Radiation and Chemical Exposure

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Historic radiation disasters

TABLE 2–7. Radiation Disasters

Toxin	Location	Date	Significance
Radium	Orange, NJ	1910s–1920s	Increase in bone cancer in dial-painting workers
Radium	US	1920s	"Radithor" (radioactive water) sold as radium-containing patent medication
Radiation	Hiroshima and Nagasaki, Japan	1945	First atomic bombs dropped at end of World War II; clinical effects still evident today
Radiation	Chernobyl, USSR	1986	Human error produced an explosion that scattered radiation throughout Europe and beyond
Cesium	Goiania, Brazil	1987	Acute radiation sickness and radiation burns

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Radiation exposure

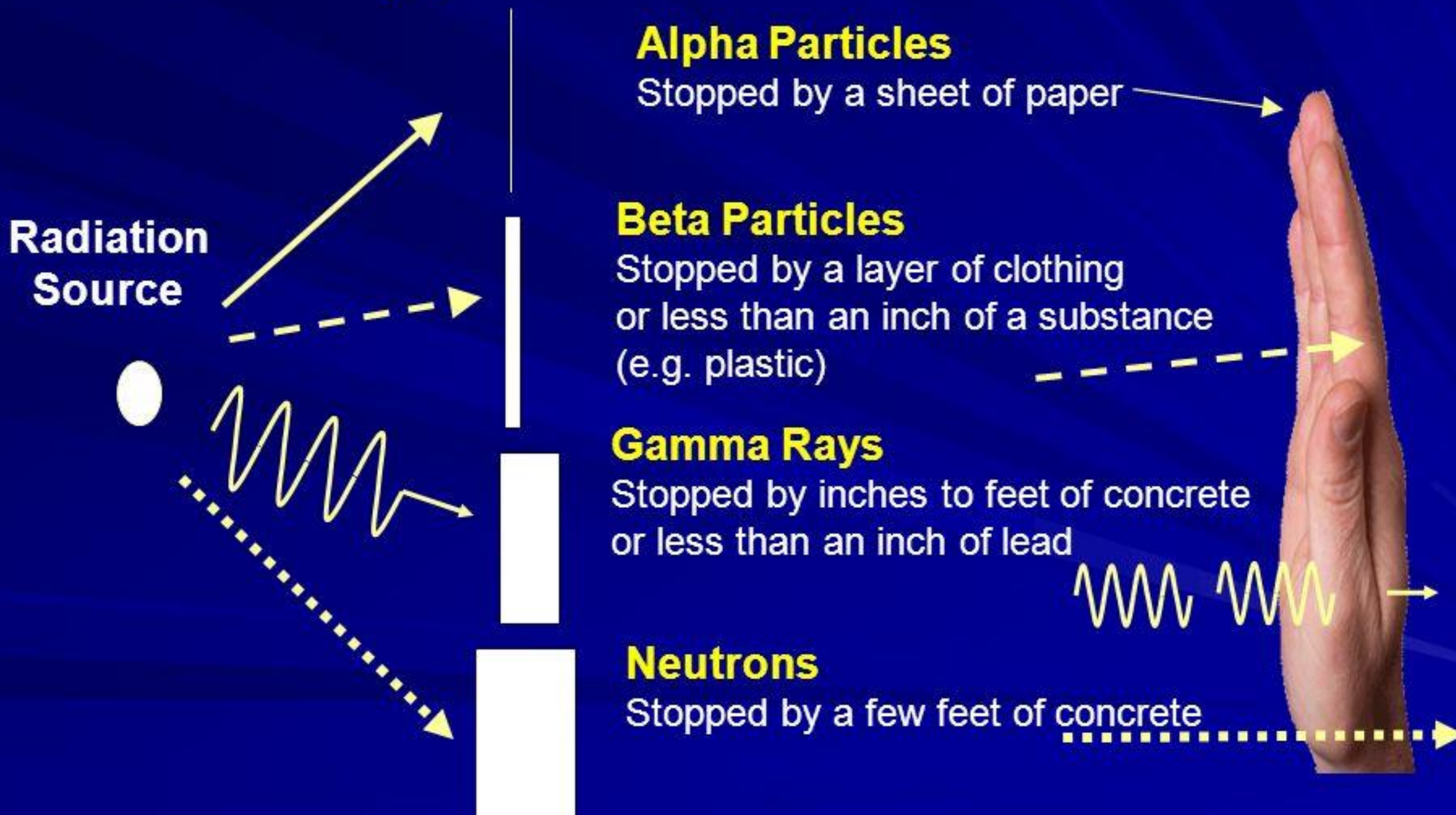
- X-ray discovery 1895 (Wilhelm Roentgen)
- 1896 Corneal injuries during experiments on newly invented x-ray generator (Thomas Edison)
- 1917 opening of the Radium Luminous Materials Corporation in Orange, NJ. 1927, about 100 employees died from osteosarcoma of the jaw and brain tumors

Decay

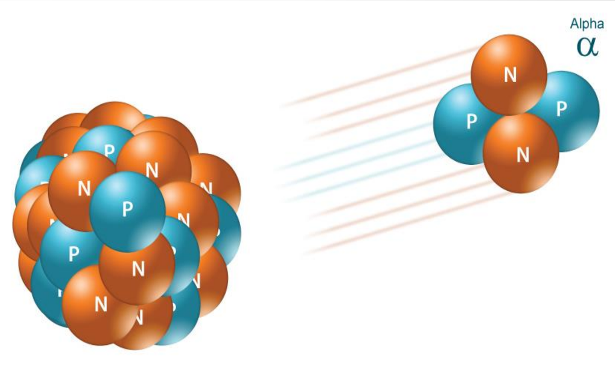
- Radioactive decay: Unstable nuclei decay or transform into more stable nuclei (daughters) via the emission of various particles or energy
- 5 mechanisms of radioactive decay:
  1) Emission of γ rays
  2) Emission of α particles
  3) Emission of β particles
  4) Emission of positrons
  5) capture of an electron

  These particles form ionizing radiation

Penetration Abilities of Different Types of Radiation



α -particles

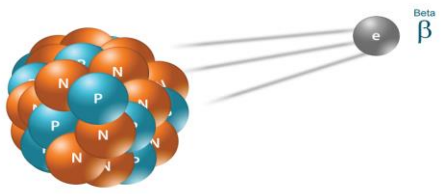


Alexander Litvinenko

https://youtu.be/fKiwU5TbRI4

- Radioactive decay of an atom nucleus giving off 2 protons and 2 neutrons
- Travel only few centimeters in air
- Unable to penetrate the outer layer of dead skin
- **Causes serious damage when ingested (incorporated)**
- E.g. Polonium-210

β-particles

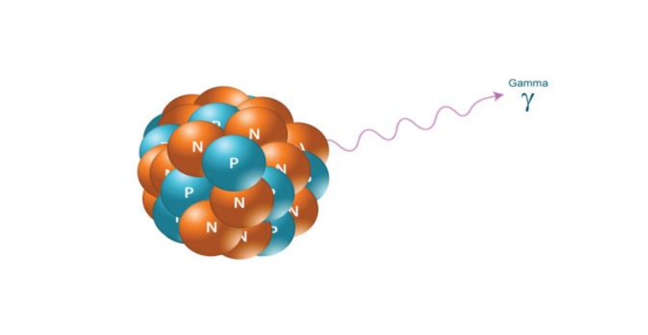


- Radioactive decay of an atom nucleus giving off an electron or a positron (positively charged electron)
- Able to travel a few meters in air due to small size
- Can be stooped by a piece of plastic or a stack of papers
- Can penetrate the skin a few centimeters
- **Causes serious damage when ingested (incorporated)**

Photons

- **Photons**: massless particles that travel at the speed of light and mediate electromagnetic radiation. Depending on the energy of the particles, and, therefore, their wavelength, the radiation has different names
- Radio waves: have the lowest energy and the longest wavelength
- Microwaves: higher energy and shorter wavelength

ϒ and X- Rays



- γ Rays and x-rays are the same and are only distinguishable by their source
- Emission of high-energy wave (photon of energy being emitted) Not a particle
- Since it has no mass or charge, it can travel much farther than aor β particles
- Can be stopped by thick material (lead is the most effective shield)

ϒ and X- Rays

- an x-ray machine generates x-rays by accelerating electrons through a large voltage and colliding them into a heavy metal target

Half-life

- Half-life ($t_{1/2}$): the period of time it takes for a radioisotope to lose half of its radioactivity

Ionizing VS nonionizing radiation

- **Ionizing radiation:** any radiation with sufficient energy to disrupt an atom or molecule with which it impacts
- **nonionizing radiation:** consists of relatively low-energy photons and is used safely in cell phone and television signal transmission, radar, microwaves, and magnetic fields that emanate from high-voltage electricity and metal detectors.

Ionizing VS nonionizing radiation

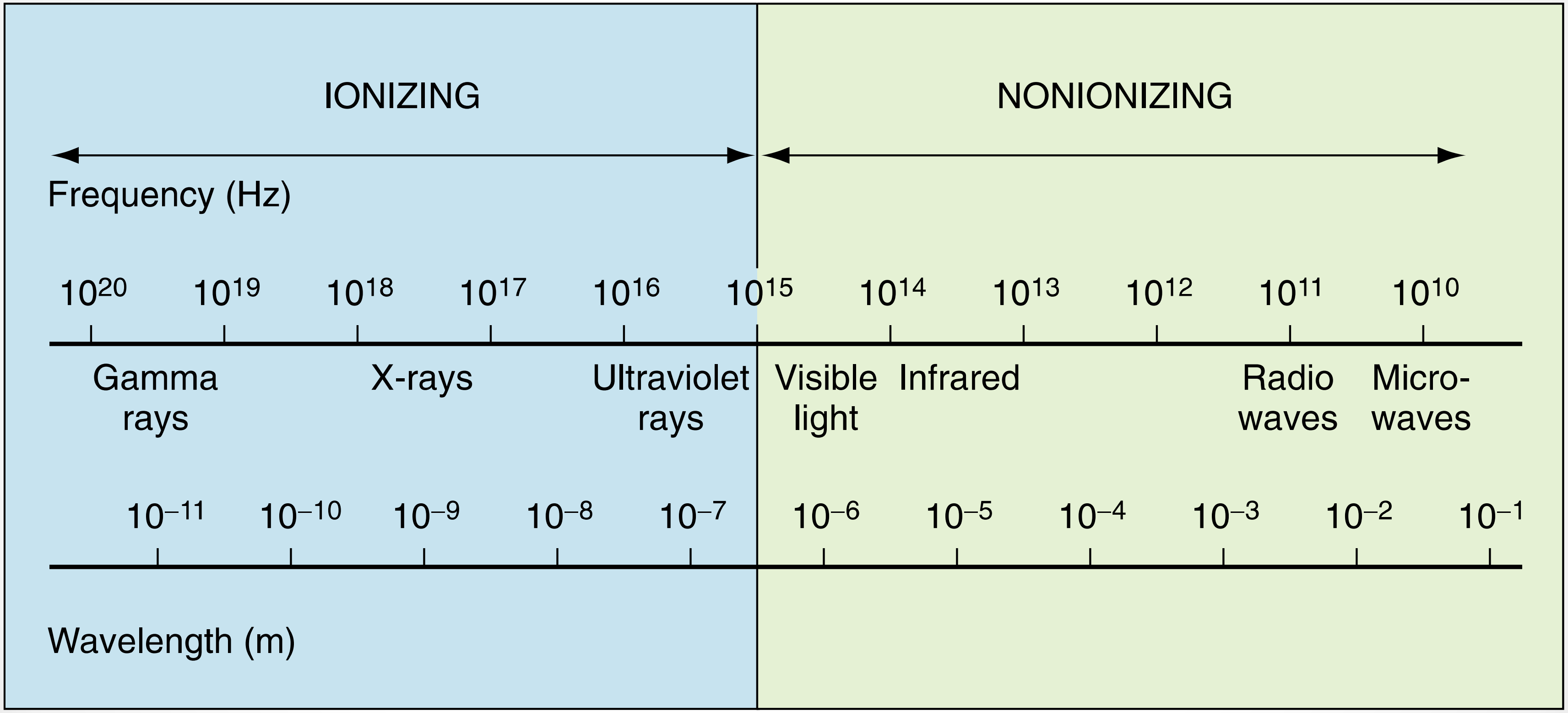


Figure 146-2. Electromagnetic spectrum.

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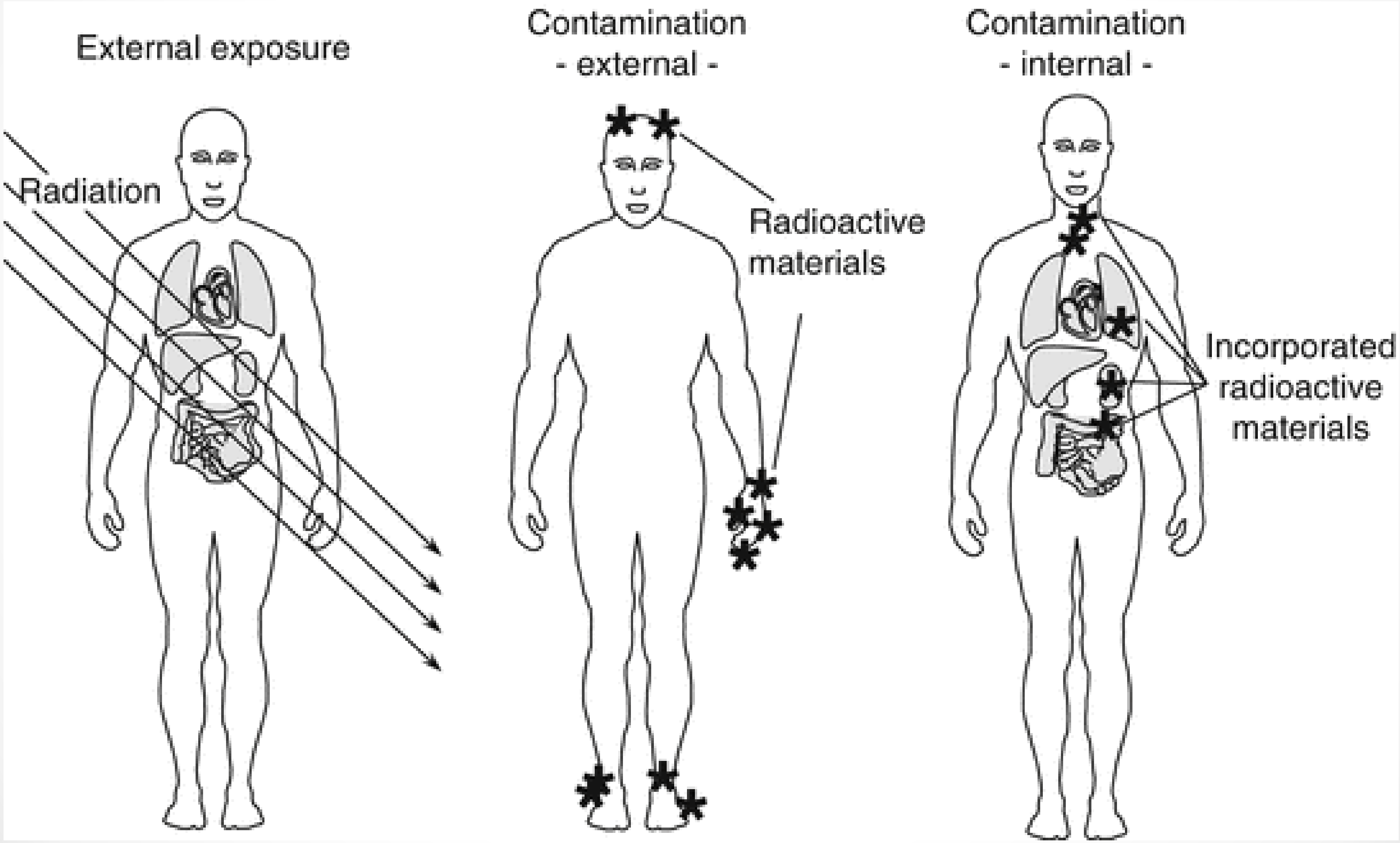
Stochastic versus deterministic effects

- **stochastic effect** : Injuries that do not require a threshold limit to be exceeded
- E.g: mutagenic and carcinogenic changes to individual cells where DNA is ultimate target

- **Deterministic effect:** require a threshold limit to be exceeded. large number of cells of an organ system must be killed before an effect becomes clinically evident

Irradiation, contamination, and incorporation



Definitions

Amount of Radioactivity

Ci / Bq

The amount of radioactivity in a radionuclide can be described either by the number of disintegrations per second, the becquerel (Bq), or by comparing the number of disintegration to that of radium, the curie (Ci).

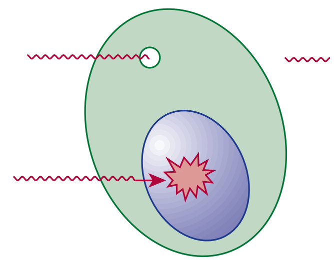
Amount of radiation emitted

Roentgens

Particles released during radioactive decay travel in all directions. When gamma or X-rays ionize the air surrounding a source, an electrostatic charge is produced. This ionization is quantified by the roentgen (R), which is an indirect measure of the amount of radiation.

Amount absorbed by tissue

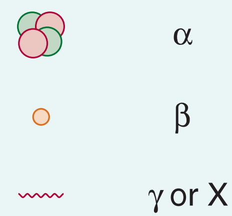
Rad / Gy



Most of these particles pass through tissue without being absorbed. Only the fraction of particles that contacts and is absorbed by tissue can cause cellular damage. This fraction is measured in rads or gray (Gy).

Degree of damage

Rem / Sv



For a given energy, larger particles cause more damage when absorbed by tissue than smaller particles. To predict the degree of damage that a given particle will cause, the dose in Gy or rad is multiplied by the particle-specific biological effectiveness coefficient (Q) to calculate rem or Sv.

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Management

- Decontamination
- ABCDE
- Treat nausea and vomiting
- Treat pain (APAP, or opioid)
- Serial CBC (biodosimetry)
- Electrolytes, Renal and hepatic function
- Specific therapy

Decontamination

- Remove all clothing
- Wash thoroughly with soap and water

    remove up to 95% of radioactive material

- Carefully scrub open wounds: to minimize the risk of internal contamination
- Use a portable dosimeter
- Collect all clothing and liquid used for decontamination and mark as **RADIOACTIVE WASTE**

Decontamination

Dosimeter

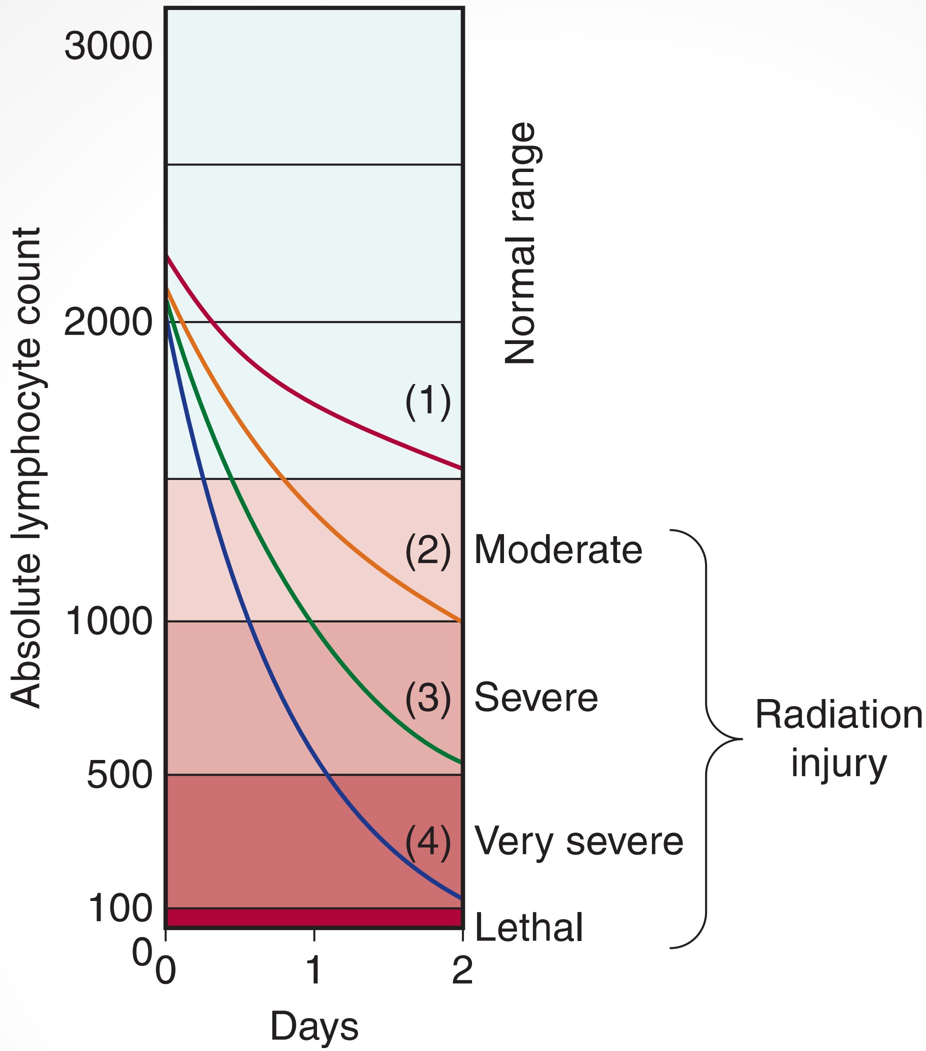

FIGURE 133–2. Classic Andrews lymphocyte depletion curves with accompanying clinical severity curves. Curves 1–4 correspond to whole body exposures of 3.1, 4.4, 5.6, and 7.1 Gy, respectively. (Adapted from Goans RE, Holloway EC, Berger ME, Ricks RC. Early dose assessment following severe radiation accidents. *Health Phys.* 1997:72:513–518.)

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Table 146-2 Prognosis According to the Lymphocyte Count within the First 48 Hours after Acute Exposure to Penetrating Whole-Body Radiation

MINIMAL LYMPHOCYTE COUNT (per mm^2)	APPROXIMATE ABSORBED DOSE (Gy)	EXTENT OF INJURY	PROGNOSIS
1400-3000 (normal range)	0-0.4	No clinically significant injury	Excellent
1000-1499	0.5-1.9	Clinically significant but probably nonlethal	Good
500-999	2-3.9	Severe	Fair
100-499	4-7.9	Very severe	Poor
100	8	Most severe	High incidence of death even with hematopoietic stimulation

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Acute radiation syndrome

Dose (Gy)	Radiation syndrome	Symptoms & Consequences	Medical Management
1 - 2	**Nausea, vomiting, diarrhea (NVD) syndrome**	Nausea, vomiting, diarrhea, anorexia, giddiness, and loss of appetite	Symptomatic treatment, antacid, sucralfate, anti-emetics
2 - 6	**Hematopoietic syndrome**	Loss of cellularity in bone marrow, spleen and thymus. The individual may die between 10-30 days without medical intervention.	Antibiotics, cytokines, bone marrow transplant, stem cell therapy
8 - 15	**Gastrointestinal (GI) syndrome**	Damage to intestinal crypt cells, loss of absorption of nutrients, dehydration, loss of weight, severe electrolyte imbalance and low blood pressure. Death occurs usually within 3–5 days without medical intervention.	Antibiotics, anti-emetics, replacement of fluids and electrolytes, stem cell therapy, bone marrow transplant
> 25	**Central Nervous System (CNS) syndrome**	Irritability, hyper excitability response, epileptic type fits and coma. Symptoms are irreversible. Death usually occurs within 48 h.	No treatment available

Specific therapy

- colony- stimulating factor (3 Gy or greater, 2 Gy if <12 or > 60.
- Probiotics
- Ca-DTPA and Zn-DTPA (decontamination of plutonium, americium, curium, and soluble uranium salts
- Prussian blue (thallium)
- KI (^{131}I)

Radiation and pregnancy

- Three principal risks to a fetus following radiation exposure:
  - Congenital abnormalities
  - Mental retardation
  - Later Development of neoplasm

Radiation and pregnancy

- Early on (0-2 weeks): risk of fatality
- 3-7 weeks: congenital anomalies and mental retardation
- 8-25 weeks: mental retardation
- The risk generally reduces at the 16th week.

However, the vast majority of routine diagnostic imaging procedures impart less than 0.05 Sv to the fetus and so are considered a negligible risk

KEY CONCEPTS

- Contaminated patients are "radioactive"; irradiated patients are not.
- No danger to medical personnel from contaminated patients exists with proper precautions and decontamination procedures.
- Decontamination should not delay or impede the stabilization of the patient in radiation emergencies.
- Careful evaluation of initial symptoms and signs is the most reliable indicator of the radiation dose received and the patient's prognosis.
- Most therapy is supportive and symptomatic except for exposures involving the ingestion or inhalation of radioactive material, when specific therapy with blocking or chelating agents may be indicated.
- Detonation of a "dirty bomb" would cause psychological terror and little or no radiation injuries.
- Formal consultation is available 24 hours a day and should be obtained when any patient with radiation injuries is evaluated.

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- Thank you!
- Questions?