Irradiation and Radiation Safety

IUH AHC Blood Bank
JKS

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Indiana University Health

Why do we irradiate blood?

To prevent transfusion-associated Graft-Versus-Host-Disease (GVHD)

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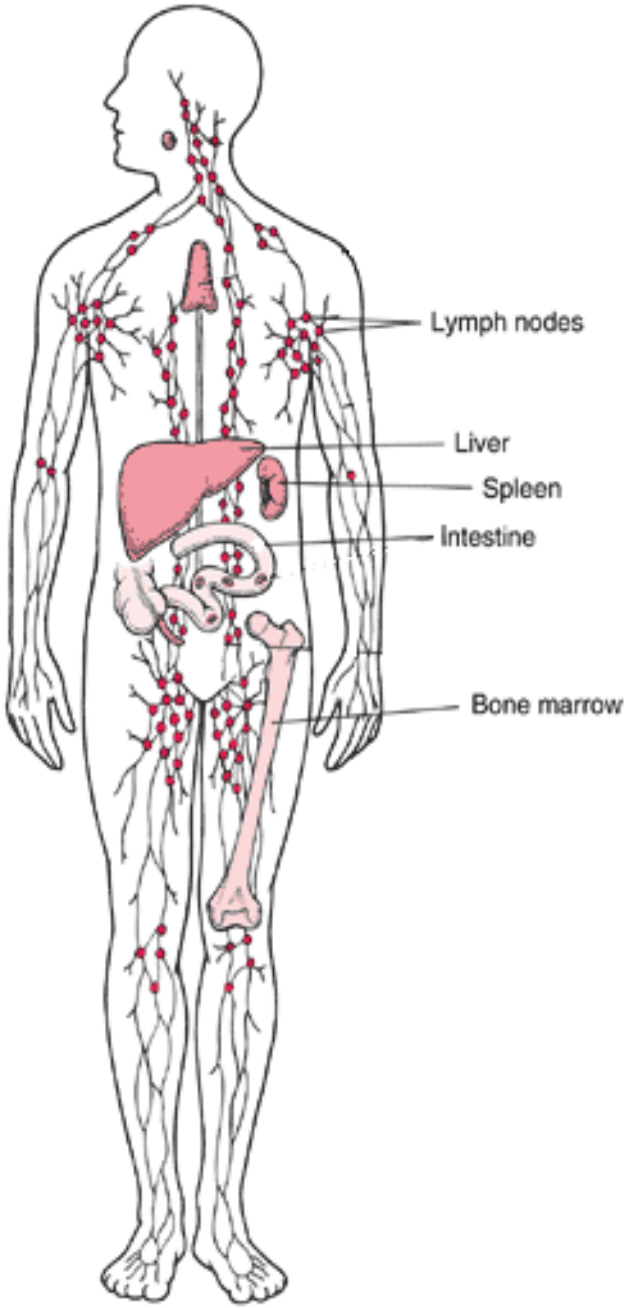
What is GVHD?

GVHD is a transfusion-associated complication that occurs when:

- There is incomplete histocompatibility between the donor and recipient
- Immunocompetent cells are present in the transfused component

Organs and systems affected by Graft Versus Host Disease

- Spleen
- Liver
- Gastrointestinal tract
- Bone marrow
- Lymph nodes
- Skin



Manifestations of GVHD

- Fever
- Skin rash
- Loss of appetite
- Nausea
- Vomiting
- Diarrhea
- Hepatitis
- Bone marrow suppression
- Death

Patients at risk for GVHD

- Immunocompromised individuals:
  - Bone marrow transplant patients
  - Chemotherapy patients
  - Radiation therapy patients
  - Fetuses and newborns
  - Heart, lung and liver transplant patients

- Non-immunocompromised individuals:
  - Recipients with same haplotype as the donor (genetically similar)
  - Blood relatives of the donor

Treatment of GVHD

- Treatment of acute onset GVHD is usually unsuccessful
- Patients with chronic GVHD may respond to immunosuppressive regimens including steroids and alkylating agents
- Because therapies have mostly been unsuccessful, prevention is paramount

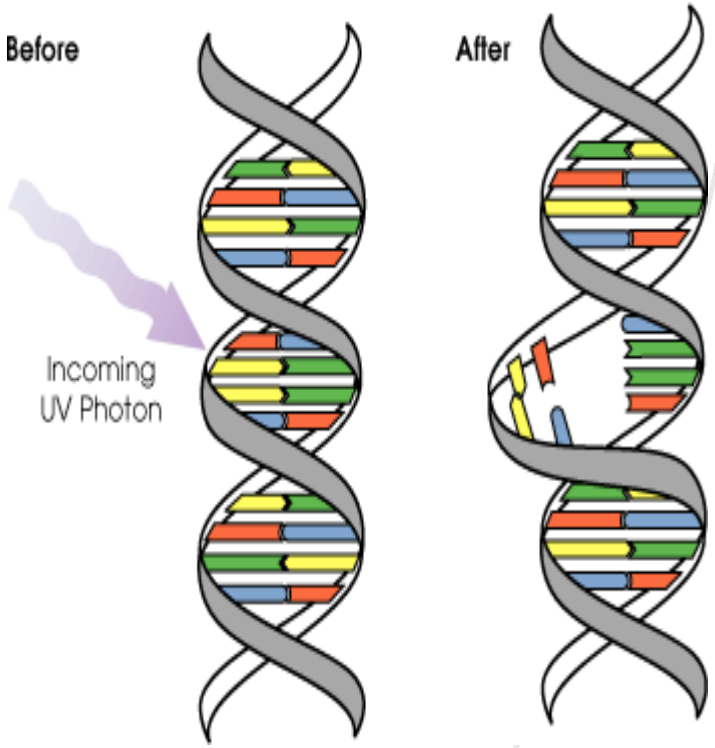
How is GVHD prevented?

Graft-Versus-Host-Disease is prevented by *irradiating blood* and platelets for all recipients who either are immunocompromised or who are blood relatives of the donor.

What happens when blood is irradiated?

When cellular blood components are irradiated, they are exposed to 25Gy of radiation:

- A sufficient dose of radiation to damage the DNA of the donor lymphocytes
- Rendering the lymphocytes incapable of replication, without affecting the function of red cells, platelets or granulocytes.



Effect on other blood cells

- Red Blood Cells:
  - Intracellular potassium loss
  - Increased free Hgb levels in supernatant
  - Cell viability shortened (28 days max)

- Platelets:
  - No qualitative or quantitative changes up for doses up to 50 Gy

Radiation Safety

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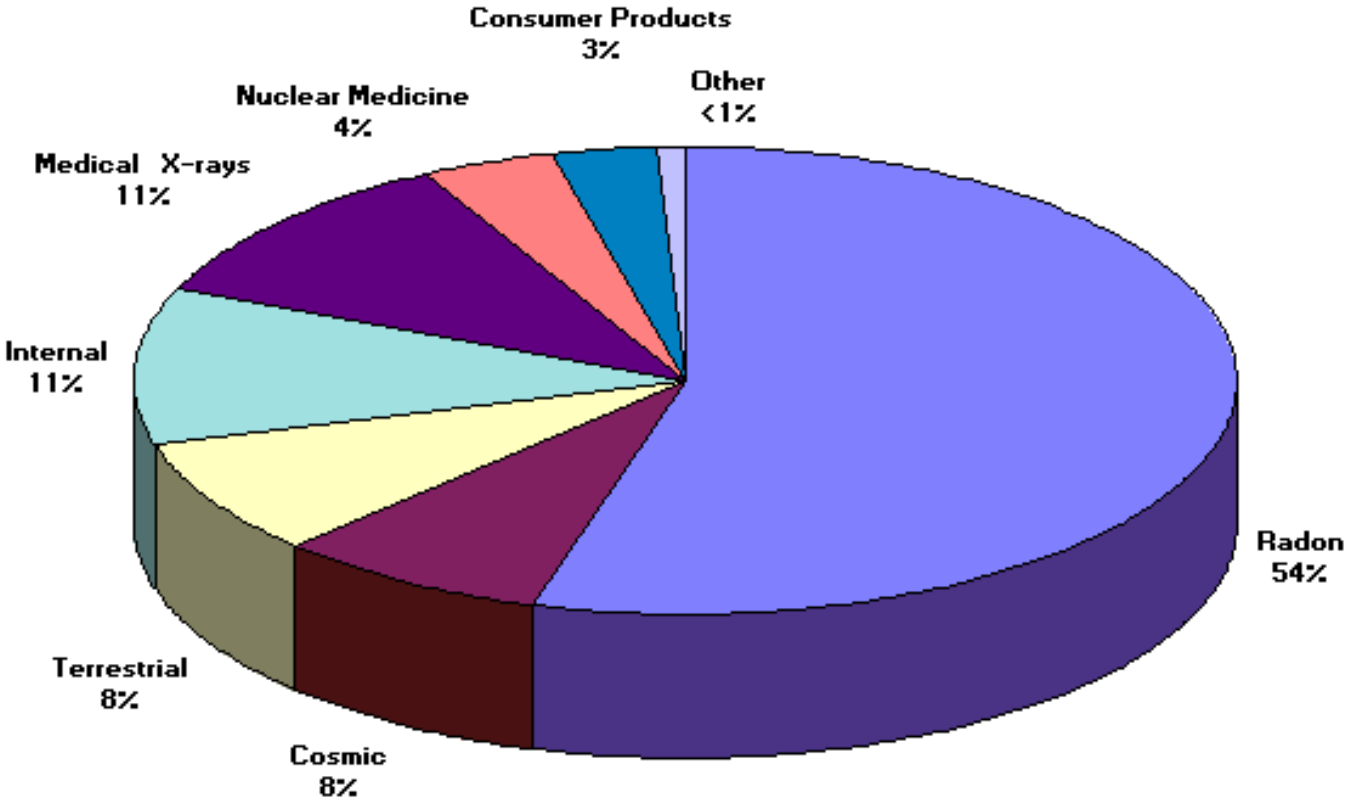
What is radiation?

Radiation is the process by which energy is emitted or propagated in the form of rays, waves or particles.

Forms of radiation

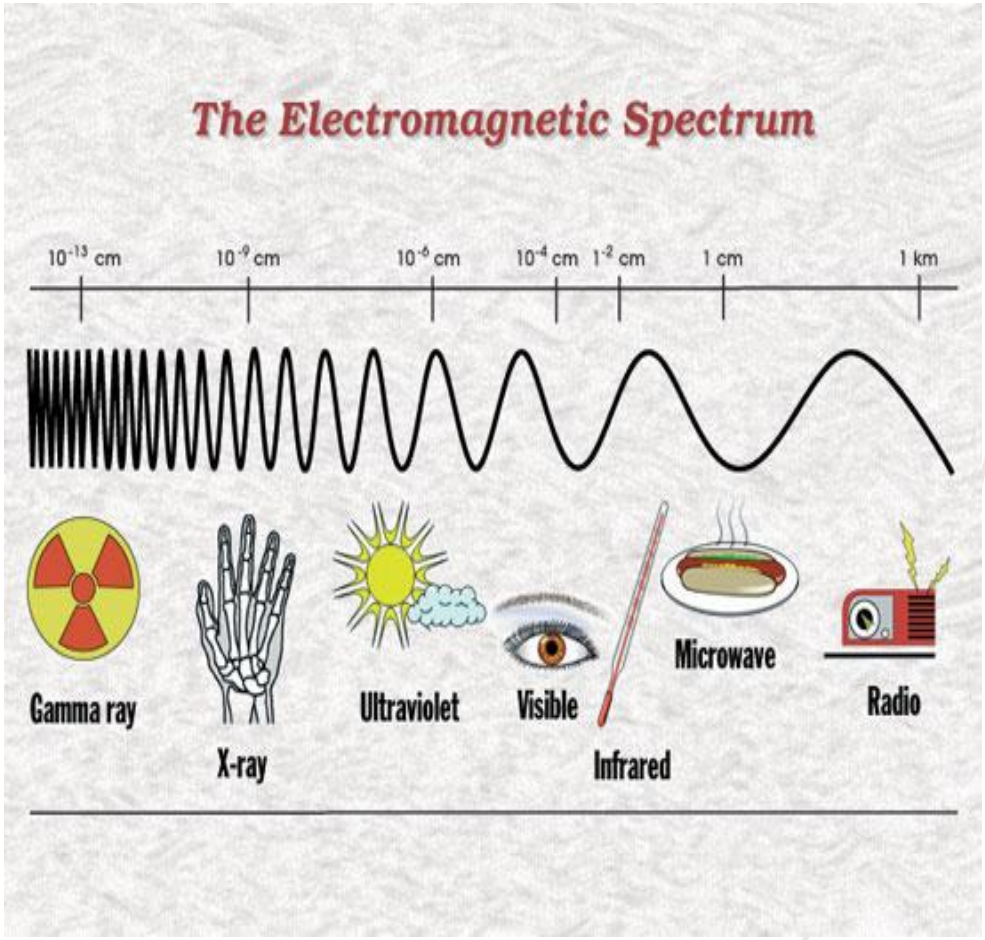
- Sunrays (Ultraviolet)
- Heat (Infrared)
- Visible light
- Microwaves (cooking; communication)
- Radio waves (radio and television)
- Background radiation (geologic or cosmic in origin)
- Nuclear radiation (x-rays used in medicine)

Sources of Radiation Exposure to the US Population



Radiation

- Radiant energy is energy traveling in a wave motion
- Electromagnetic radiation is measured in wavelengths
- Radiation is the process of emitting radiant energy
- There are two types of radiant energy:
  - Ionizing
  - Non-ionizing

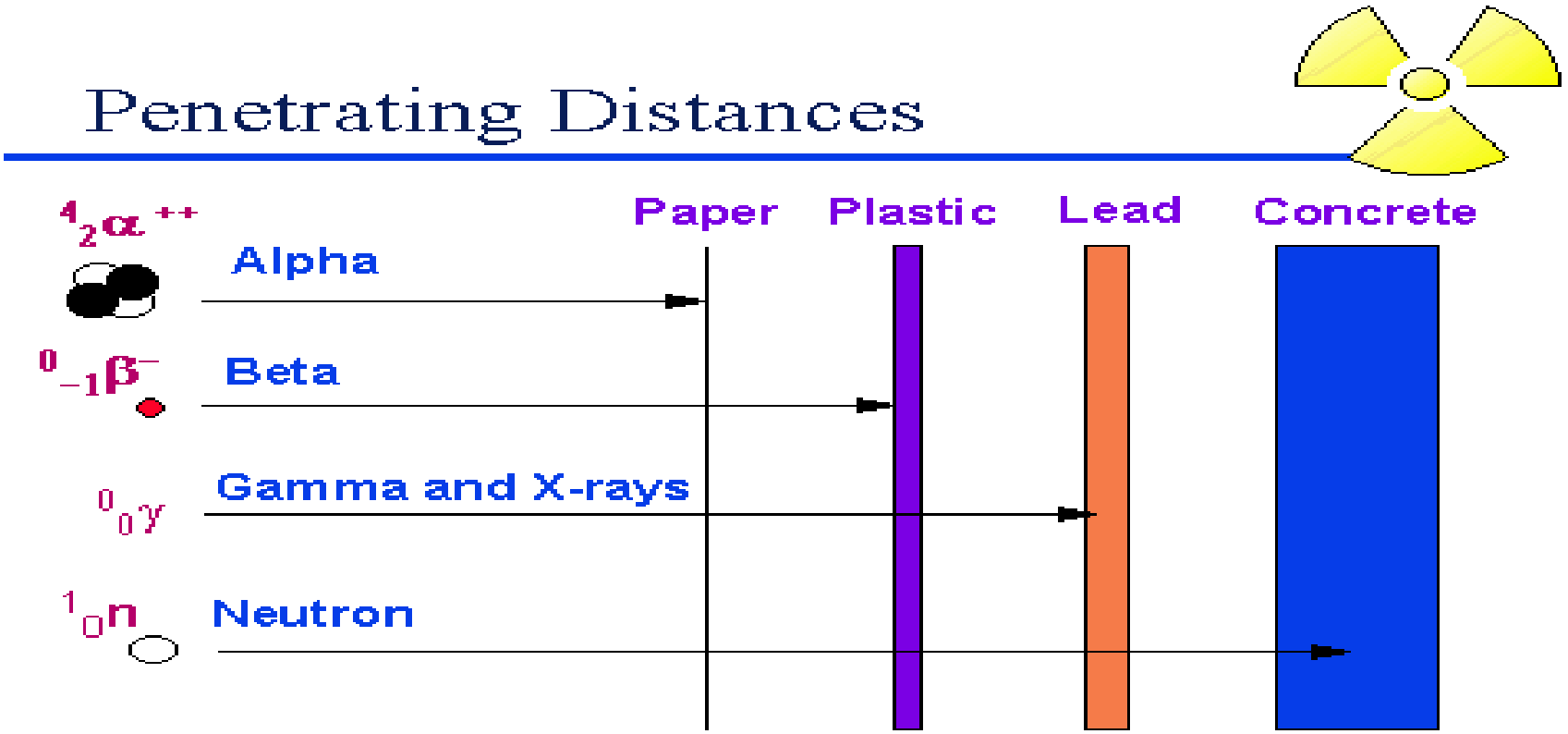


Types of radiation

- **Non-ionizing radiation**
  - Type of energy that when striking an object it causes vibration leading to friction and therefore heat but not enough movement to remove tightly bound electrons from their orbit
  - Example: ordinary white light

- **Ionizing radiation**
  - When an atom is exposed to ionizing radiation there is enough energy to remove electrons from their orbits causing the atom to become charged or ionized
  - Examples: photons (x-rays, gamma rays), alpha and beta particles, neutrons

Radiation penetration



Ionizing radiation

Gamma Rays:

- A photon, similar to ordinary visible light but shorter in wavelength than ultraviolet light, hence the higher energy level
- Produced following spontaneous decay of cobalt-60 or cesium-137 (the CIS-US IBL 437 Irradiator utilizes cesium-137 as its radioactive material)
- Can travel unimpeded for great distances
- Can easily go right through people but can be blocked by lead

Ionizing radiation

X-rays:

- Also a photon, has similar characteristics to gamma rays
- When high speed electrons hit metals such as tungsten, electrons are deflected and release energy in the form of electromagnetic waves (x-rays)
- As with gamma rays, x-rays have high penetration (depending on energy level) and can readily penetrate the body

Limiting Radiation Exposure

The three variables to keep in mind are:

Time

Distance

Shielding

Time

- Decrease the Time, Decrease the Exposure
- Increase the Time, Increase the Exposure

Distance

- Increase the Distance, Decrease the Exposure
- Decrease the Distance, Increase the Exposure

Shielding

- Increase the Shielding, Decrease the Exposure
- Decrease the Shielding, Increase the Exposure

Measuring Radiation

As part of quality control and safety procedures, it is necessary to monitor the function, efficacy and safety of the irradiator. Radiation measurement devices include:

- Survey meters (Geiger counter)
- Dosimeters (Film badges are not required at FBS)
- Rad-sure labels (indicator changes when exposed to adequate dose of radiation)

ALARA

As Low As Reasonably Achievable

ALARA is the acronym for *As Low As Reasonably Achievable*, a radiation safety principle for minimizing radiation doses and releases of radioactive materials by employing all reasonable methods.

ALARA is practiced through safety training, continuing education, quality and safety controls.

Summary

- Irradiation for Prevention of GVHD

- Radiation Safety