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RADIATION

Primary Care Paramedicine

Module: 20

Section: 02d

Lecture Outline

- Basic radiation definitions
- Exposure, contamination and incorporation
- Effects of radiation exposure
- Acute radiation sickness
- Radiation incident triage
- Radiation decontamination

Radiation

- Energy transmitted by electromagnetic waves or energetic particles
  - Sources: sun, soil, x-rays, occupational exposures encountered in the field
- Amount absorbed and exposure time affect degree of damage

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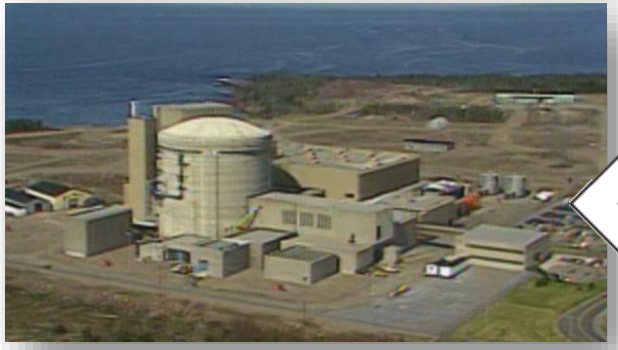
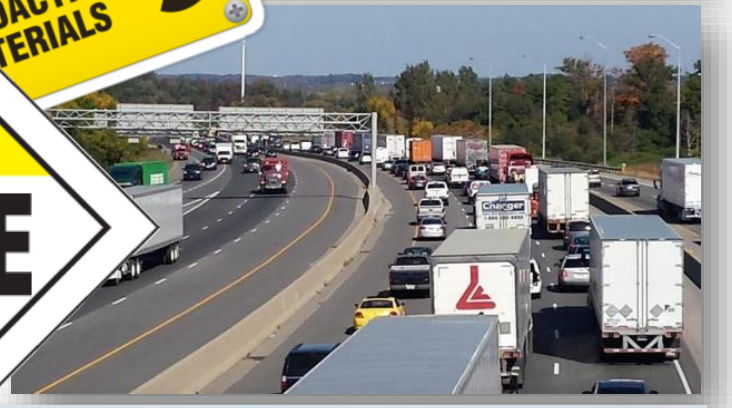
Radioactive Material





Radioactive Material

- Radioactive material consists of atoms with unstable nuclei.
- The atoms spontaneously change (decay) to more stable forms and emit radiation.
- A person who is contaminated has radioactive material on his/her skin or inside his/her body (e.g. inhalation, ingestion or wound contamination).

Radiologic/Nuclear Devices

- Sources of radiologic material
  - Hospitals, colleges/universities, chemical/industrial sites, power plants
- Radiologic dispersal devices
  - Dirty bombs
- Nuclear weapons
  - Nuclear bombs/missiles
  - Special Atomic Demolition Munitions (SADM)

Causes of Radiation Exposure/Contamination

Accidents

- Nuclear reactor
- Medical radiation therapy
- Industrial irradiator
- Lost/stolen medical or industrial radioactive sources
- Transportation

Terrorist Event

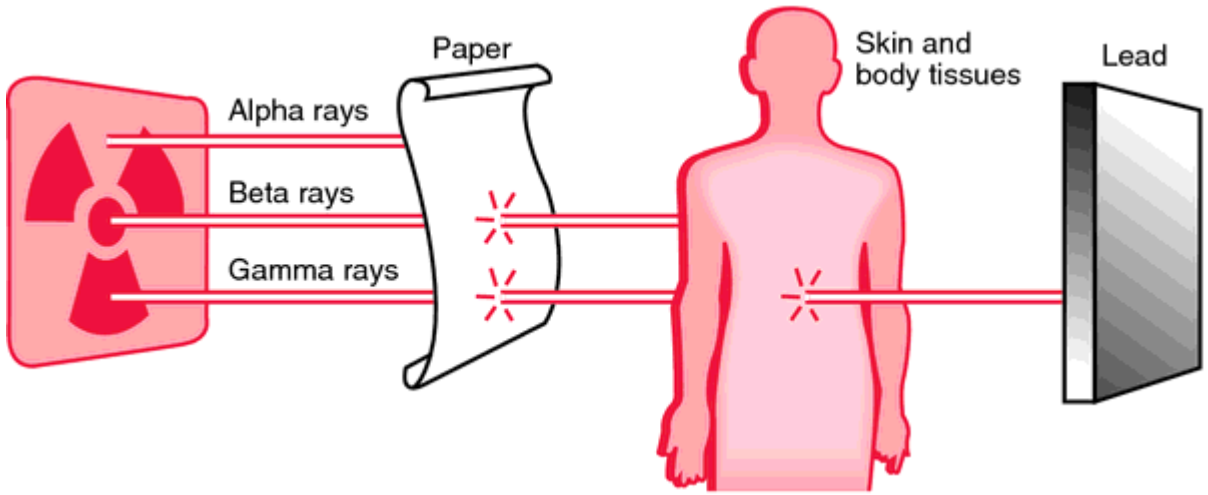
- Radiological dispersal device (dirty bomb)
- Attack on or sabotage of a nuclear facility
- Low-yield nuclear weapon

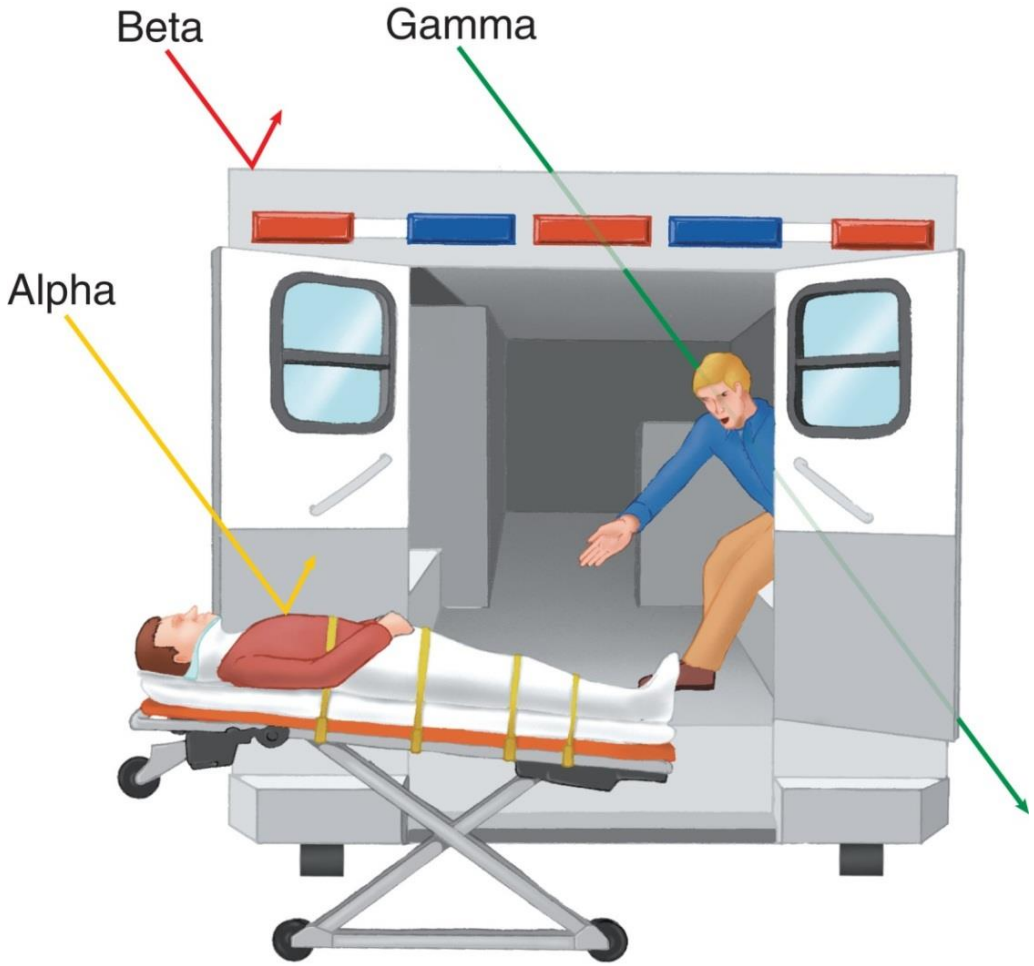
Ionizing Radiation

- Ionizing radiation is radiation capable of imparting its energy to the body and causing chemical changes.
- Ionizing radiation is emitted by:
  - Radioactive material
  - Some devices such as x-ray machines

Ionizing radiation

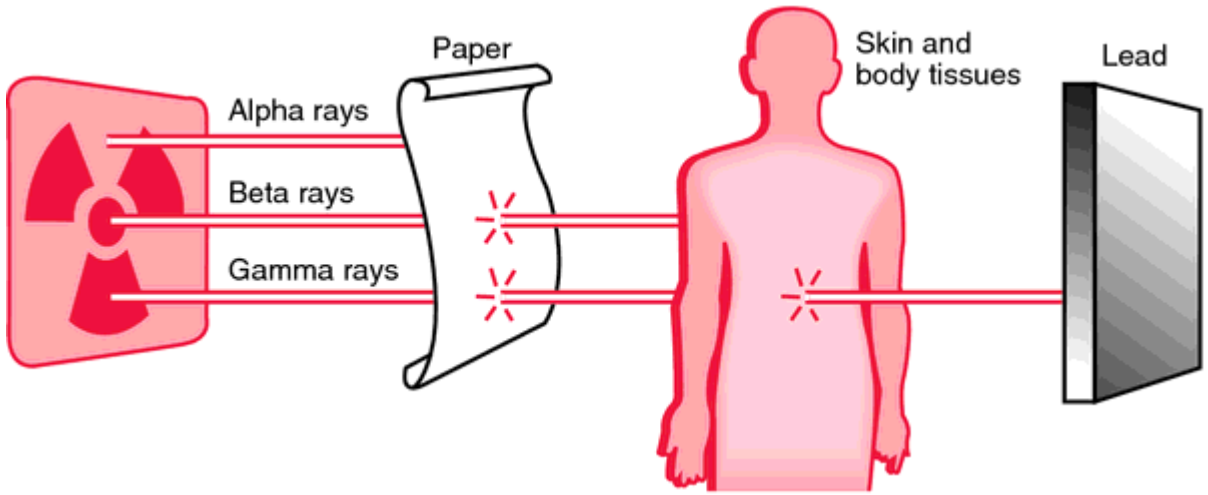
- Alpha
  - Can not penetrate human skin
  - Can be inhaled/penetrate open wounds

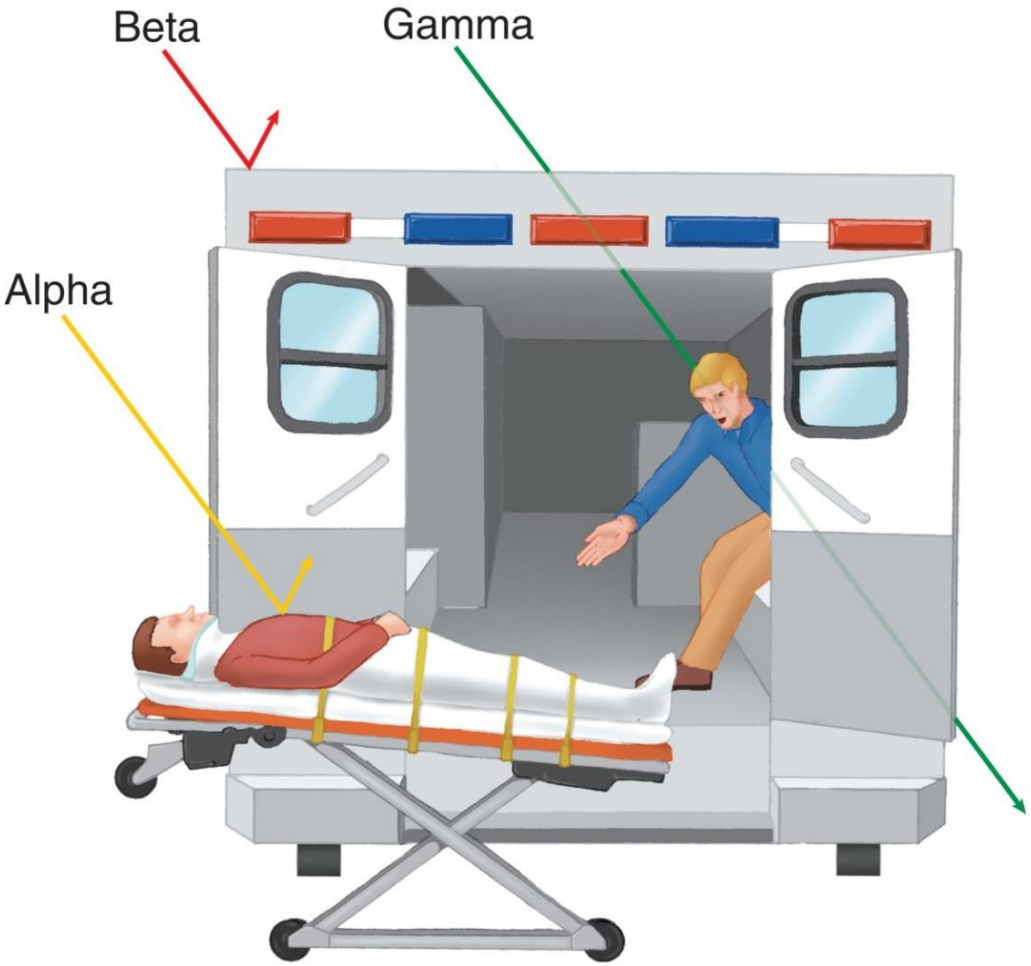




Ionizing radiation

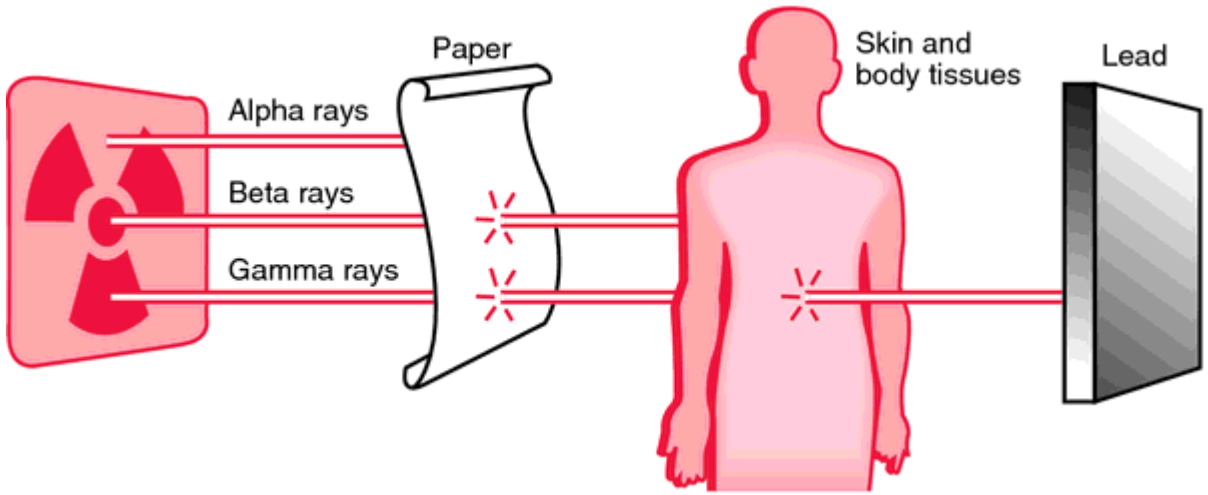
- Beta
  - Can penetrate human skin
  - Can not penetrate wood
  - If ingested/absorbed, beta particles can be absorbed into the bones

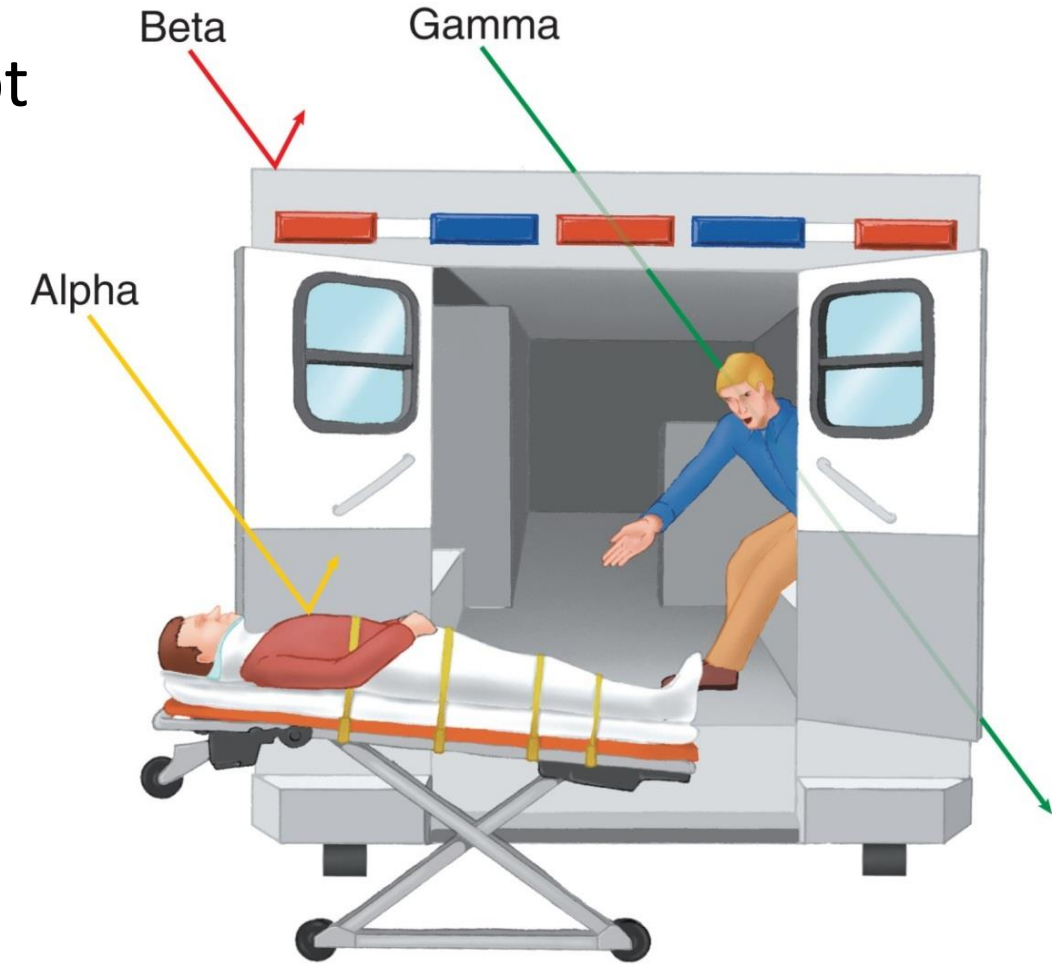




Ionizing radiation

- Gamma
  - Will penetrate almost everything except a concrete wall
  - Will cause severe damage to internal organs





Non-ionizing Radiation

- Comes from electromagnetic waves
- Does not have sufficient energy to change human cells
- Examples: Sound waves, radio waves, microwaves

Radiation Units

Measure of	Quantity	Unit
Amount of radioactive material	Activity	Curie (Ci)
Ionization in air	Exposure	Roentgen (R)
Absorbed energy per mass	Absorbed Dose	Rad
Absorbed dose weighted by type of radiation	Dose Equivalent	Rem

$1\ R \approx 1\ Rad \approx 1\ Rem$

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Detecting Radiation

- Radiation cannot be seen, heard, tasted or smelled
- But, it can be easily measured if you have the right equipment

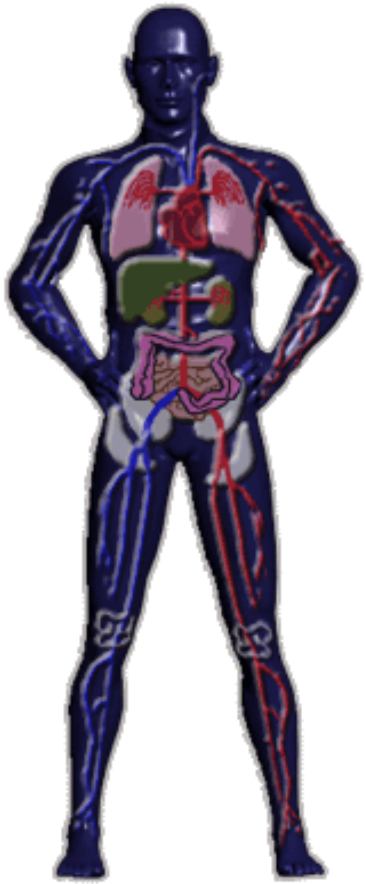
Exposure, Contamination and incorporation

- There are 3 ways a patient may be exposed to radiation:
  - Exposure to a source outside the body
  - Contamination with a radioactive source
  - Incorporation of the material into body tissues

Exposure vs Contamination

- External Exposure: external irradiation of the body with rays or particles → absorbed dose

- Contamination: radioactive material (radionuclides) on patient (external) or within patient (internal)



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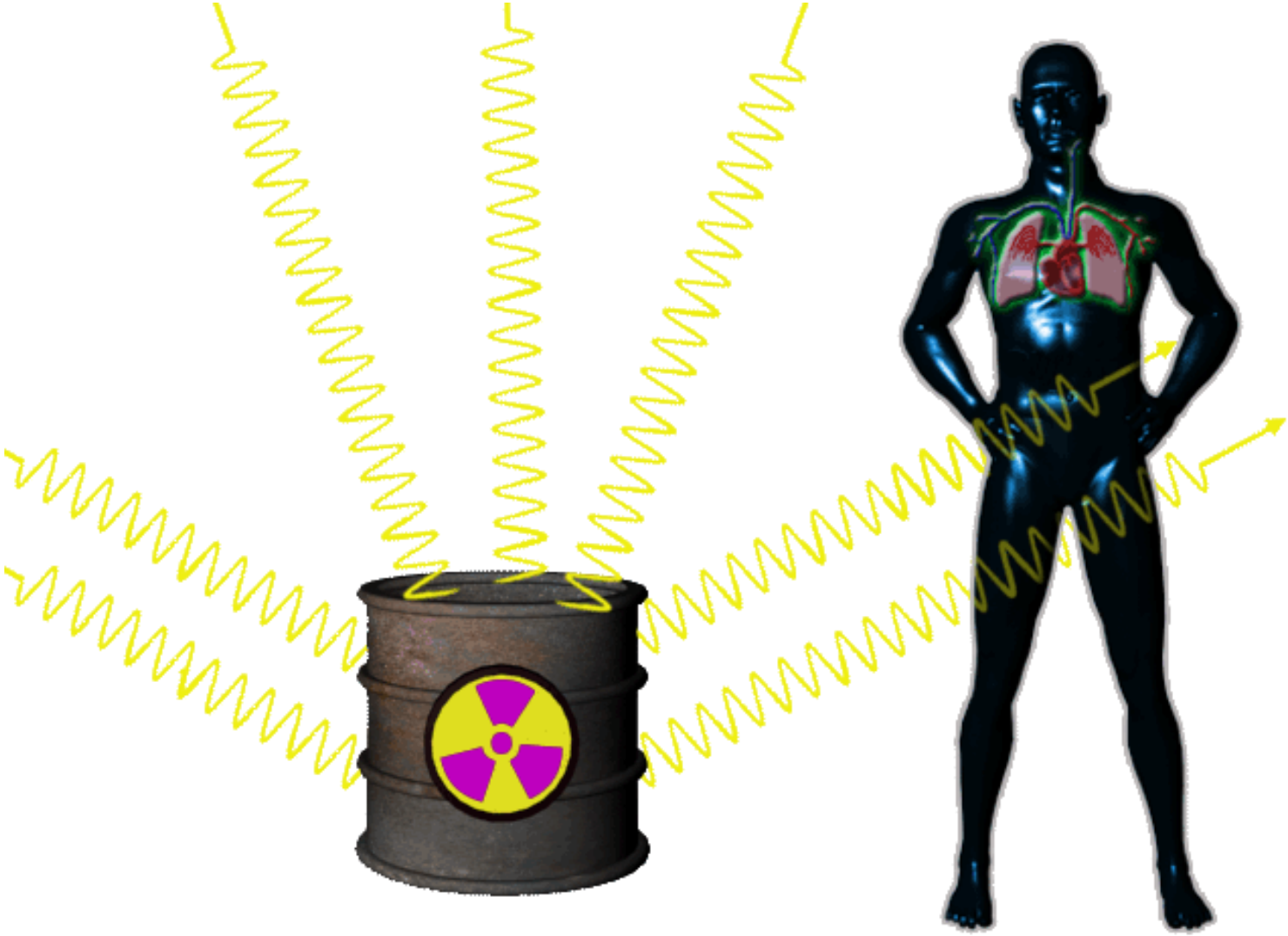
Exposure



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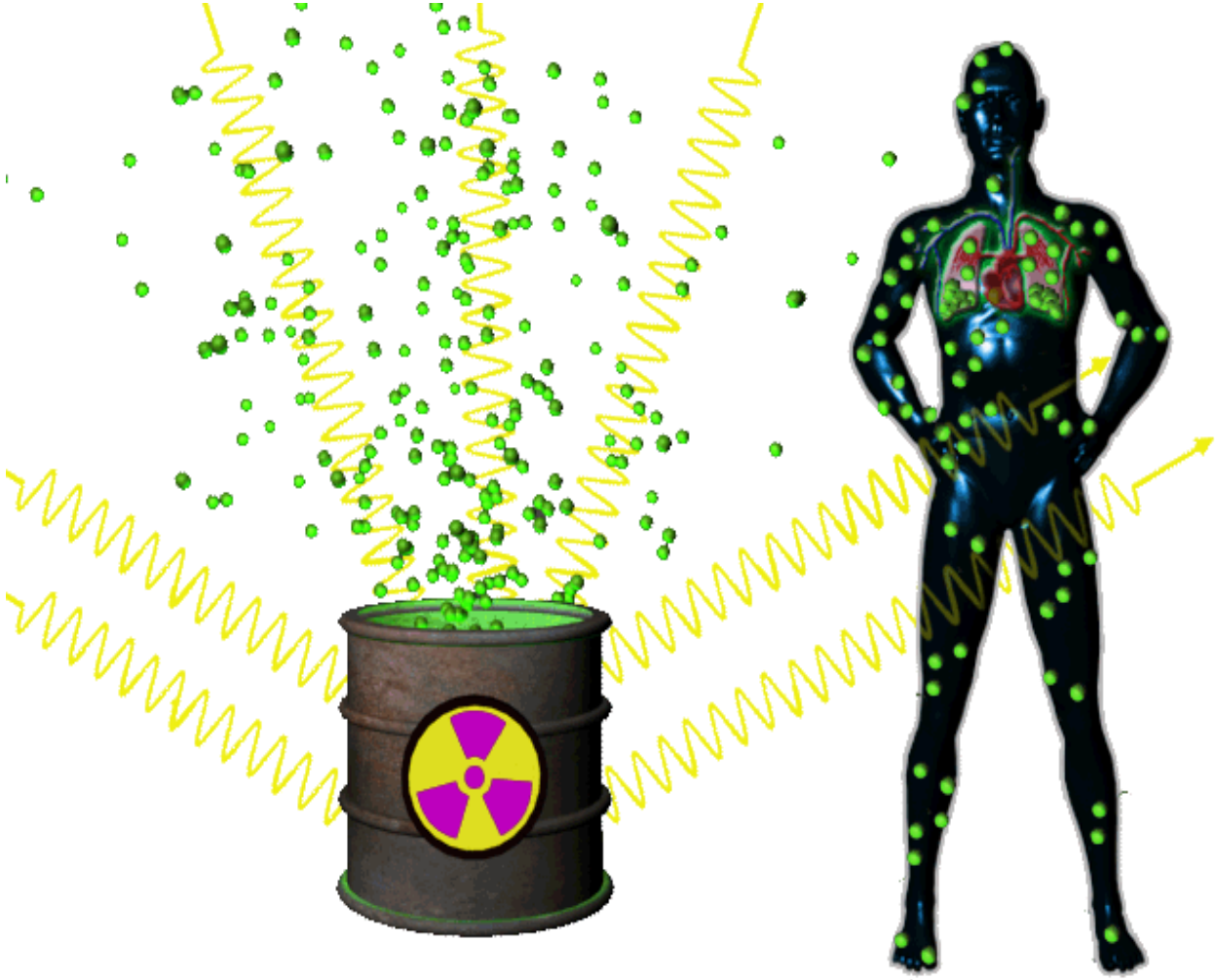
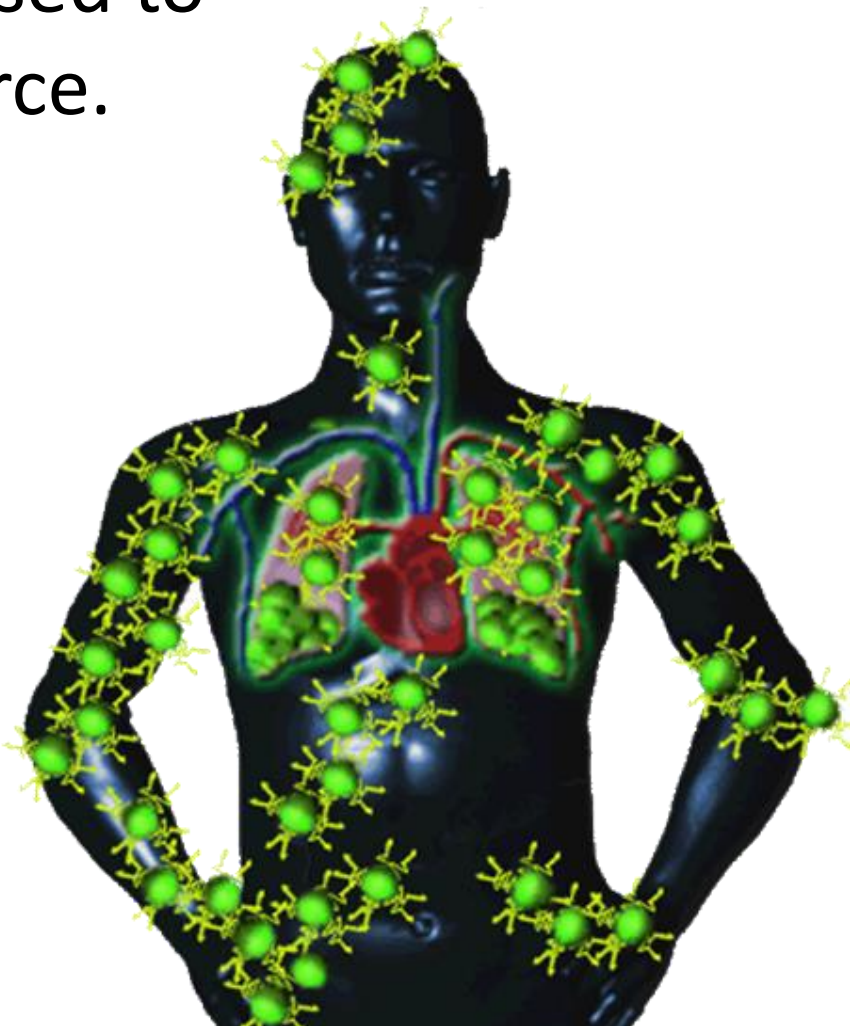
Radioactive Material



External Contamination

- Occurs when all or part of the body is exposed to penetrating radiation from an external source.
- Can be absorbed by the body or it can pass completely through.
- Patient not radioactive



Internal Contamination

- Contact with radioactive material (radionuclides) that can be spread to other people/properties
- Inhaled, ingested, transferred from surface to surface

Incorporation

- Following contamination, radioactive materials are incorporated into the cells of the body
- Refers to the uptake of radioactive materials by body cells, tissues and target organs

Chemical vs. Radiological Contamination Terminology

Chemical

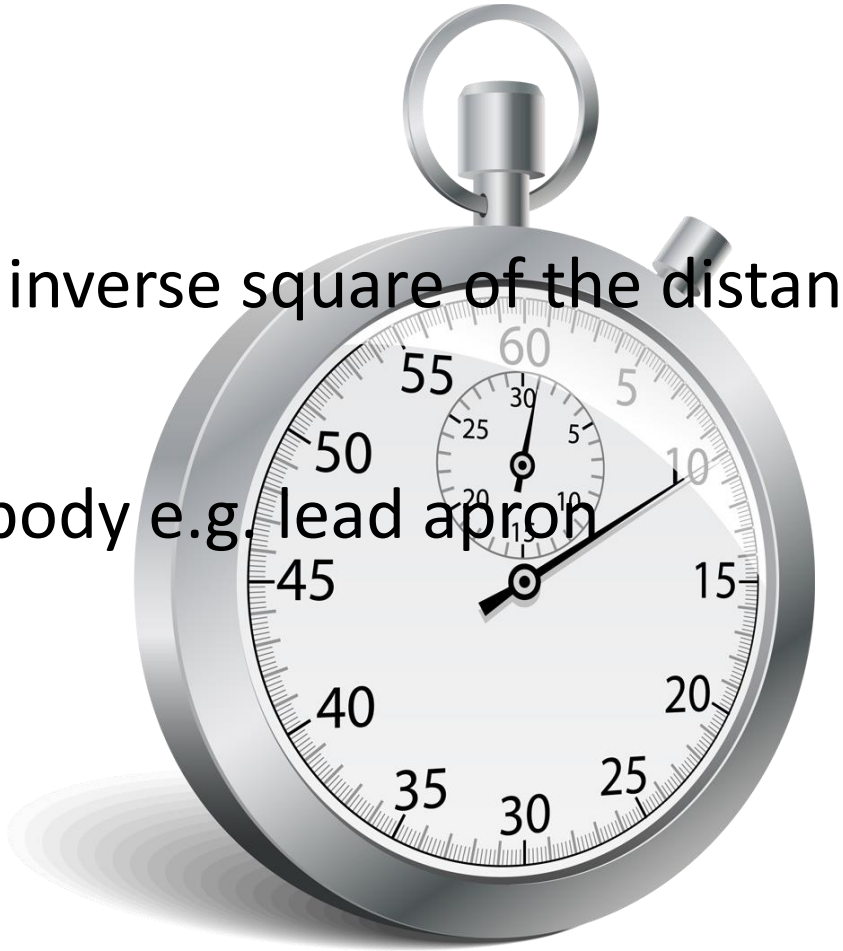
- Absorption
- Distribution
- Metabolism
- Elimination

Radiological

- Internal contamination
- Incorporation
- Incorporation
- Decorporation

Factors Determining Radiation Exposure

- Time
  - Longer exposed, greater the risk
- Distance
  - The degree of exposure varies with inverse square of the distance
- Shielding
  - Reduce exposure by shielding your body e.g. lead apron



Effects of Radiation exposure

- Radiation damages the main components of the cell, particularly the cell membrane, proteins and DNA.
- Direct damage causes breaks in DNA strands
- Indirect produces free radicals and by-products of water ionization to damage DNA.

Effects of Radiation Exposure

- Deterministic effects (dose dependent) occur relatively quickly and include Acute Radiation sickness, cataracts and birth defects.
- Stochastic effects (low level exposure) occur months to years later. This includes cancer and birth defects

Injuries Associated with Radiological Incidents

- Acute Radiation Syndrome (ARS)
- Localized radiation injuries/cutaneous radiation syndrome
- Internal or external contamination
- Combined radiation injuries with
  - Trauma
  - Burns
- Fetal effects

Ionizing Radiation

Table 36-4 Dose-Effect Relationships to Ionizing Radiation

Whole Body Exposure	
Dose (RAD)	**Effect**
5–25	Asymptomatic. Blood studies are normal.
50–75	Asymptomatic. Minor depressions of white blood cells and platelets in a few patients.
75–125	May produce anorexia, nausea, and vomiting, and fatigue in approximately 10–20% of patients within two days.
125–200	Possible nausea and vomiting. Diarrhea, anxiety, tachycardia. Fatal to less than 5% of patients.
200–600	Nausea and vomiting, diarrhea in the first several hours, weakness, fatigue. Fatal to approximately 50% of patients within six weeks without prompt medical attention.
600–1,000	Severe nausea and vomiting, diarrhea in the first several hours. Fatal to 100% of patients within two weeks without prompt medical attention.
1,000 or more	"Burning sensation" within minutes, nausea and vomiting within 10 minutes, confusion ataxia, and prostration within one hour, watery diarrhea within 1–2 hrs. Fatal to 100% within short time without prompt medical attention.

Localized Exposure	
Dose (RAD)	**Effect**
50	Asymptomatic.
500	Asymptomatic (usually). May have risk of altered function of exposed area.
2,500	Atrophy, vascular lesion, and altered pigmentation.
5,000	Chronic ulcer, risk of carcinogenesis.
50,000	Permanent destruction of exposed tissue.

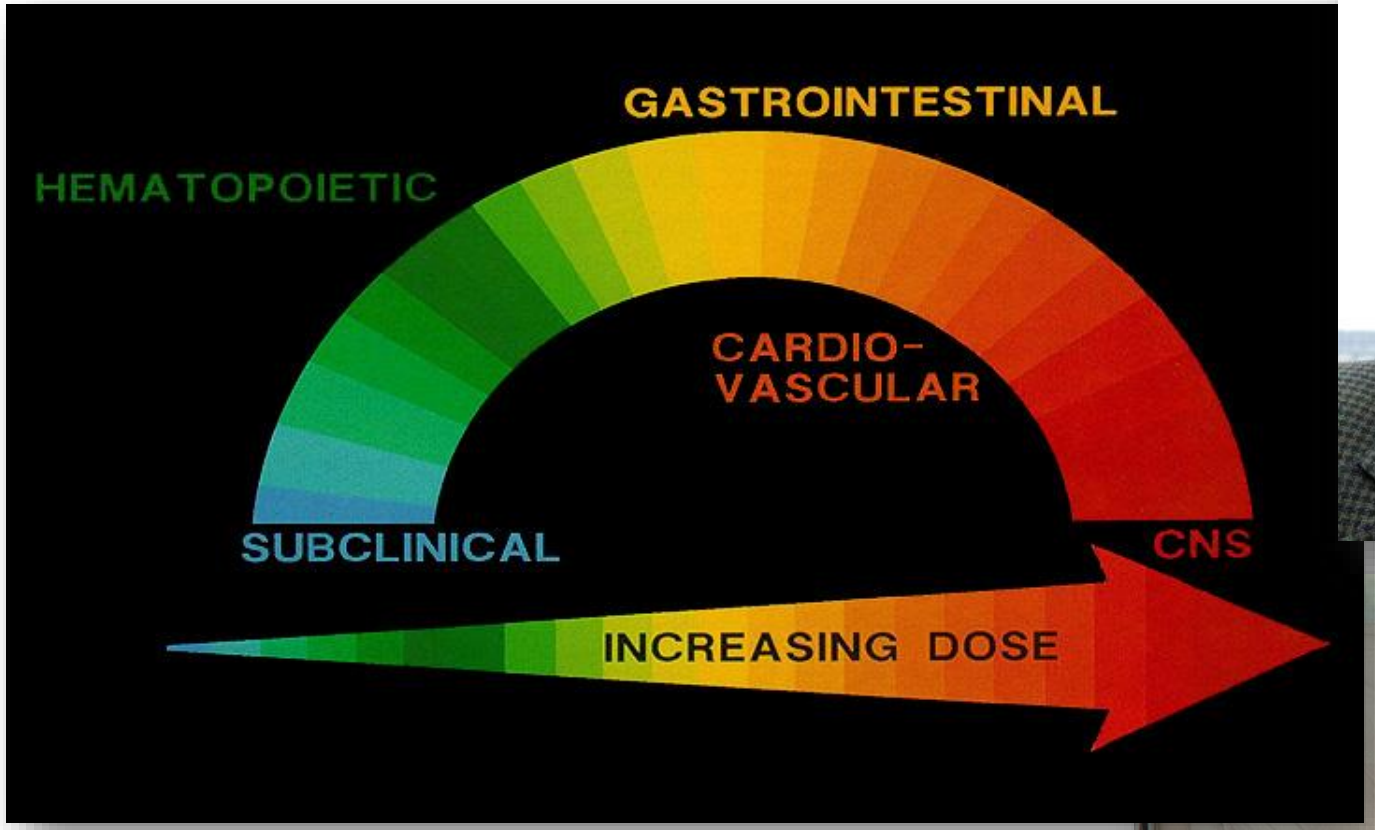
Signs and Symptoms of Radioactive Exposure

- Vary depending on:
  - Amount of radiation and route of exposure
- Three levels
  - Radioactive exposure
  - External contamination
  - Internal contamination

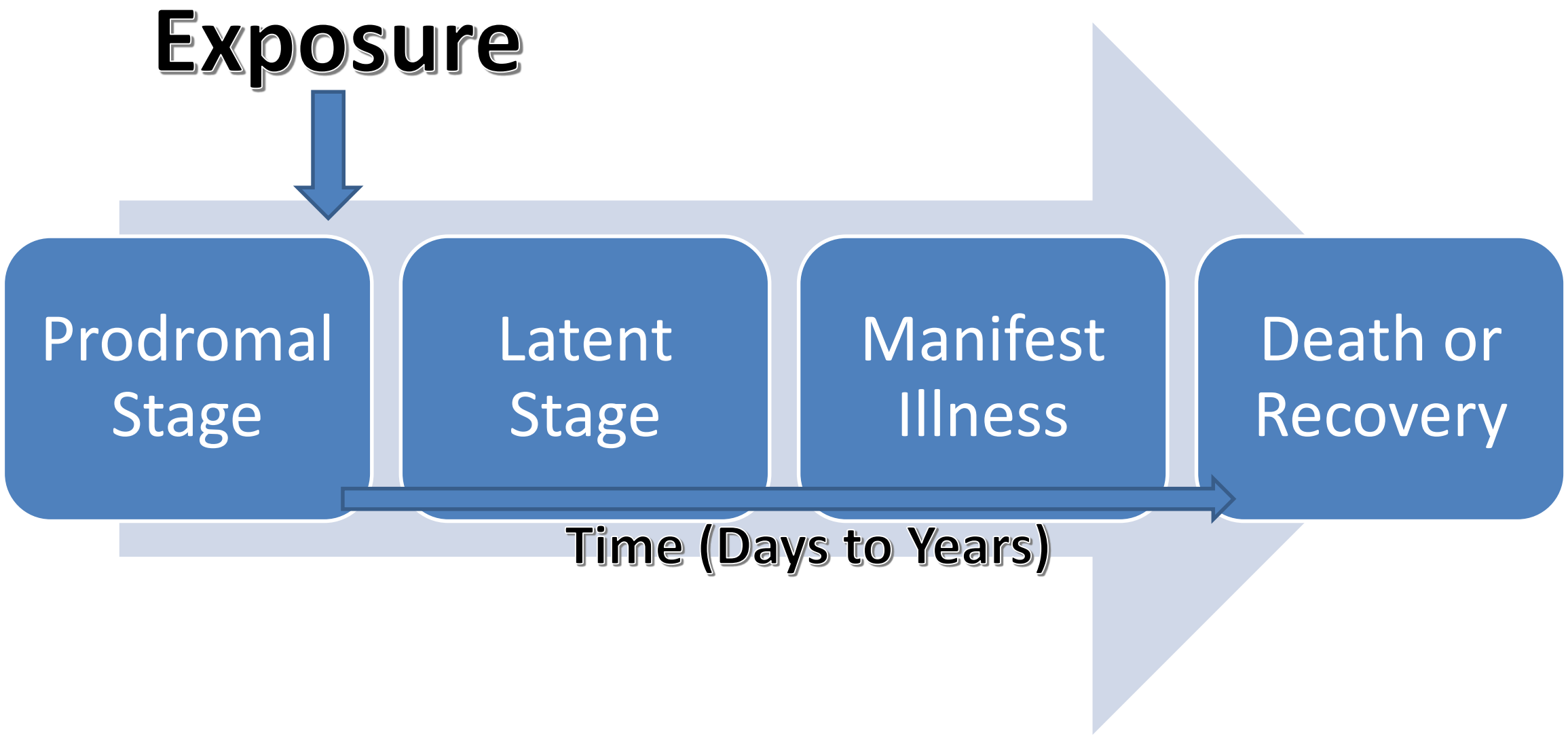
Acute Radiation Syndrome

- Onset of symptoms is dependent on the levels of exposure for the patient, from hours to weeks.
- Rapidly dividing cells tend to be effected first (blood cells, GI tract and skin). Loss of these cells compounds the effects exponentially.

Acute Radiation Syndrome
A Spectrum of Disease



Phases of Acute Radiation Syndrome



Stages of Acute Radiation Syndrome

- Stage 1: Subclinical (50 - 150 rads)
  - No symptoms or minimal viral symptoms for up to 48 hours
  - Spontaneous recovery usually occurs
  - Sterility is a risk
- Stage 2: The Hematopoetic Syndrome (150 - 400 rads)
  - Whole body exposure
  - Bone marrow suppression occurs with loss of WBC and platelets
  - Infection and bleeding problems occur
  - LD 50 250 - 400 rads

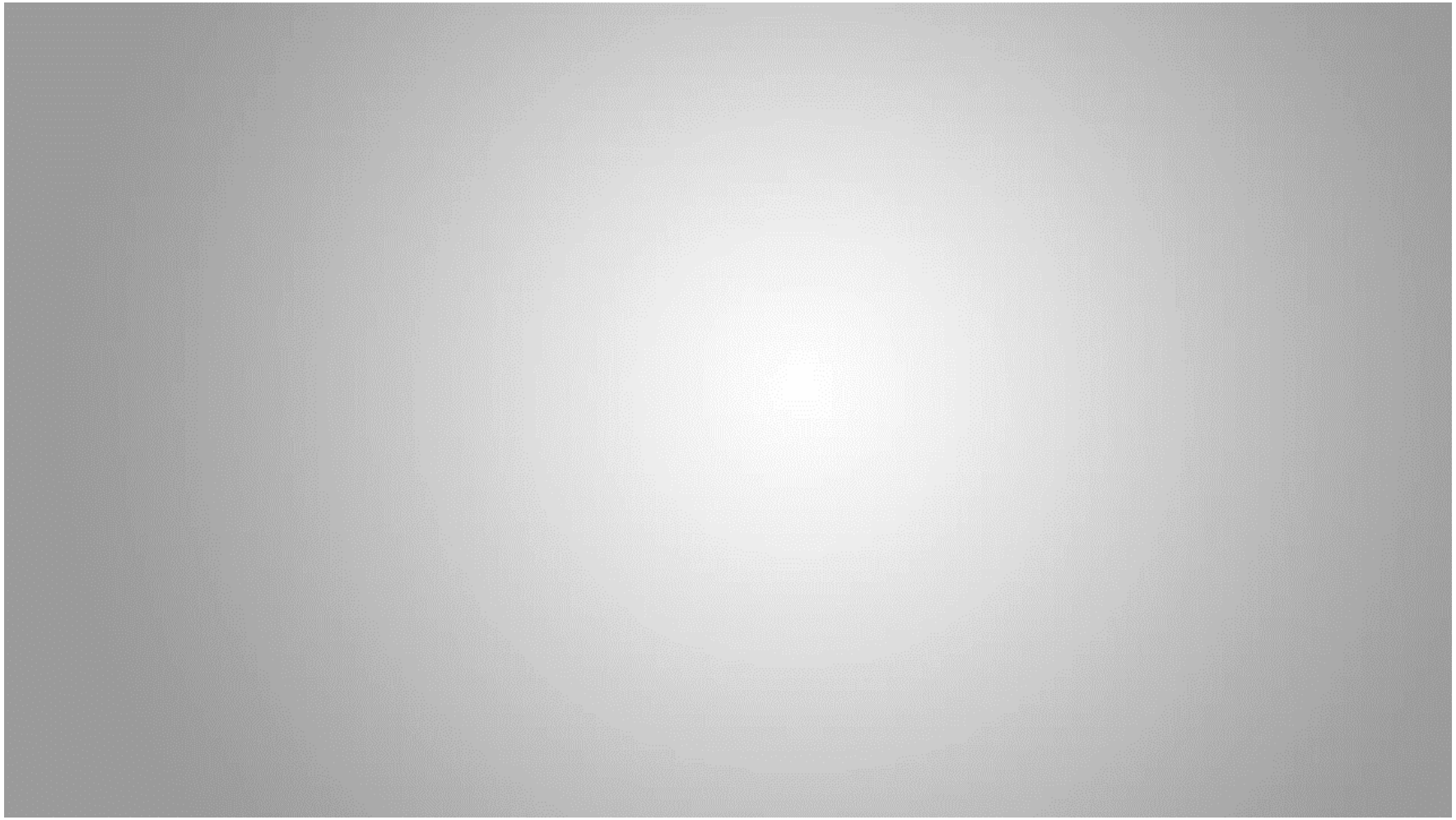
Stages of Acute Radiation Syndrome

- Stage 3: Severe Hematopoetic Syndrome (150 - 400 rads)
  - Life saving bone marrow transplantation needed
  - Care rationing during MCI will lower LD50
- Stage 4: The Gastrointestinal Syndrome (400 - 1500 rads)
  - GI lining cells die
  - Severe diarrhea and electrolyte losses
  - Life saving fluid and electrolyte replacement

Stages of Acute Radiation Syndrome

- Stage 5: The CNS Syndrome (>1500 rads)
  - Confusion, ataxia and sensory deficits
  - Death within 48 hrs regardless of treatment
  - Early appearance of CNS symptoms is an ominous sign

Stages of Acute Radiation Syndrome



Pre-Hospital Management

- Evacuation of persons who are in the path of a radiation cloud is the most effective pre-hospital measure
  - This action is the responsibility of public health authorities
- Need effective communication with residents as to steps they can take to reduce exposure

Radiation Triage

- Despite the seriousness of the exposure, triage priorities focus on decontamination and medical stabilization.
- Patients with trauma and radiation exposure need to be stabilized within the first 48 hours. After that point surgery is avoided for 2-3 months until resolution of loss of platelets, RBC’s and immunocompromised

Decontamination

- Needs to be conducted by specially trained personnel. (FD HazMat or Military Nuclear Emergency Response Team)

Radiation Decontamination

- Respiratory
  - Adequate ventilation and oxygenation.
- Skin/ Hair
  - Remove all clothing and jewelry, wash with warm water and soap while avoiding vigorous scrubbing.
  - Skin decon is not required for exposure to gamma rays or radioactive gas exposure

Patient Management - Priorities

- Initial triage and decontamination are ideally done outside the hospital (have a plan in place) to avoid contamination of the ED
- Patients exposed only to external EM radiation (e.g. x-ray or gamma rays) are not radioactive; patients exposed to particulate radiation will be radioactive
- Standard medical triage is the highest priority
- Radiation exposure and contamination are secondary considerations

Management

- Contaminated patient – immediately isolate until monitored and decontaminated
  - Monitor EMS and ambulance
- ABC's
- Cover all wounds
- Radiation burns are like sun burns

External Contamination

- Radioactive material (usually in the form of dust particles) on the body surface and/or clothing
- Radiation dose rate from contamination is usually low, but while it remains on the patient it will continue to expose the patient and staff

Key Points

- Ionizing radiation includes:
  - Electromagnetic radiation: X and gamma
  - Particulate radiation: alpha, beta, neutrons
- Patient can be:
  - Irradiated externally
  - Contaminated with radionuclides
- Which patients are radioactive?
  - Those contaminated with radionuclides
  - These patients need to be decontaminated
  - Some internally deposited radionuclides can be removed with chelation therapy

Key Points

- Protect yourself from radiation:
  - Reduce the time of exposure
  - Increase the distance from the radiation source
  - Apply shielding between yourself and the radiation source
- Acute Radiation Syndrome:
  - Stages progress from hematopoietic to gastrointestinal to central nervous system with increasing dose
  - The absolute lymphocyte count is the best predictor of dose
- Long-term consequences
  - Increase in cancer, especially thyroid cancer
  - With radioiodine exposure, thyroid dose can be reduced by using KI (potassium iodide)