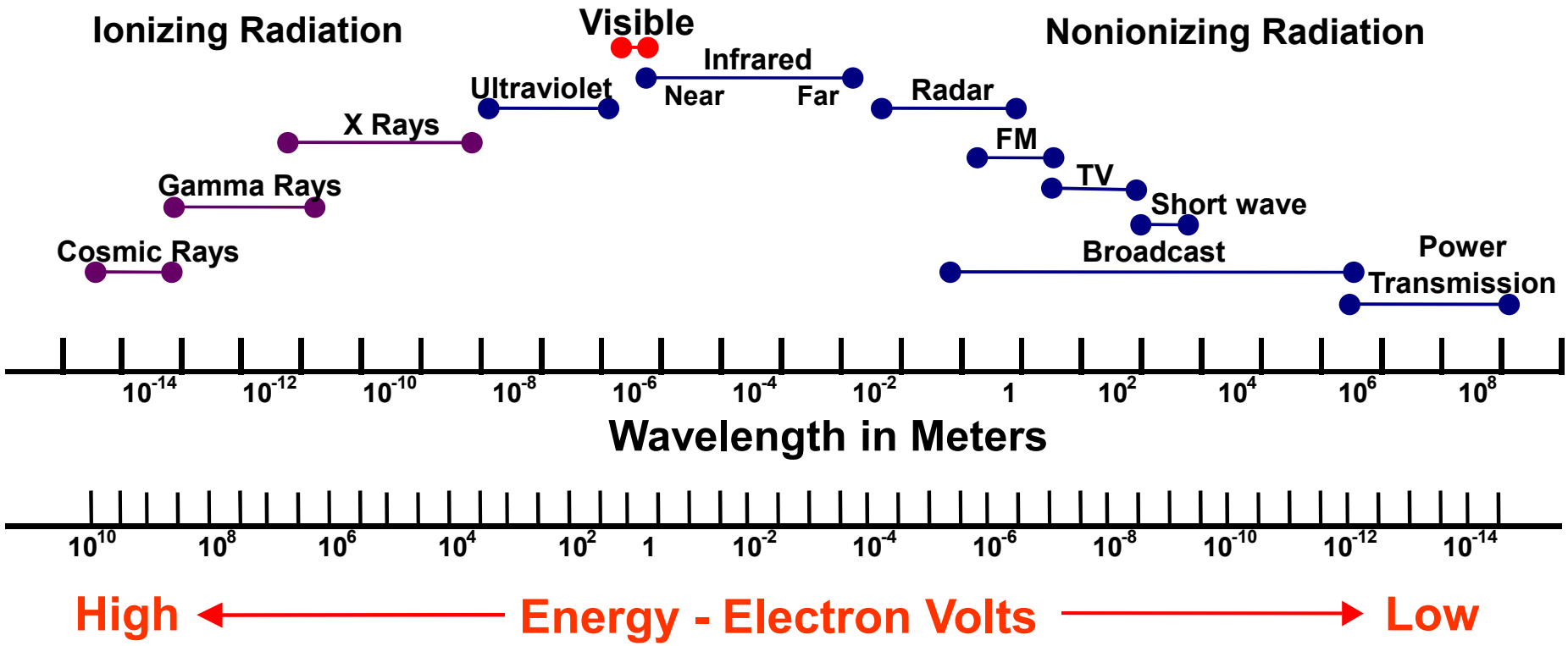
- Electromagnetic radiation (Photon): x-rays, gamma rays
- Particulate or corpuscular radiation: alpha particles, beta particles, protons, neutrons, heavy charged ions

- X-rays are produced mechanically by making electrons strike a target, which causes the electrons to give up their kinetic energy as x-rays;
- They have no charge, travel in straight lines, attenuate continuously as they traverse the tissue

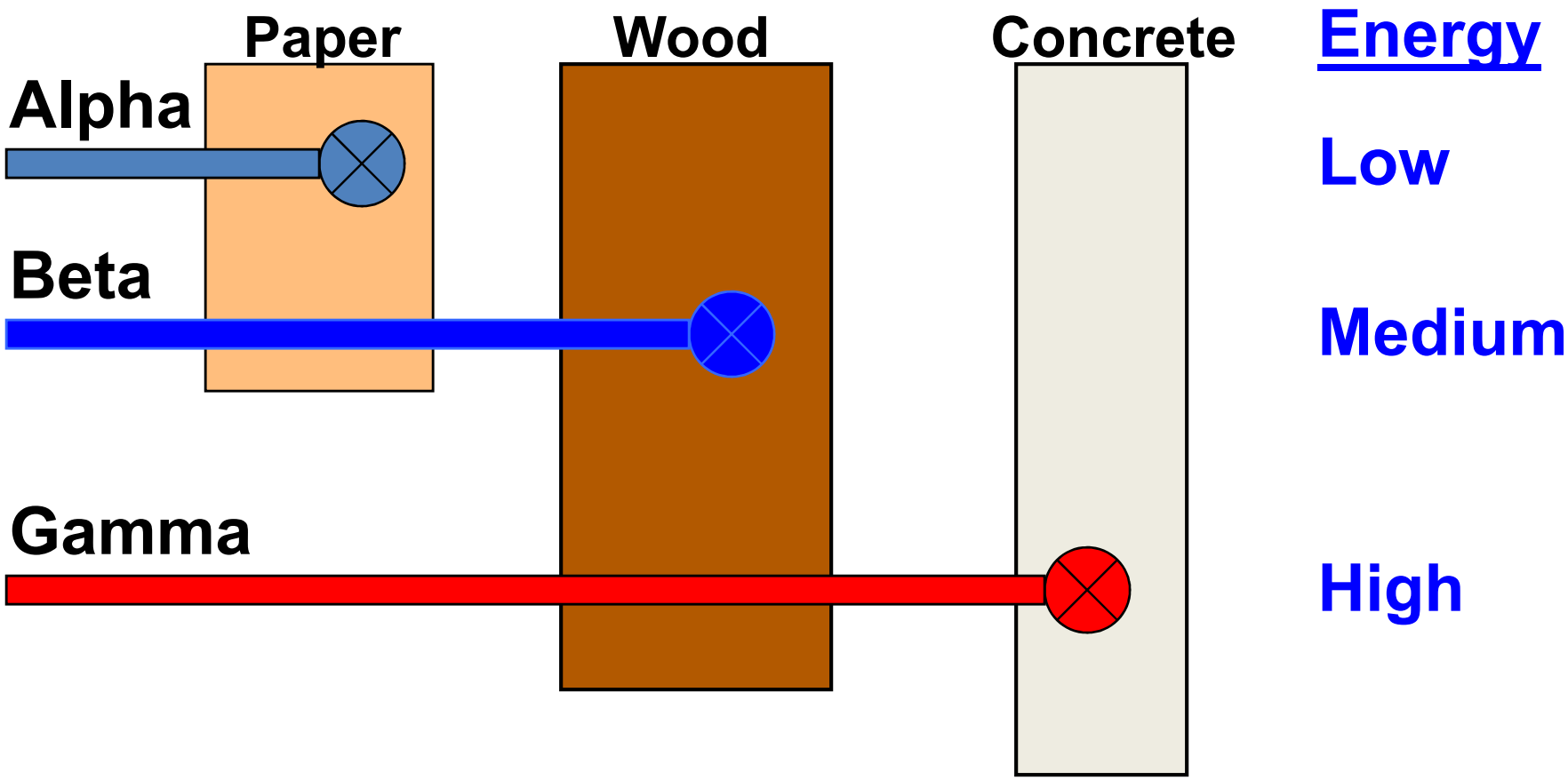
Non-ionizing Radiation

- Because of longer wavelengths, energy value of this type of radiation is low
- E.g.
  - UV rays
  - Visible light
  - Infrared radiation
  - Microwave radiation
  - Radiofrequency radiation

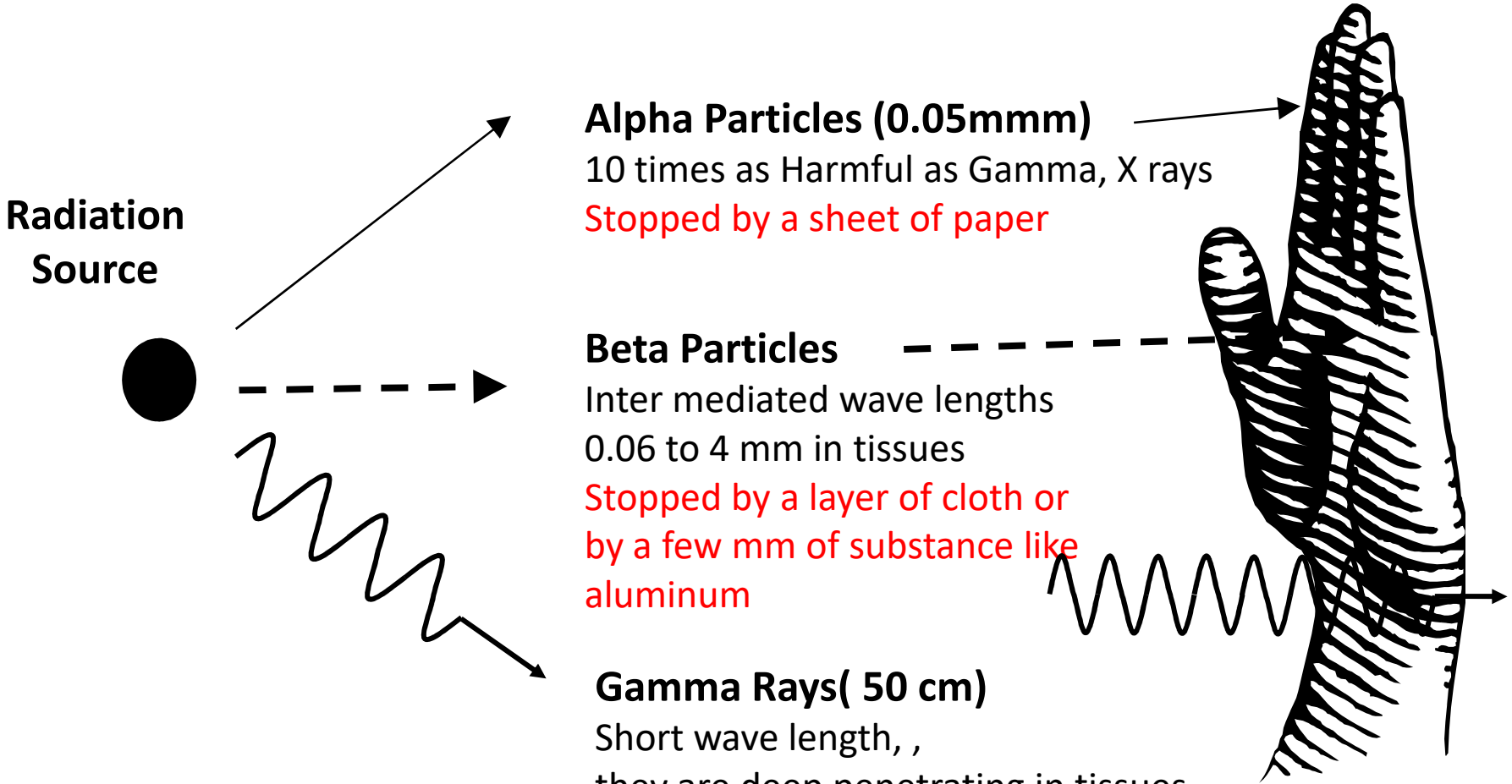
Electromagnetic Spectrum



Ionizing Radiation



Types of Ionizing Radiation



Radiation Unit

Measure of	Quantity	Unit
Amount of radioactive material	Activity	curie (Ci)
Ionization in air	Exposure	roentgen (R)
Absorbed energy per mass	Absorbed Dose	Rad (Replaced by
Absorbed dose weighted by type of radiation	**Dose Equivalent**	Rem (Replaced by Sievert Sv)

Dose Equivalent

- As all type of radiation do not produce same biological effect per unit absorbed, the concept of **Dose Equivalent** has been introduced.
- **Sv = DQ**
- Where Sv= sievert,

  D= absorbed dose and

  Q= quality factors depends upon the density produced in the tissue by radiation

Radiation Dosage

- Standard Radiation Units
  - Roentgen applies only to X-rays and gamma rays.
  - Rad measures Absorbed Dose; i.e., the amount of ionizing radiation (any type) absorbed into a material.
  - Rem is the most commonly used unit of measure and is used for dose equivalence.

Acute Radiation Exposure

- **is the result of a large dose in a short period of time.**
- **possible effects:**
  - lowering of the white blood cell count
  - nausea and vomiting
  - diarrhea
  - loss of appetite
  - reddening of the skin
  - fatigue
  - hair loss
  - possible sterility

ACUTE DOSE(RAD) EFFECT

0-25	No observable effect.
25-50	Minor temporary blood changes.
50-100	Possible nausea and vomiting and reduced WBC.
150-300	Increased severity of above and diarrhea, malaise, loss of appetite.
300-500	Increased severity of above and hemorrhaging, depilation. Death may occur
> 500	Symptoms appear immediately, then death has to occur.

Biological effects

1. **Somatic:**

   Immediate: Radiation sickness

   Acute radiation syndrome

   Delayed : Leukemia

   Carcinogenesis

   Foetal developmental abnormalities

2. **Genetic:**

   Chromosomal mutations

   Point mutation

Effects of radiation exposure

Experts say even small radiation doses, as low as 100 millisieverts (mSv), can slightly raise cancer risk.

Exposure in mSv

10,000
Single dose, fatal within weeks

5,000
Single dose; would kill half of those exposed within a month

1,000
Single dose could cause radiation sickness; nausea, but not death

100
Recommended limit for radiation workers every five years

16.00
CT scan, heart

10.00
CT scan, full body

2.00
Radiation most people are exposed to per year

0.01
Dental x-ray

Immediate effects

Cell damage, especially fast-growing cells

Brain Fatigue, nausea

Hair follicles Hair loss

Intestine lining
Diarrhea, malnutrition

Skin cells
Sores, peeling

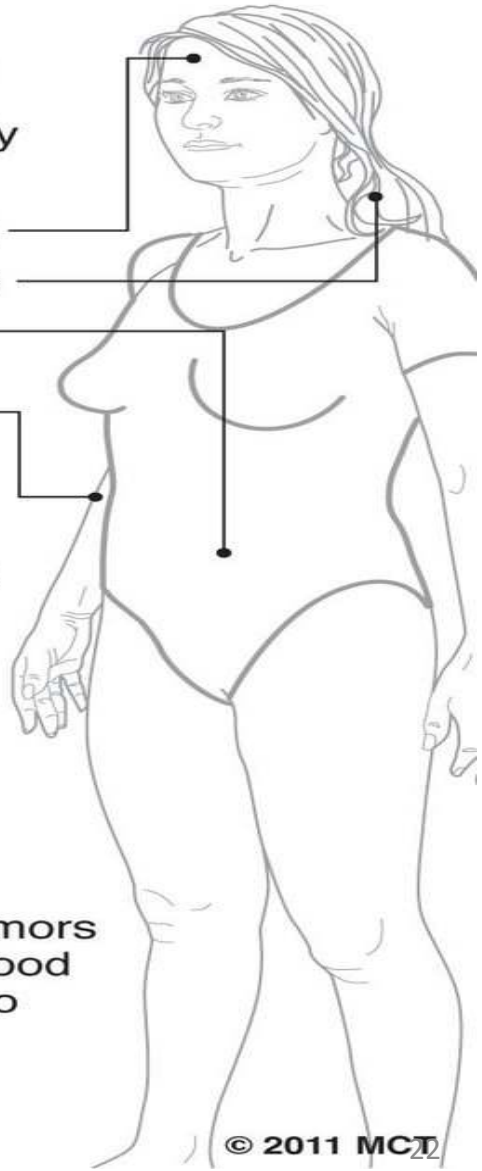
White blood cells and bone marrow
Immune system failure

Later

DNA damage
in cell nucleus

Egg and sperm cells
with damaged DNA can produce babies with birth defects

Body cells develop tumors or abnormal growth; blood cell damage can lead to leukemia



Source: U.S. Environmental Protection Agency, Reuters
Graphic: Melina Yingling

Radiation exposure

As fears of a meltdown in Japan rise, so do the fears of radiation exposure.
What does radiation do to the human body?

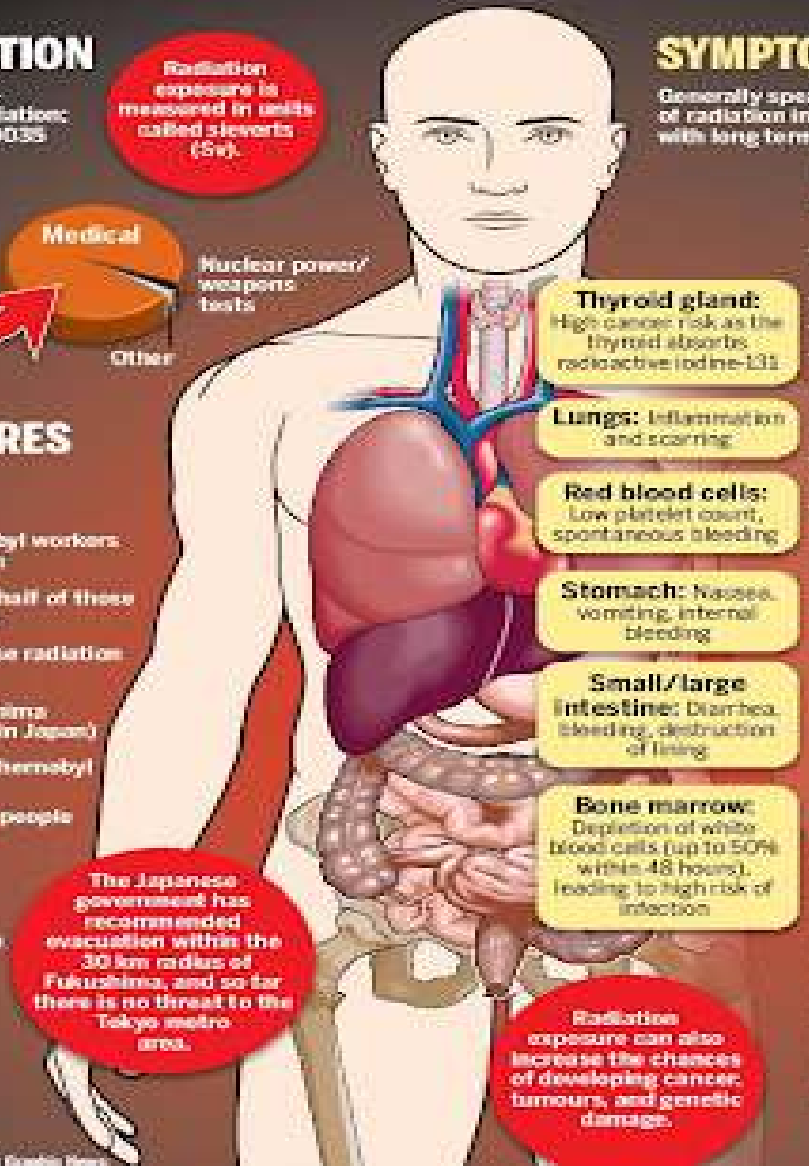
BACKGROUND RADIATION

Everybody is exposed to both naturally-occurring and artificial background radiation; levels typically range from 0.0035 – 0.0035 Sv/year:

Radiation exposure is measured in units called sieverts (Sv).

COMPARING EXPOSURES

10 Sv	Fatal within weeks
6	Typical levels in Chernobyl workers who died within a month
5	A single dose would kill half of those exposed within a month
1	A single dose could cause radiation sickness and nausea
0.4	Detected level at Fukushima (as of Tuesday morning in Japan)
0.35	Exposure of relocated Chernobyl residents
0.10	Recommended limit for people working with radiation every 5 years
0.01	Full-body CT scan
0.002	Typical natural radiation per year
0.0004	Mammogram x-ray
0.0001	Chest x-ray
0.00001	Dental x-ray



The Japanese government has recommended evacuation within the 30 km radius of Fukushima, and so far there is no threat to the Tokyo metro area.

Radiation exposure can also increase the chances of developing cancer, tumours, and genetic damage.

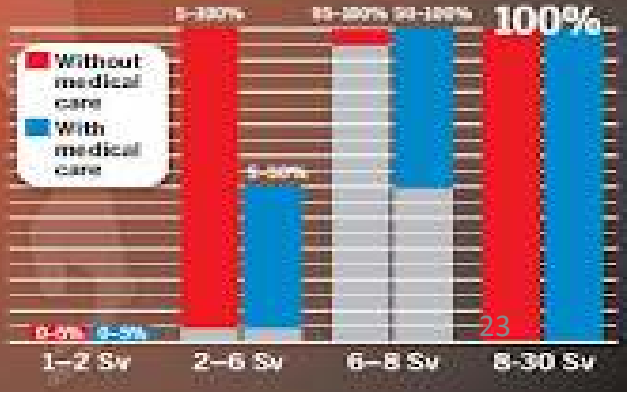
SYMPTOMS OF RADIATION EXPOSURE

Generally speaking, radiation sickness is brought on by a large dosage of radiation in a short period of time, but it has also occurred with long term exposure.

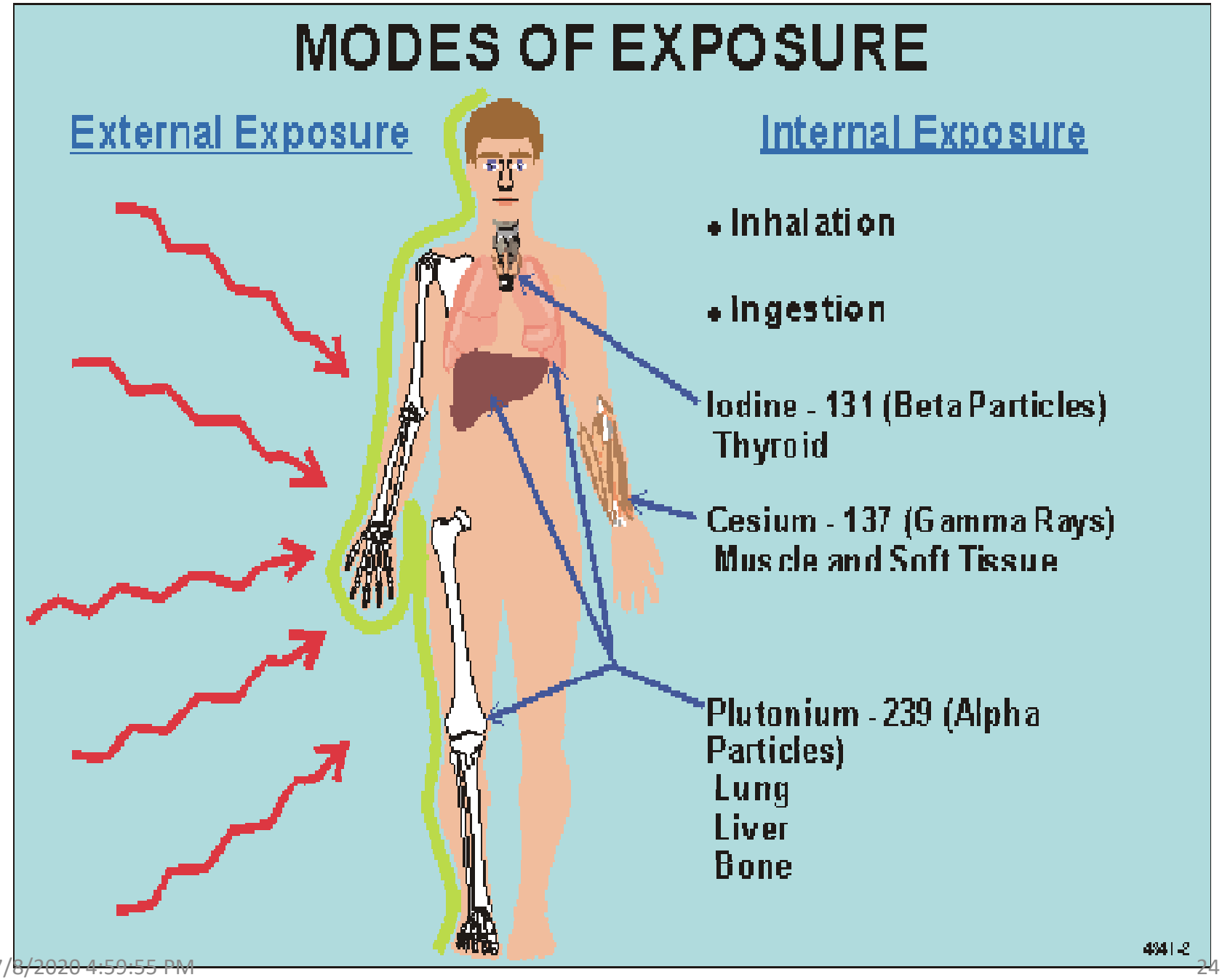
Early symptoms, exposure levels and time to symptom onset

	1–2 Sv	2–6 Sv	6–8 Sv	8–10 Sv
Nausea, vomiting	6 hrs.	2 hrs.	1 hr.	10 min.
Diarrhea	—	3 hrs.	3 hrs.	1 hr.
Headache	—	24 hrs.	4 hrs.	2 hrs.
Fever	—	3 hrs.	1 hr.	1 hr.
Later symptoms				
Dizziness, disorientation	—	—	1 wk.	Immediate
Weakness, fatigue	4 wks.	1–4 wks.	1 wk.	Immediate
Hair loss, bloody vomit and stools, infections, poor wound healing, low blood pressure	—	1–4 wks.	1 wk.	Immediate

CHANCES OF DEATH BASED ON EXPOSURE LEVEL



MODES OF EXPOSURE



Radiation Protection

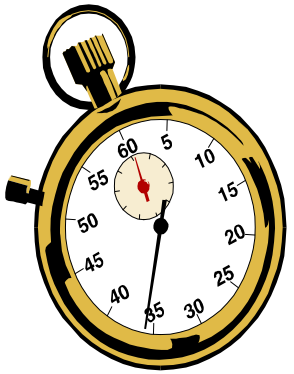
- Avoid unnecessary x ray examinations
- Adequate control and surveillance of installations
- Improvements in techniques and in dose reduction
- Protection of radiation workers and staff:
  - Lead shields
  - Lead aprons
  - Face masks
  - Dosimeter
  - Periodic medical check up
  - Working hours
  - Breaks/ shifts in other units

Radiation hygiene

Detecting and Measuring Radiation

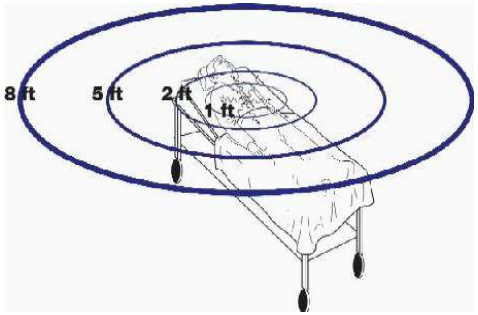
- **Instruments**
  - Locate contamination - GM Survey Meter (Geiger-mullre counter)
  - Measure exposure rate - Ion Chamber
- **Personal Dosimeters - Measure doses to staff**
  - Radiation Badge - Film
  - Self-reading dosimeter (analog and digital)

Radiation Protection
Reducing Radiation Exposure



Time

Minimize time spent near radiation sources.



To Limit Caregiver Dose to 5 rem		
Distance	**Rate**	**Stay time**
1 ft	12.5 R/hr	24 min
2 ft	3.1 R/hr	1.6 hr
5 ft	0.5 R/hr	10 hr
8 ft	0.2 R/hr	25 hr

Distance

Maintain maximal practical distance from radiation source.

Shielding

Place radioactive sources in a lead container.

Standards

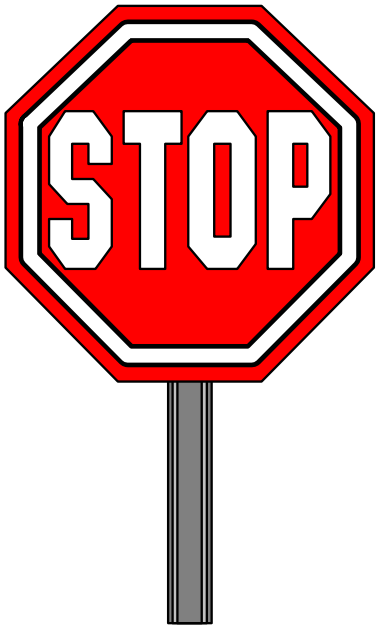
US National Council on Radiation Protection (NCRP)

International Council on Radiation Protection (ICRP)

Occupational Exposure Guidelines

- **100 mSv over 5 years (average 20 mSv/year) with a maximum of 50 mSv in any one year**
- **General public – back ground about 3 mSv/year – Guideline 1 mSv/year**

Best Radiation Protection



Prevention of Contamination!

ALARA

An acronym that represents the concept of reducing exposure to ionizing radiation

- As
- Low
- As
- Reasonably
- Achievable

Thanks