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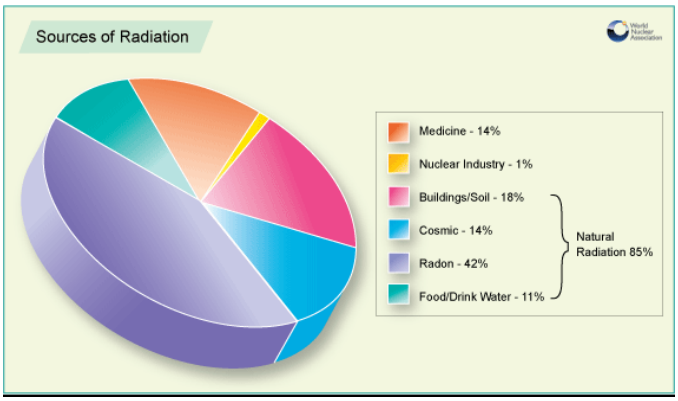
Radiation Basics

Background radiation: ~ 3 mSv/yr (300 mrem/yr) in North America and slightly higher in Asia. 88% of background radiation comes from natural sources (half of this from radon gas), almost all the remaining radiation comes from medical sources.



World Nuclear Organization

Safety Levels: American regulatory limit for occupational exposure: 50 mSv/yr (5 rem/yr). This limit was chosen because it is the lowest rate at which there is evidence of cancer being caused in adults. Pregnant women and children should have no more than a 10th of this (5 mSv/yr or 500 mrem/yr). A lethal full-body dose for a man is around 4-5 Sv (400-500 rem) in a short time period.

Radiation Sickness Threshold: 1000 mSv (1 Sv or 100 rem) in a short time period. Symptoms: nausea, hair loss, weakness, skin burns

Long-term Radiation Exposure: cancer, cell mutation, birth defects. The danger of continued overexposure to radiation is that symptoms can appear after 20 years after exposure.

Radiation Exposure vs. Distance: if you double the distance, you reduce the exposure by a factor of 4.

Ionizing Radiation Types

Alpha
Penetration: stopped by skin or paper, dangerous when ingested or breathed in.

Beta
Penetration: stopped by aluminum plate or 1 cm of human flesh, heavy clothing may be needed.

Gamma & X-rays
Penetration: easily passes through most matter, shielding requires concrete, lead or water.

Neutron
Penetration: Just like gamma rays, shielding requires concrete or water. Neutron radiation only comes from cosmic rays and nuclear reactions, and although it isn't ionizing, it can cause other materials to become radioactive and is often accompanied by other radioactive materials.

Protection from Radiation

Limiting Time: For people who are exposed to radiation in addition to natural background radiation through their work, the dose is reduced by limiting exposure time.

Distance: In the same way that heat from a fire is less the further away you are, the intensity of radiation decreases with distance from its source.

Shielding: Barriers of lead, concrete or water give good protection from penetrating radiation such as gamma rays. Radioactive materials are therefore often stored or handled under water, or by remote control in rooms constructed of thick concrete or even lined with lead.

Containment: Radioactive materials are confined and kept out of the environment. Radioactive isotopes for medical use, for example, are dispensed in closed handling facilities, while nuclear reactors operate within closed systems with multiple barriers which keep the radioactive materials contained. Rooms have a reduced air pressure so that any leaks occur into the room and not out from the room.

Radiation Exposure Units of Measurement

Exposure: measure of the strength of a radiation field at some point in air. Basic unit: "roentgen" (R).

Dose: absorbed dose is the amount of energy that ionizing radiation imparts to a given mass of matter. Basic units: "gray" (Gy) and "radiation absorbed dose" (rad). 1 Gy = 100 rads. In human tissue, 1 R of gamma radiation = 1 rad of absorbed dose.

Dose Equivalent: relates to the absorbed dose to the biological effects of that dose. Basic units: "sievert" (Sv) and "roentgen equivalent in man" (rem). 1 Sv = 100 rem.

Dose Rate: a measure of how fast a radiation dose is being received. Basic units: mSv/yr, mrem/yr, etc.

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Half-life: The time it takes for half the nuclei in a specific isotope to undergo decay.

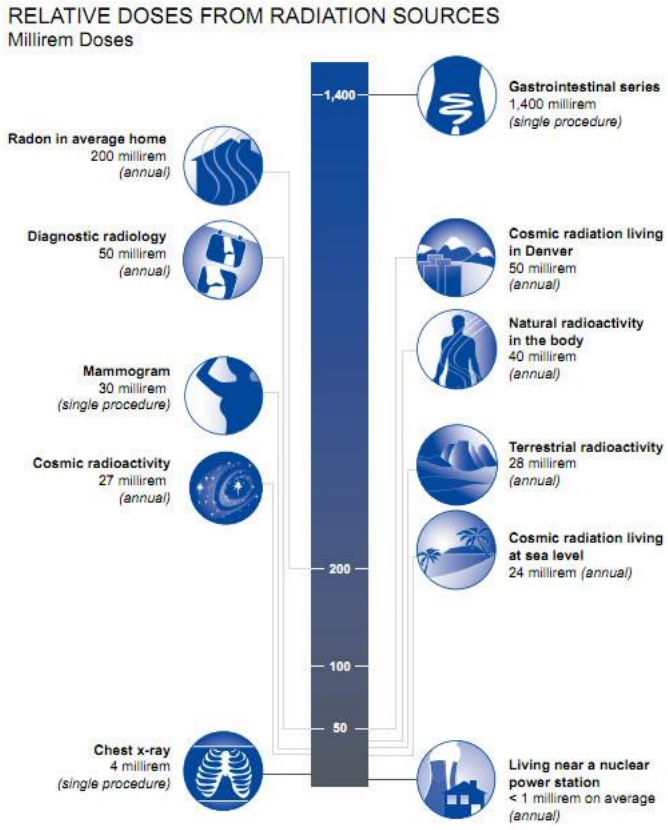
Radiation Examples

Air travel: measured dose during air travel is 5 µSv/hr (43.8 mSv/yr or 4.38 rem/yr) according to the FAA. This is about 15 times background radiation.

Watching TV: 4 hours a day adds up to 2 mSv/yr (200 mrem/yr)

Allowable short-term dose for workers on the Fukushima accident: 250 mSv (25 rem)

Radiation Measurement on the perimeter of the Fukushima Nuclear Plant: 1-3 mR/h (about 10-30 µSv/h)



U.S. Environmental Protection Agency

Atomic Shorthand

Example: "Iodine-131" = $_{53}I^{131}$

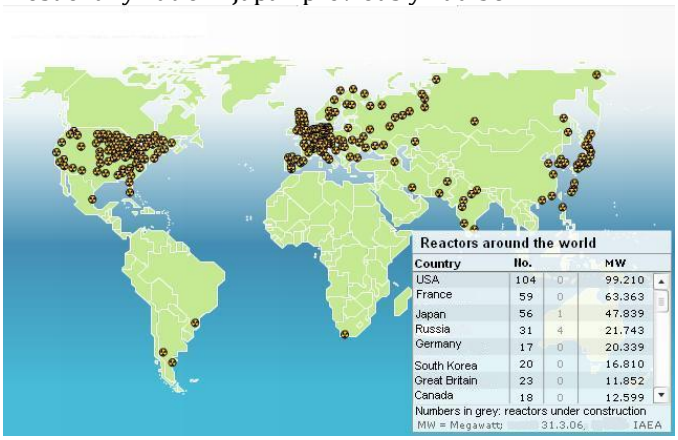
Radioactive Iodine

Iodine concentrates in the thyroid. Because of this, radioactive iodine (a byproduct of nuclear reactions) contributes to thyroid cancer more than other types of cancer. For this reason, potassium iodide tablets are given to increase the amount of safe iodine in the body, as this limits the amount of radioactive iodine the body will absorb.

The most common kind of radioactive iodine (Iodine-131) has a half-life of only 8 days.

Nuclear Plants

There are over 440 commercial nuclear power plants operating in 30 countries which accounts for about 14% of the world's power. The US has 104 operating reactors, the most of any nation. Japan previously had 56.



International Atomic Energy Agency

Alarm Levels for the MiniRad-D Radiation Detector

Alarm Level	µrem/hr	mrem/hr	µSv/hr	mSv/hr
1	35	0.035	0.35	0.00035
2	40	0.04	0.4	0.0004
3	55	0.055	0.55	0.00055
4	65	0.065	0.65	0.00065
5	100	0.1	1	0.001
6	200	0.2	2	0.002
7	350	0.35	3.5	0.0035
8	600	0.6	6	0.006
9	1100	1.1	11	0.011

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Radiation facts and protection information from the World Nuclear Association
Health information from the US Environmental Protection Agency