Mailstop S3-97
Richland, WA 99352
(509)373-1311

Hanford Fire Department

Radioactive Materials Emergencies

Radiation Fundamentals for Firefighters

Student Handout

Prepared by Hanford Fire Department Training Group
(509)373-2123

Objectives

- **To understand the hazards of responding to events involving radioactive materials**
- **To know the fundamentals of radioactive contamination**
- **To understand the biological affects of exposure to radioactive materials**
- **To know how to respond to hazmat events involving radioactive materials**

RADIOLOGICAL TERMS

- CURIE (Ci)
  - The basic unit of activity. A quantity of any radionuclide that undergoes an average of 37 billion transformations per second.
  - One curie is the approximate activity of 1 gram of radium.
  - Named after Marie and Pierre Curie, who discovered radium in 1898

- **Rad (radiation absorbed dose)-**
  - Measures a quantity called “absorbed dose” which means the amount of energy actually absorbed in a material.
  - The rad measures any type of radiation, but it does not describe the biological effects.

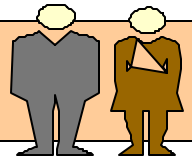
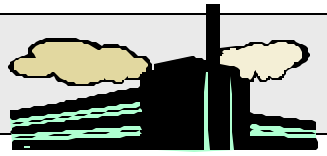
- **Rem (roentgen equivalent man)-**
  - Measures a quantity called “equivalent dose” which relates the absorbed dose in human tissue to the resulting biological damage.
  - This measurement is necessary because not all radiation has the same biological effect.
  - The rem measurement is obtained by measuring the rad and multiplying it by a quality factor that is unique to a specific type of radiation.

- **Roentgen (R)-**
  - A unit of exposure to ionizing radiation.
  - It is the amount of gamma or x-rays required producing ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions.
  - Named after Wilhelm Roentgen, German scientist who discovered x-rays in 1895.

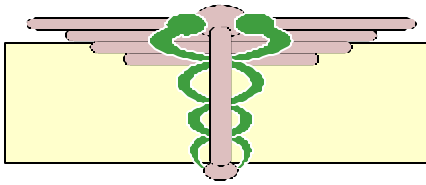
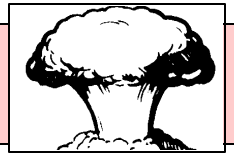
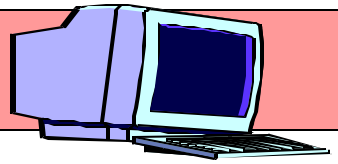
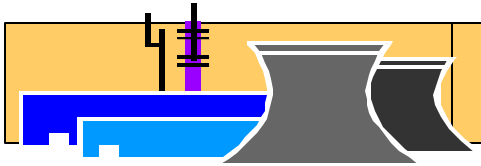
SYSTEME INTERNATIONAL

Traditional Unit	SI Unit	Conversion Factor
Curie (Ci)	Becquerel (Bq)	1Ci = 37 Billion Bq
Rad	Gray (Gy)	1 Gy = 100 Rad
Rem	Sievert (Sv)	1 SV = 100 Rem
Roentgen (R)	Coulombs per kilogram (C/kg)	1 R = 25800 C/kg

Radiation from Natural Sources

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

Radiation from Manmade Sources

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

Radioisotopes used in Medicine and Industry

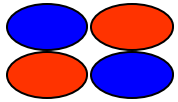
Isotope	Example of Uses	Form for Shipping	Mode of Transport
Americium 241	Used in Industry to: • Determine oil well drill locations • Smoke detectors • Measure lead in dried paint • Ensure uniformity in steel and paper production	Powder (enclosed in a capsule)	Highway Rail Air
Californium 252	Used in Medicine to: • Research and treat cancer (especially cervical, ovarian and brain cancers)	Solid	Highway Air
Cobalt 60	Used in Medicine to: • Treat Cancer • Suppress immune reaction in transplants • Sterilize surgical instruments Used in Industry to: • Test welds and castings • Check for internal structural flaws • Locate buried utility lines Used in Agriculture to: • Preserve poultry, fruits and spices	Solid	Highway Rail Air
Iodine 131	Used in Medicine to: • Diagnose and treat medical disorders • Trace medical observations	Solid	Highway Rail Air

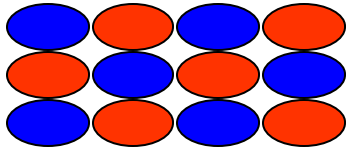
Atoms

Elements are defined by the number of protons

= Proton

= Neutron



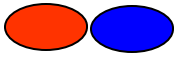


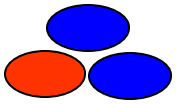
Hydrogen
1 Proton

Helium
2 Protons

Carbon
6 Protons

1. **What elemental nuclei are these?**



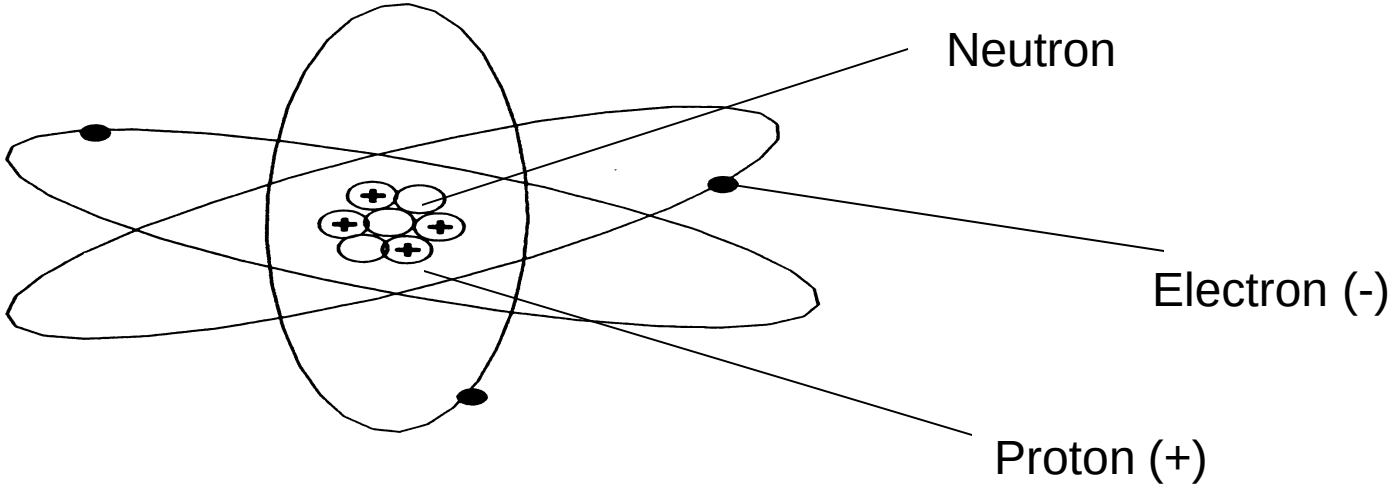


2. **How many neutrons does Carbon 60 have?**

3. **How many neutrons and protons does Carbon 13 have?**

Answers:
1. Because they have only one proton, all these nuclei are different isotopes of hydrogen
2. Carbon 60 has 54 neutrons (plus 6 protons)
3. Carbon 13 has 7 neutrons and 6 protons

Parts of an Atom

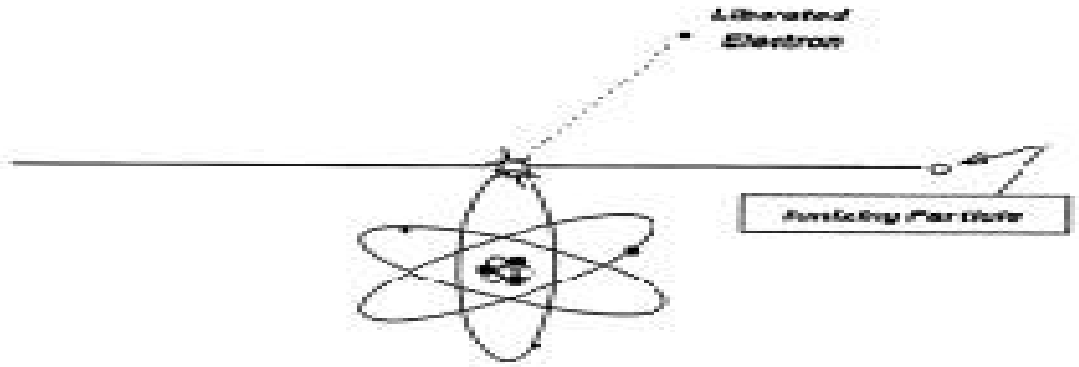


The nucleus contains positively charged protons and neutrons, which are not charged

Orbiting electrons are negatively charged

When the number of protons and electrons are equal, charges are balanced and the atom is stable

Ionization



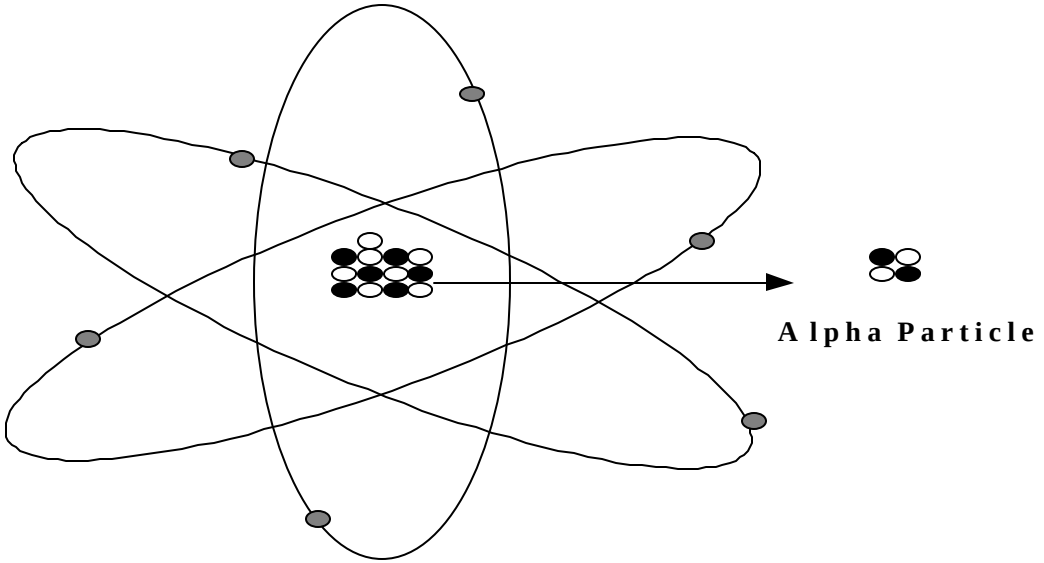
An electron can be knocked from its orbit

The atom becomes charged, or “ionized”

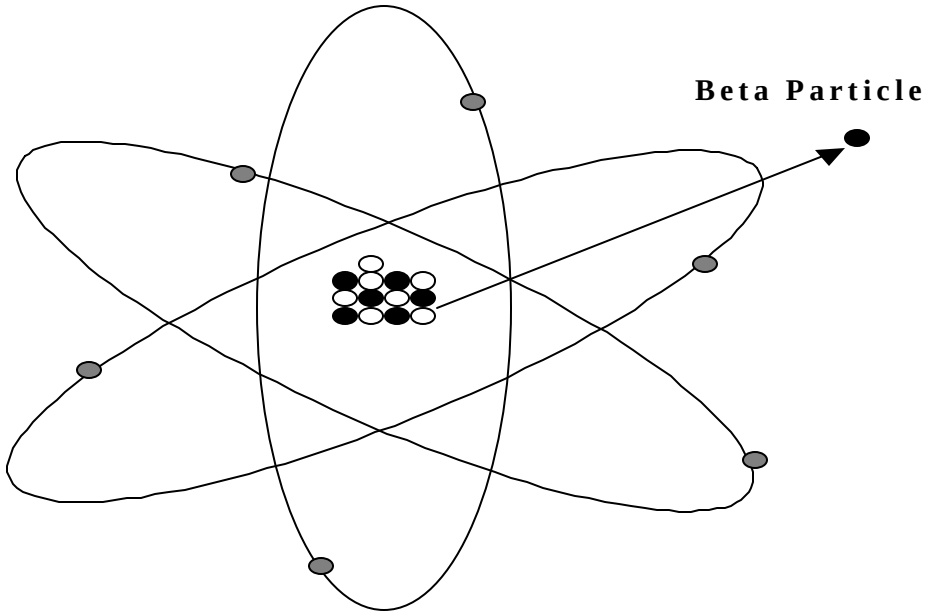
TYPES OF RADIATION

- ALPHA PARTICLES
- BETA PARTICLES
- GAMMA RAYS
- X-RAYS
- NEUTRONS

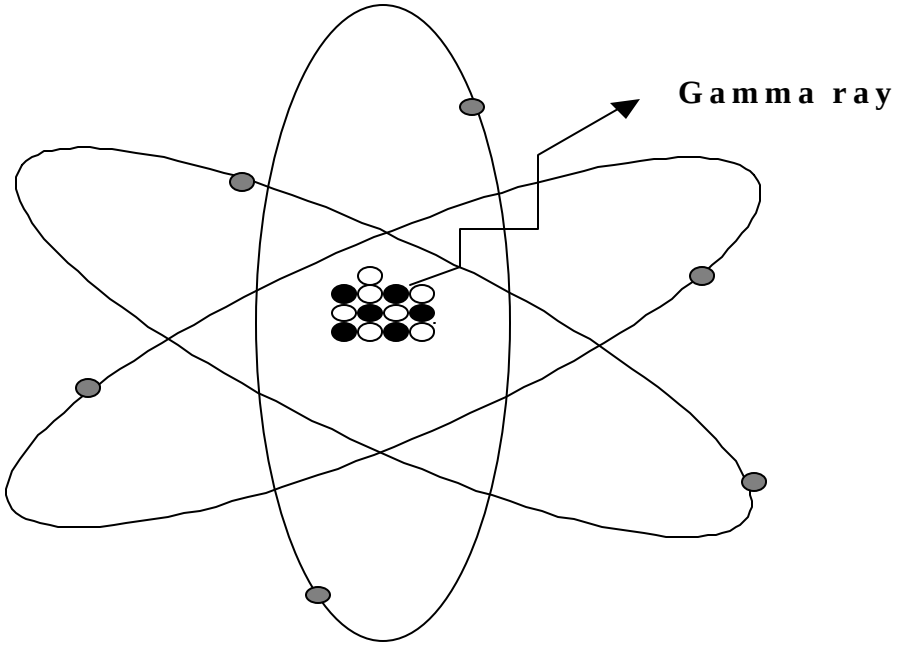
ALPHA PARTICLE



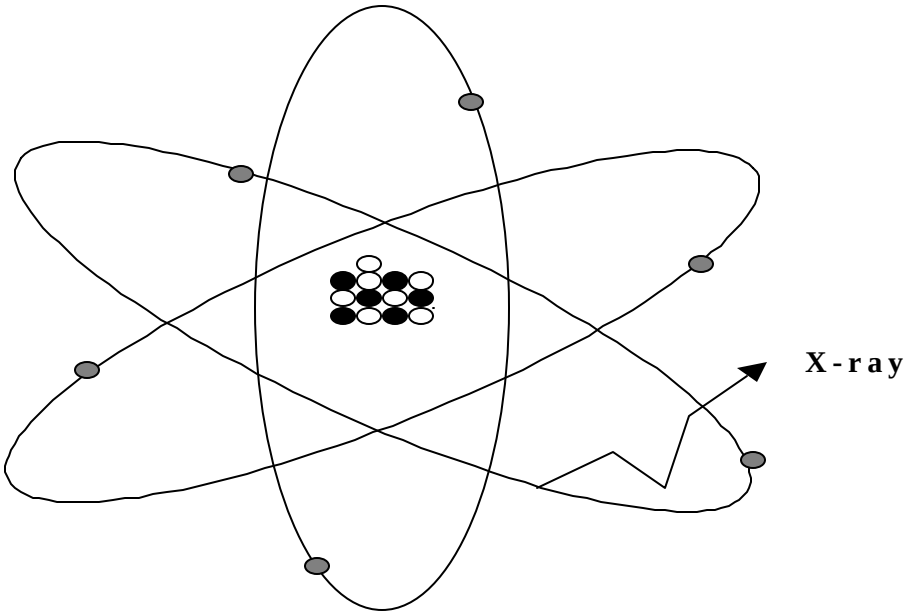
BETA PARTICLE



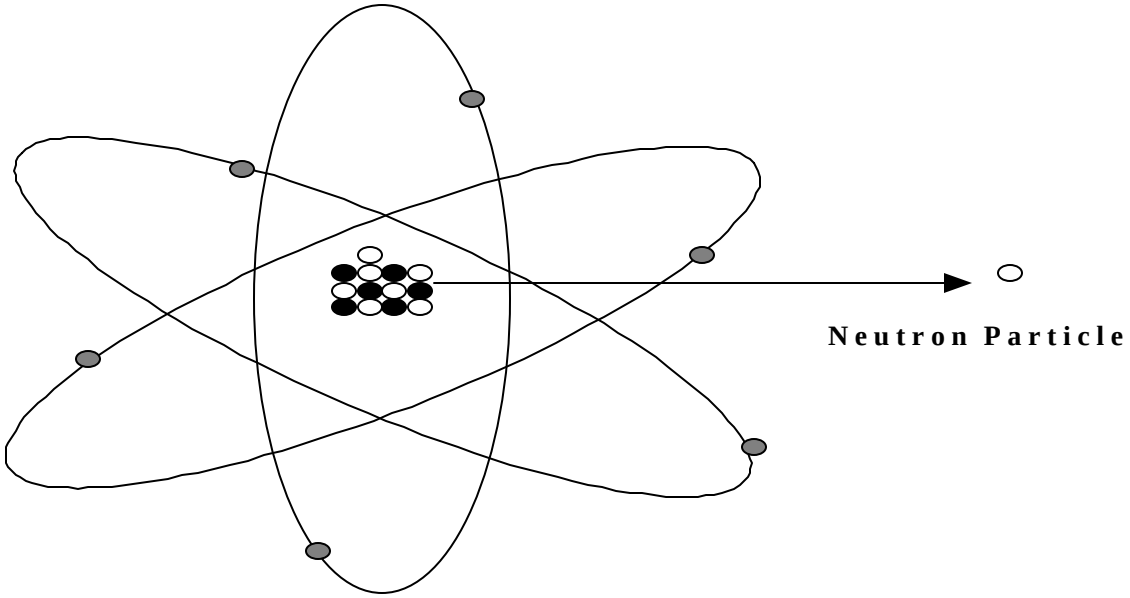
GAMMA RAY



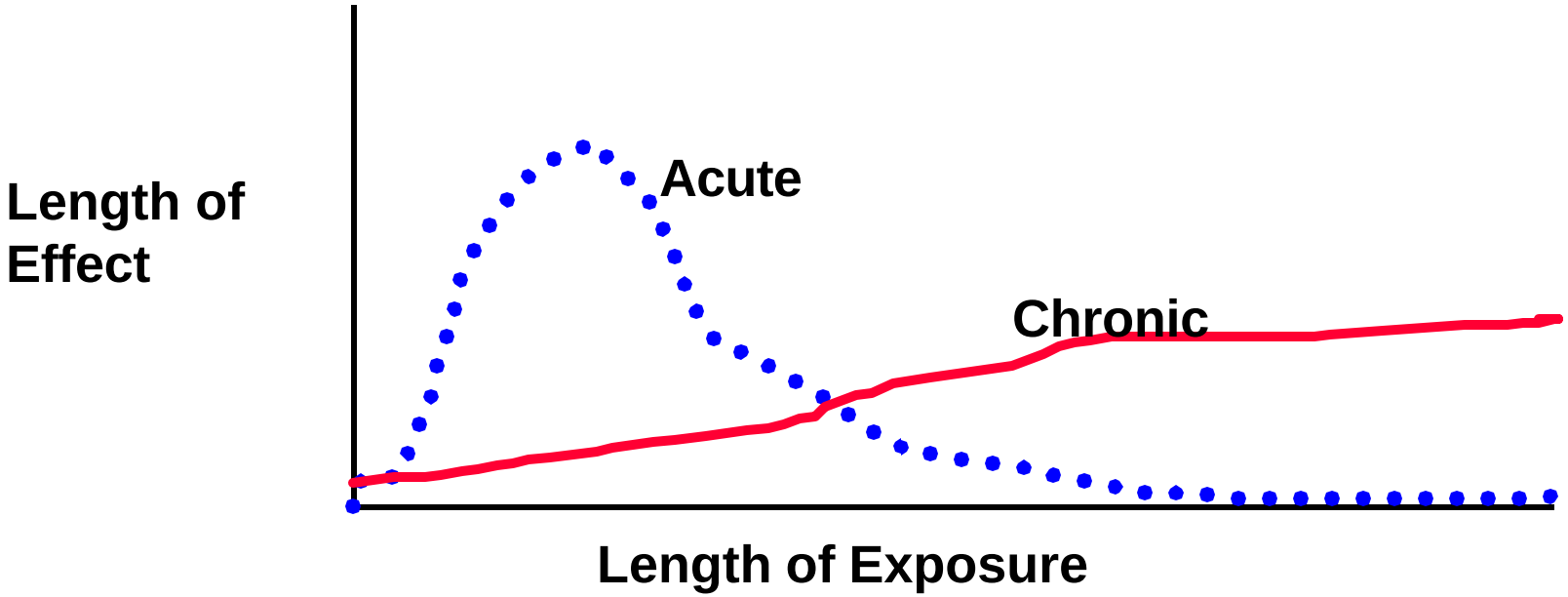
X-RAY



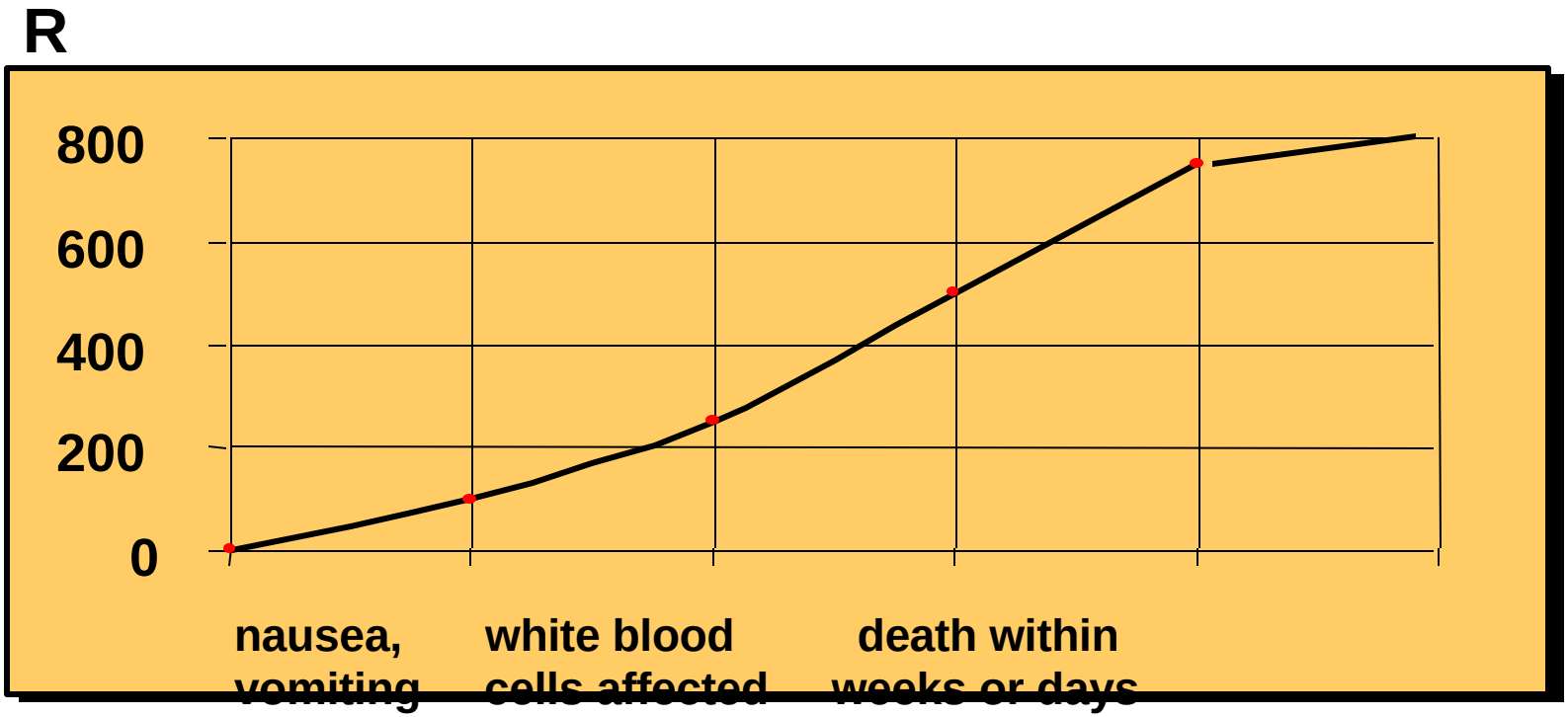
NEUTRONS



Acute vs. Chronic Effects



Stages of Acute Radiation Syndrome



DOSE LIMITS

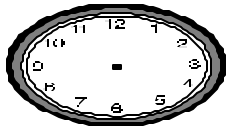
Table 1.4 Dose Limits for Emergency Workers	
Rem	**Condition**
5	General monitoring (no life safety involved)
10	Protection of a large population
25	Life saving (once in a lifetime)
>25	Life saving (authorization required)

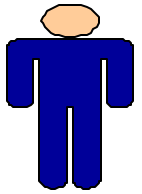
Source: U.S. EPA 400 1994

For exposures above 25 rem, responders must be fully aware of the risks involved, and the person or agency in command must authorize in writing.

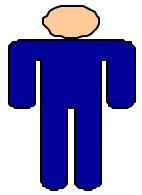
Precautions for Radiation Hazards

Time

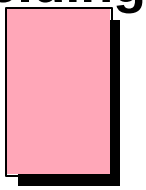


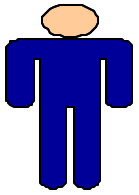


Distance

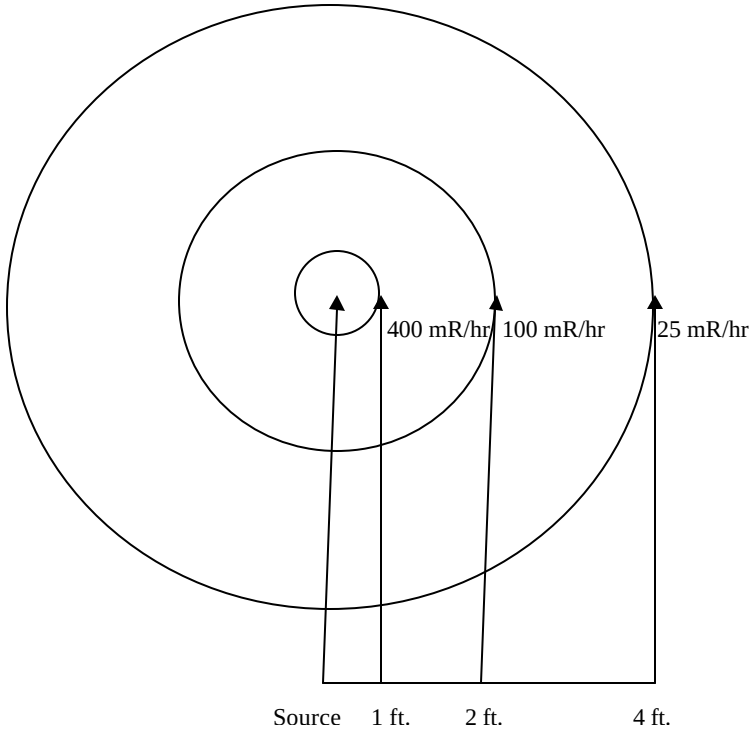


Shielding

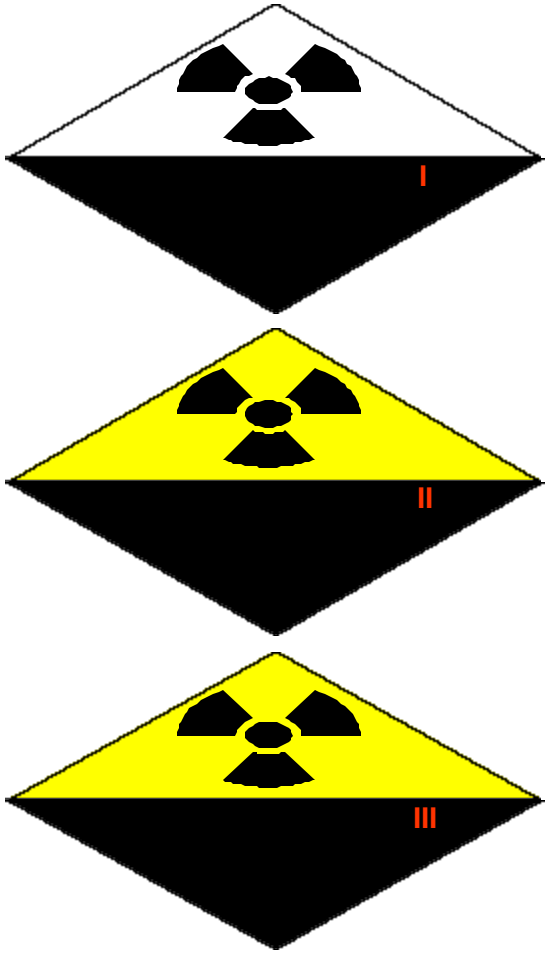




INVERSE SQUARE LAW



Placards/Labels for Radioactive Materials

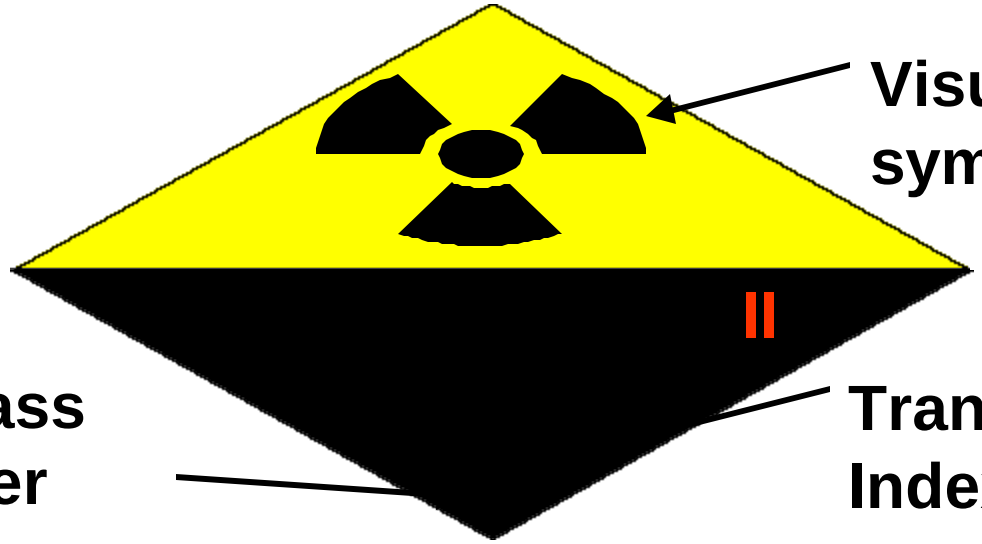


Radioactive white - I
Contains almost no radiation (0.5 mR/hr on surface)

Radioactive yellow - II
Low radiation levels (50 mR/hr maximum on surface; 1 mR/hr maximum at 1 meter)

Radioactive yellow - III
Higher radiation levels (200 mR/hr maximum on surface; 10 mR/hr maximum at 1 meter)

Transport Index



Visual hazard symbol

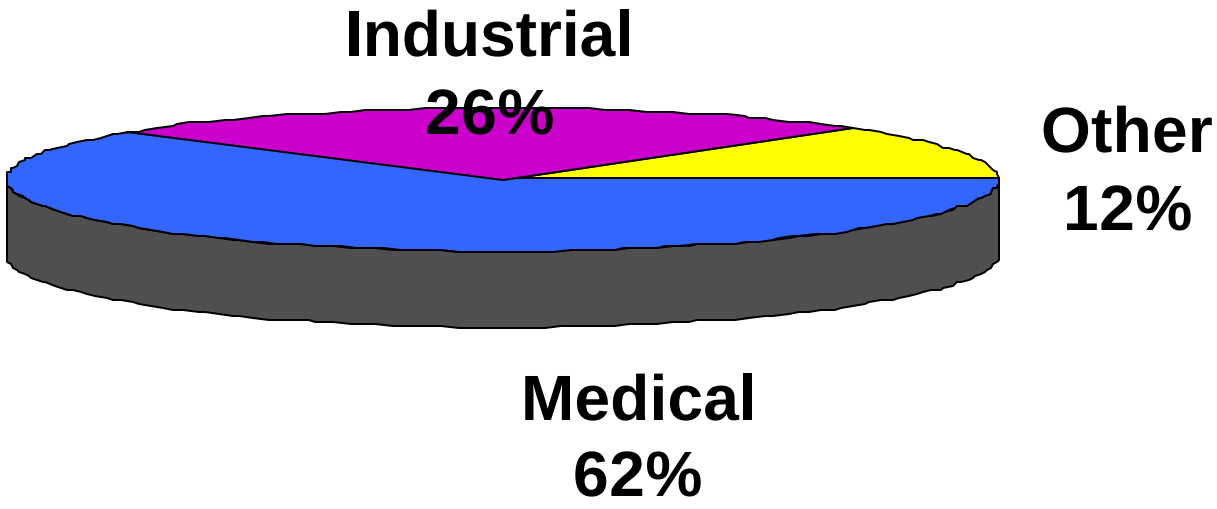
UN Class Number

Transport Index

RADIOLOGICAL SHIPMENTS BY INDUSTRY

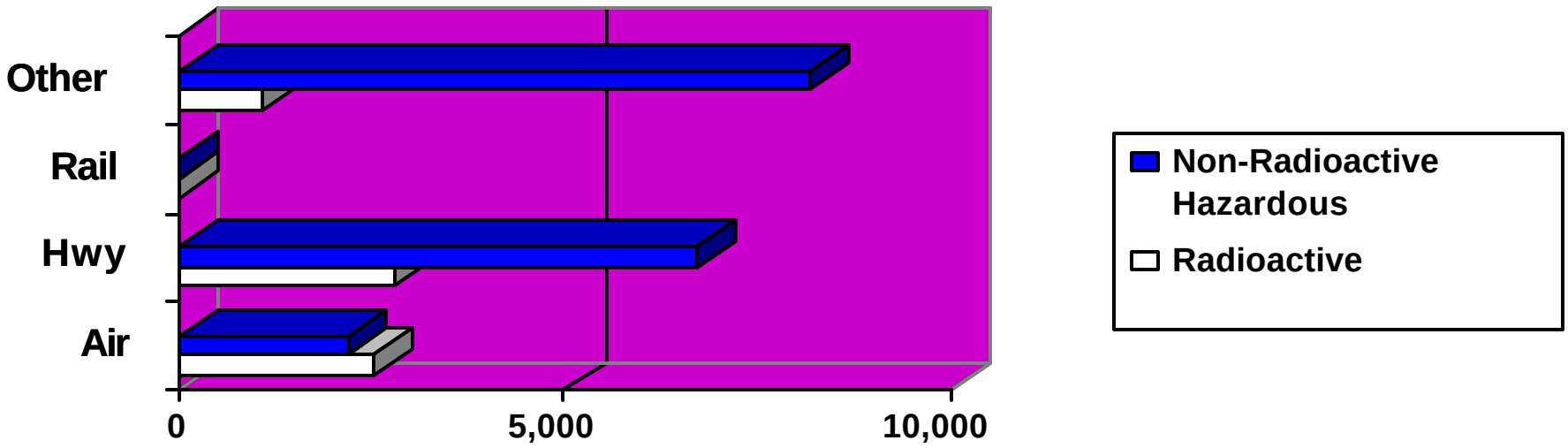
Radiological Shipments by Industry						
Medical/ Research	Uranium Compounds	Empty Containers	Nuclear Fuel	Spent Fuel	Rad Waste	Misc.
54.5%	**10.7%**	**6%**	**1.8%**	**0.2%**	**14.8%**	**12%**

Radiological Shipments by Industry



“Other” includes fuel rods, fissile materials, utility waste, and military shipments

DOE Shipments by Transportation Mode

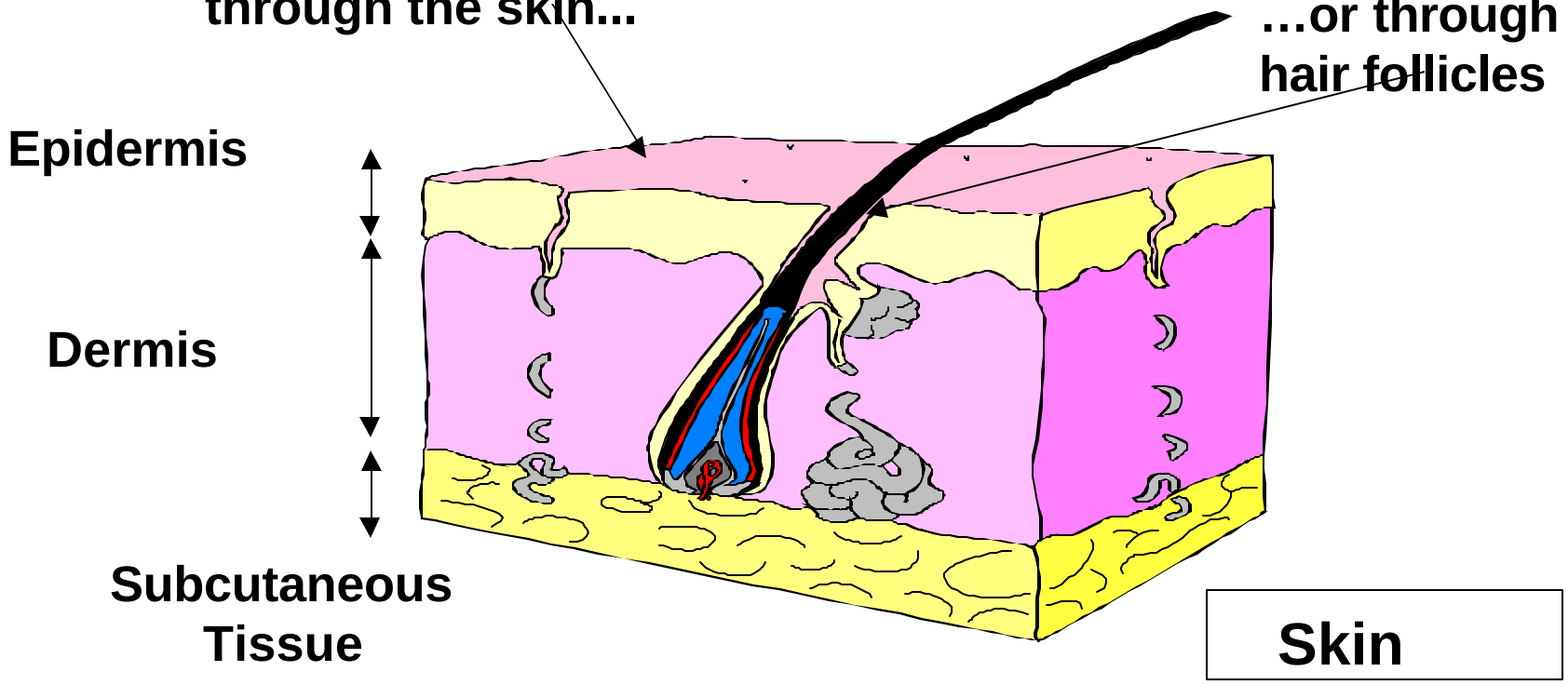


“Other” includes ship, private motor carrier, and parcel and freight forwarders.

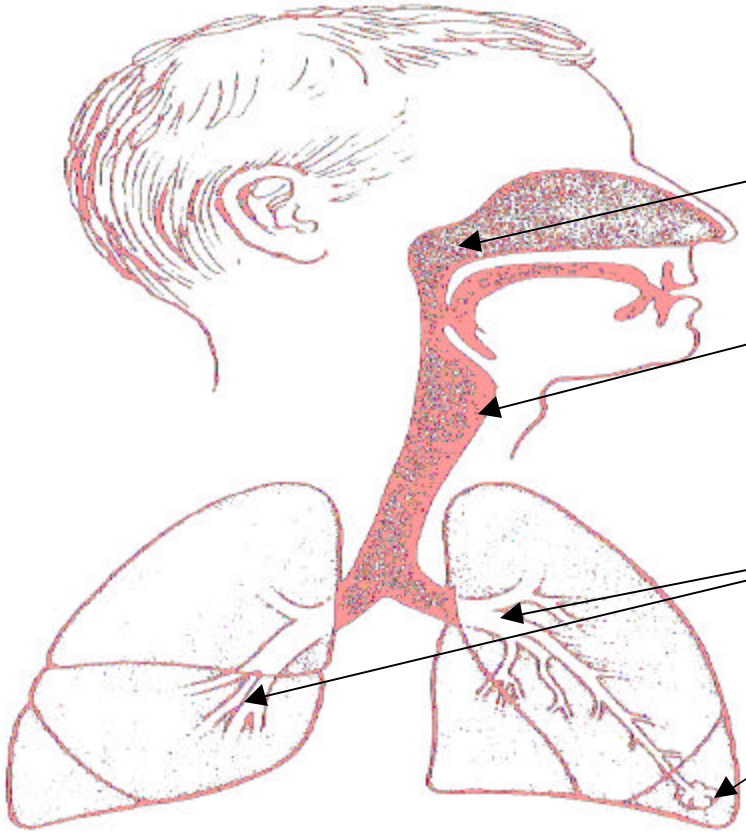
Routes of Exposure: Direct Contact

Chemicals can enter directly through the skin...

…or through hair follicles



Routes of Exposure: Inhalation



Pharynx

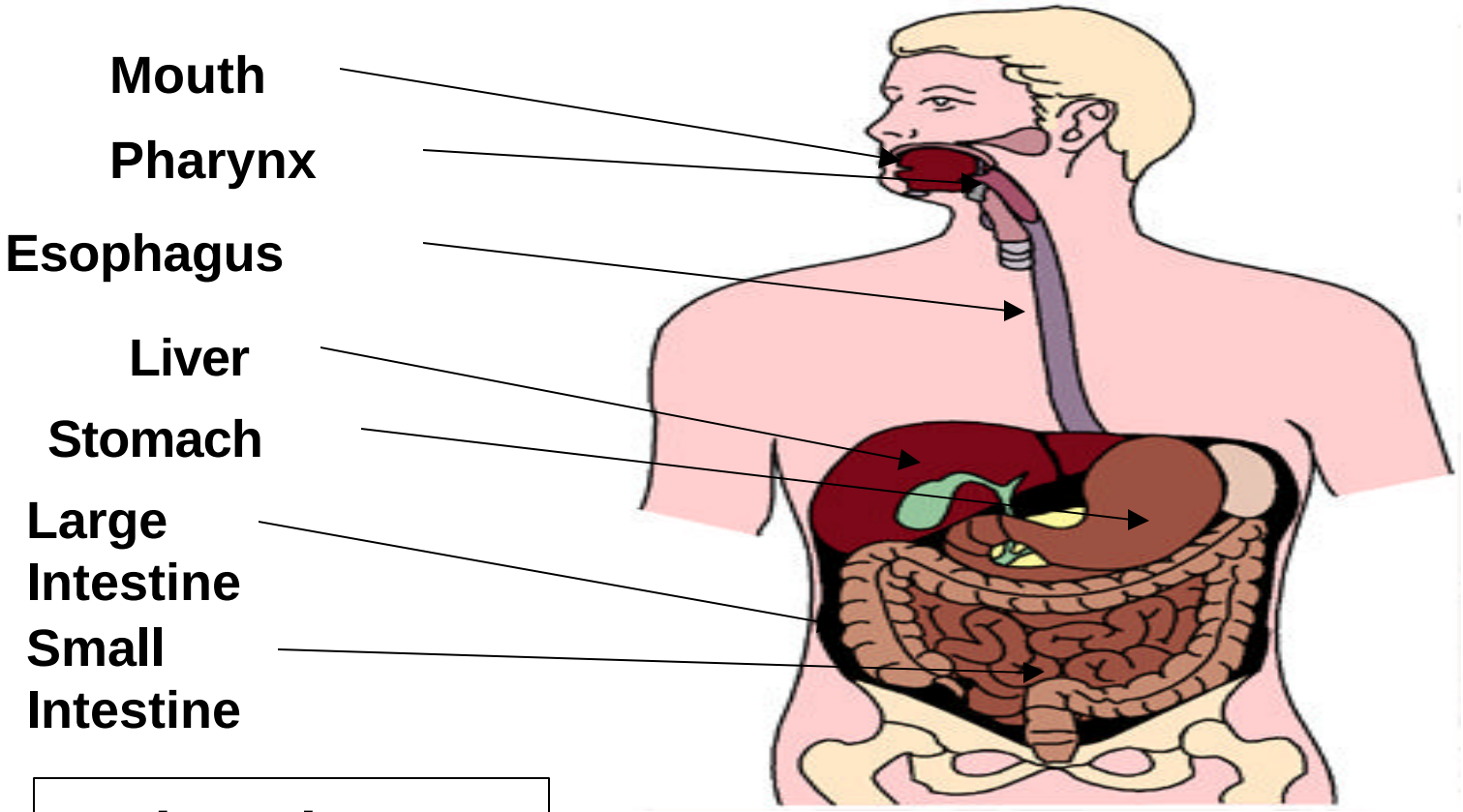
Trachea

Bronchii

Bronchiole

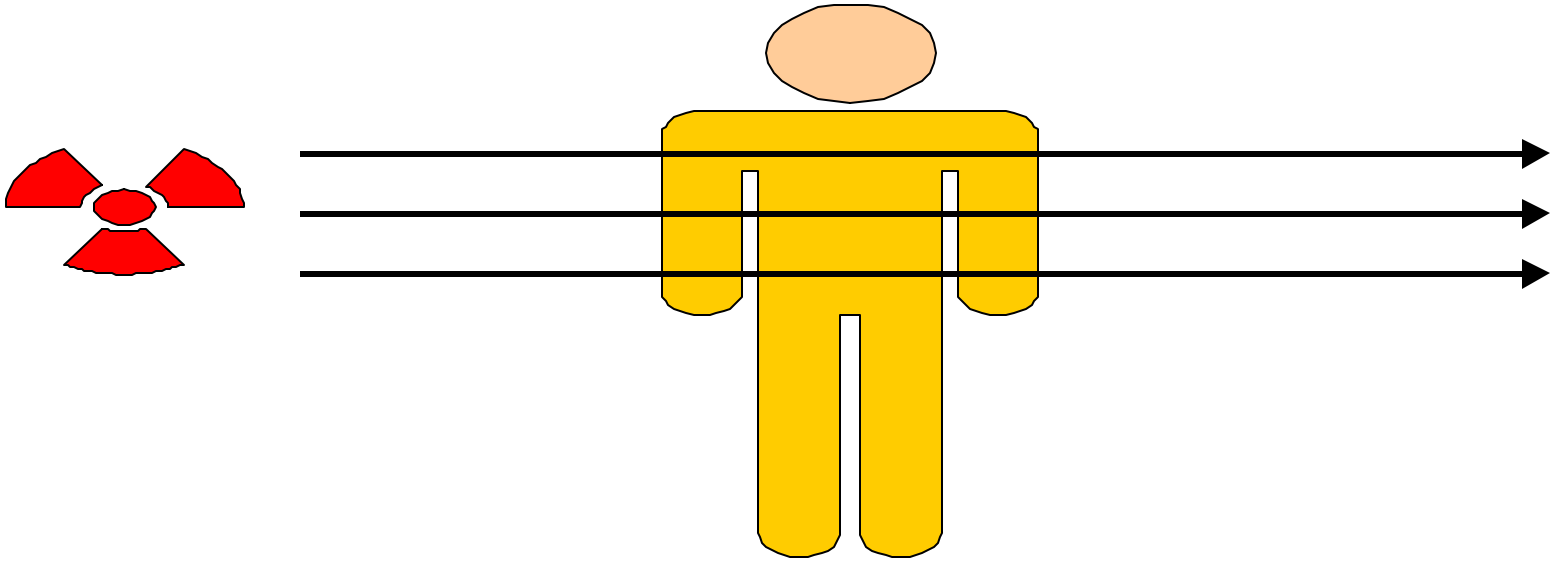
Respiratory System

Routes of Exposure: Ingestion



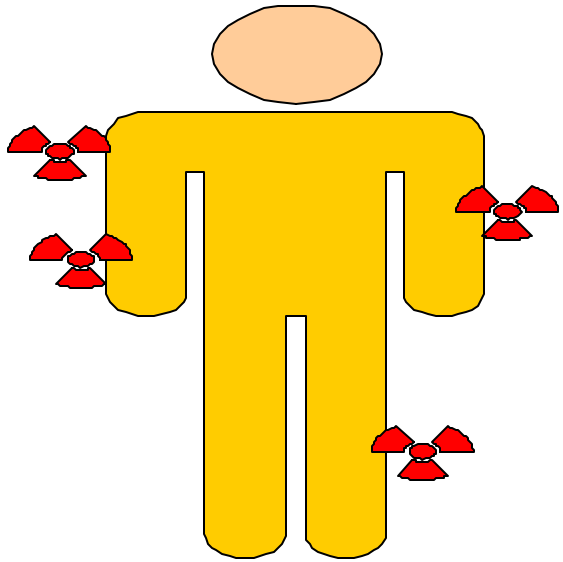
Digestive System

Exposure to External Sources



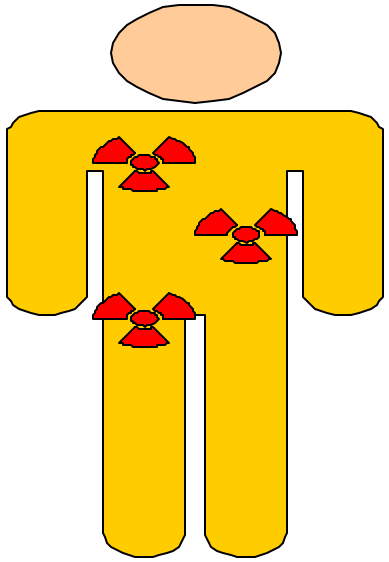
Patients exposed to external sources of radiation do not pose contamination problems

External Contamination



Externally-contaminated patients should be checked with radiation meters and given on-scene emergency care ASAP

Internal Contamination



Internally-contaminated patients must be given medical care for injuries but there is little you can do to treat radiation exposures