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Understanding Radiation and Its Effects

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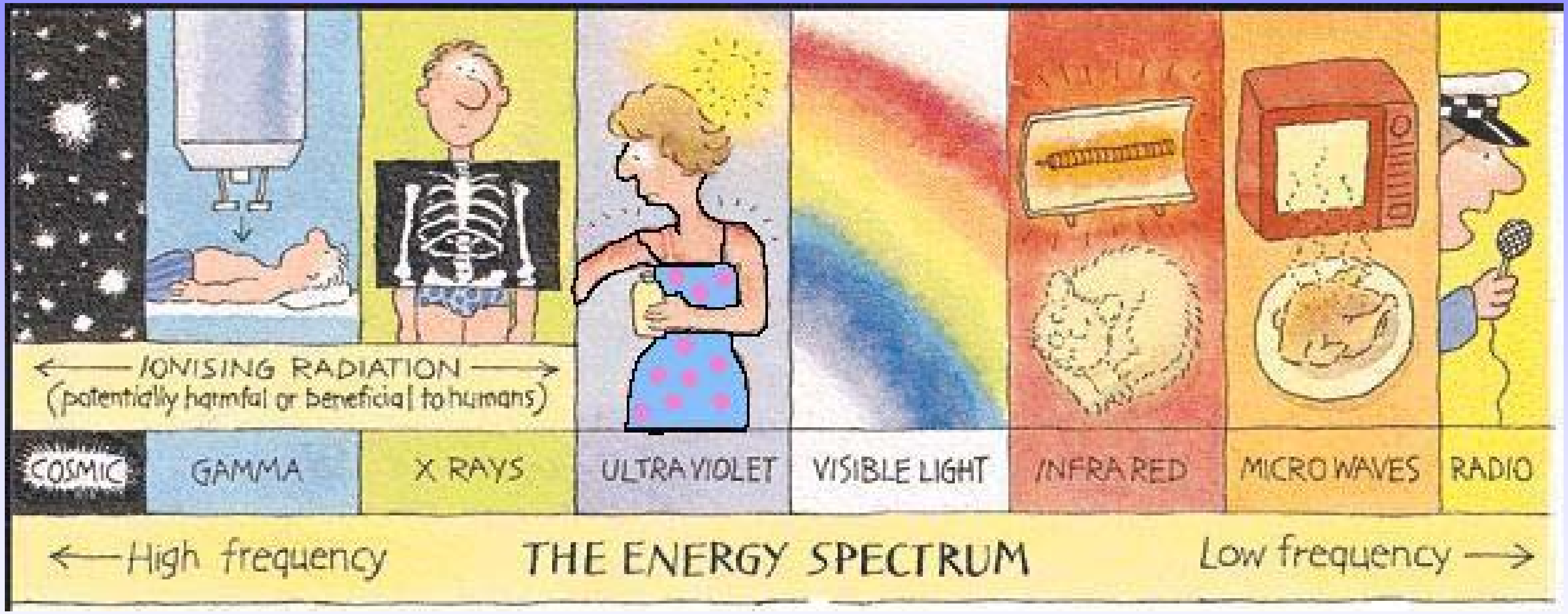
Radiation is Energy

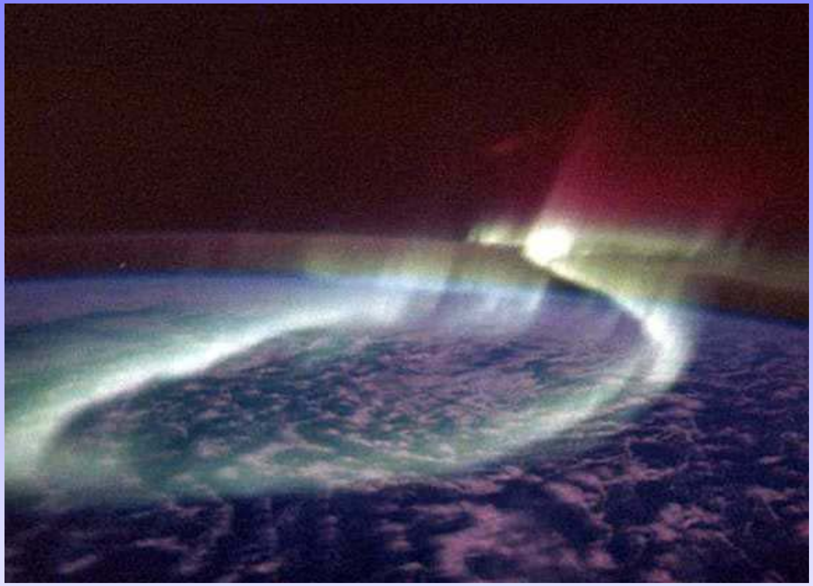
- **The energy is given off by unstable (radioactive) atoms and some machines.**



- **For this talk, we will be focusing on <u>ionizing radiation</u> and its health effects.**

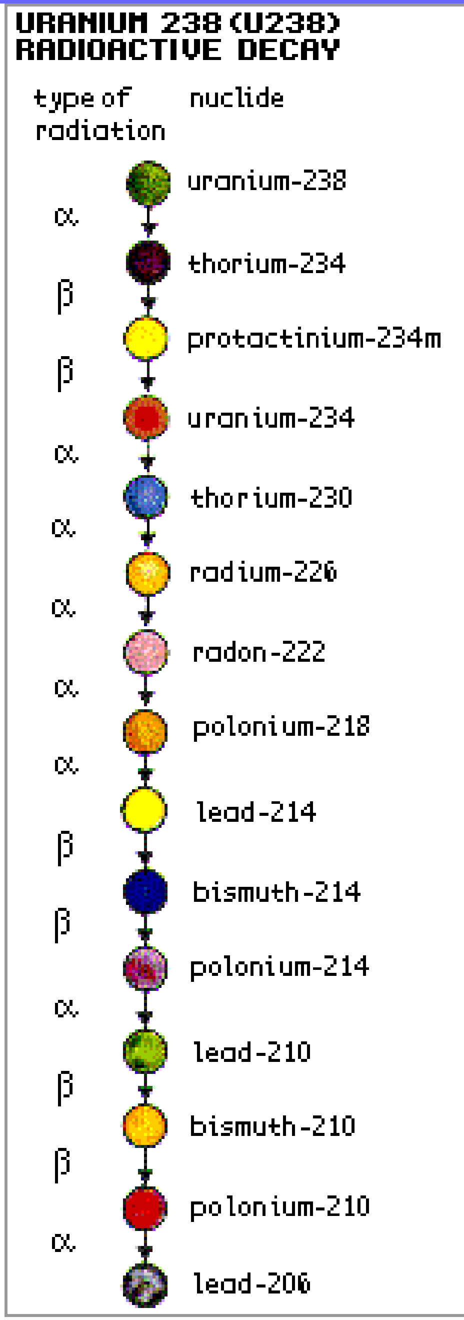
Radiation and Radioactive Material are a Natural Part of Our Lives

- We are constantly exposed to low levels of radiation from outer space, earth, and the healing arts.
- Low levels of naturally occurring radioactive material are in our environment, the food we eat, and in many consumer products.
- Some consumer products also contain small amounts of man-made radioactive material.



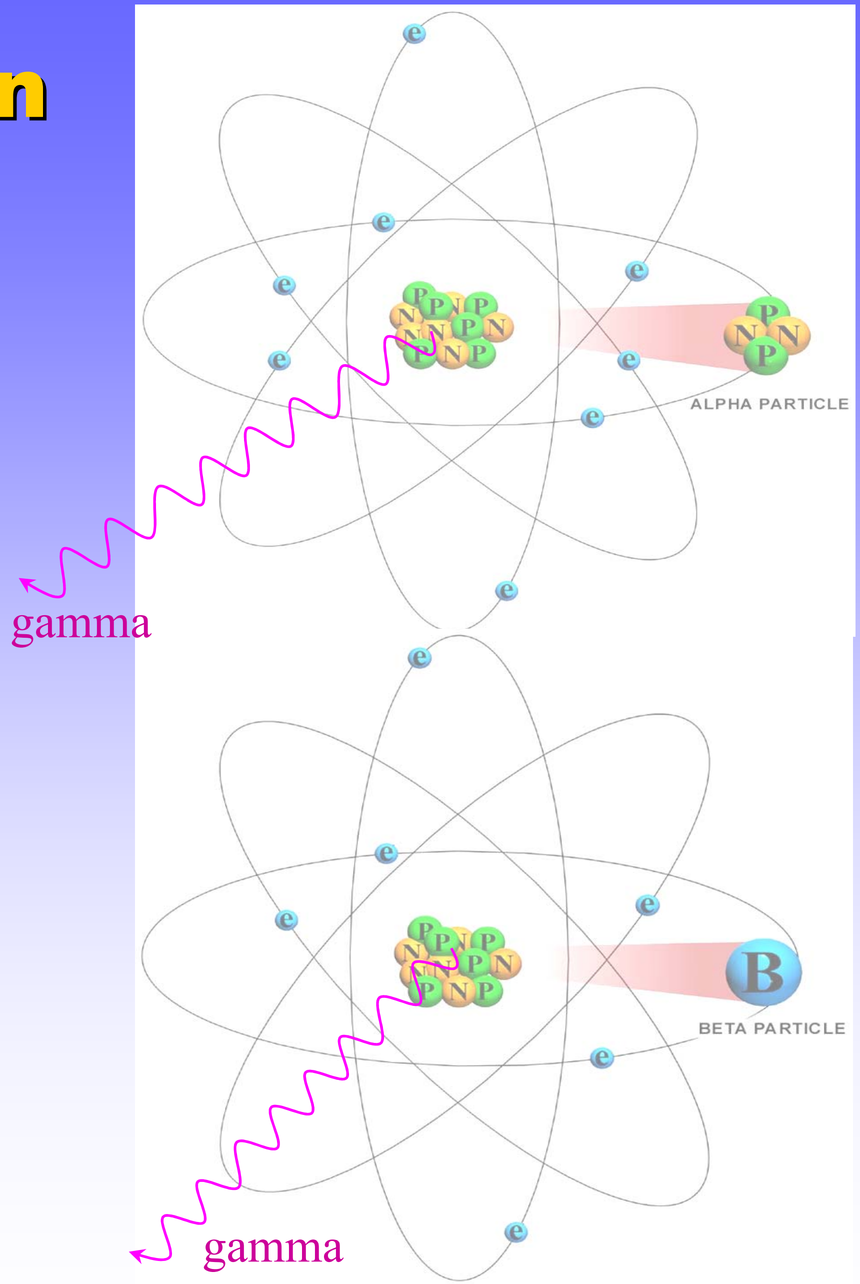
Unstable Atoms Decay

- The number of “decays” that occur per unit time in the radioactive material tell us how radioactive it is.
  - Units include Curies (Ci), decays per minute (dpm), and Becquerels (decays per second).
- When an unstable atom decays, it ***transforms*** into another atom and releases its excess energy in the form of radiation.
- Sometimes the new atom is also unstable, creating a “decay chain”



Forms of Radiation

- When unstable atoms transform, they often eject particles from their nucleus. The most common of these are:
  - Alpha Radiation
    High energy, but short range (travels an inch in air, not an external hazard)
  - Beta Radiation
    Longer range (10 – 20 feet in air) and can be a skin and eye hazard for high activity beta sources.
- Gamma Rays (electromagnetic radiation)
  Often accompany particle radiation. This "penetrating" radiation is an external hazard and can travel 100s of feet in air.



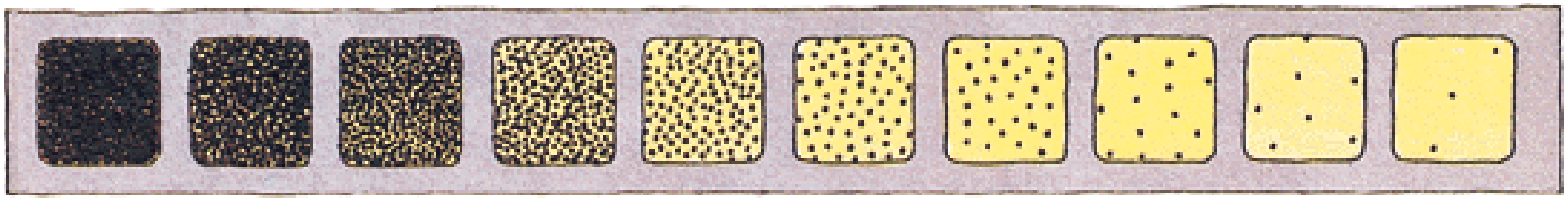
How Unstable Is It?

- The "Half-Life" describes how quickly Radioactive Material decays away with time.

  It is the time required for **half** of the unstable atoms to decay.

- Some Examples:
  - Some natural isotopes (like uranium and thorium) have half-lives that are billions of years,
  - Most medical isotopes (like Technicium-99m) last only a few days

Decay rate of radioactivity: After ten half lives, the level of radiation is reduced to one thousandth



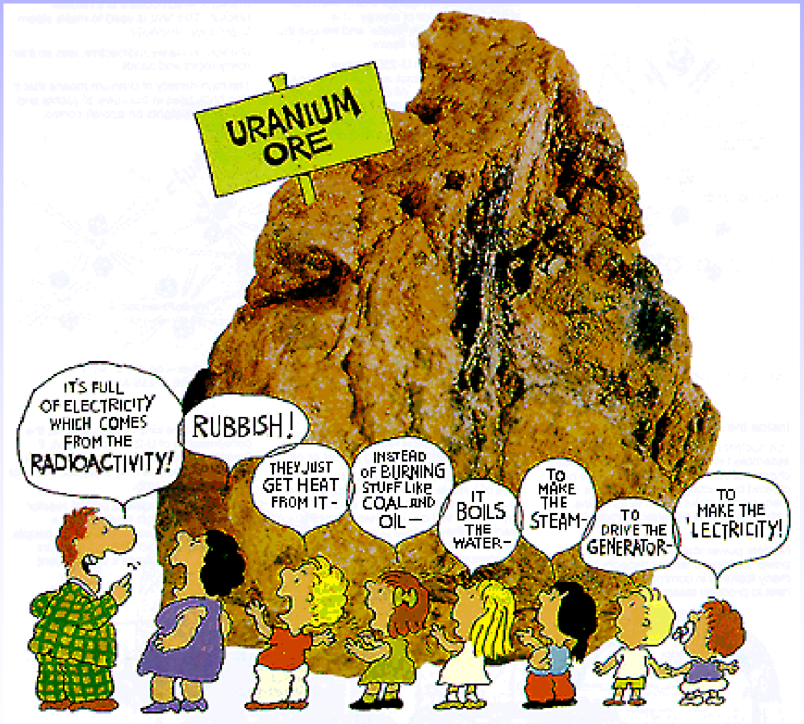
Some Isotopes & Their Half Lives

ISOTOPE	HALF-LIFE	APPLICATIONS
Uranium	**billions of years**	Natural uranium is comprised of several different isotopes. When enriched in the isotope of U-235, it's used to power nuclear reactor or nuclear weapons.
Carbon-14	**5730 y**	Found in nature from cosmic interactions, used to "carbon date" items and as radiolabel for detection of tumors.
Cesium-137	**30.2 y**	Blood irradiators, tumor treatment through external exposure. Also used for industrial radiography.
Hydrogen-3	**12.3 y**	Labeling biological tracers.
Irridium-192	**74 d**	Implants or "seeds" for treatment of cancer. Also used for industrial radiography.
Molybdenum-99	**66 h**	Parent for Tc-99m generator.
Technicium-99m	**6 h**	Brain, heart, liver (gastoenterology), lungs, bones, thyroid, and kidney imaging, regional cerebral blood flow, etc.

The Amount of Radioactivity is NOT Necessarily Related to Size

- Specific activity is the amount of radioactivity found in a gram of material.
- Radioactive material with <u>long half-lives</u> have <u>low specific activity</u>.

<u>1 gram</u> of Cobalt-60
has the same activity as
<u>1800 tons</u> of natural Uranium



What is a "Dose" of Radiation?

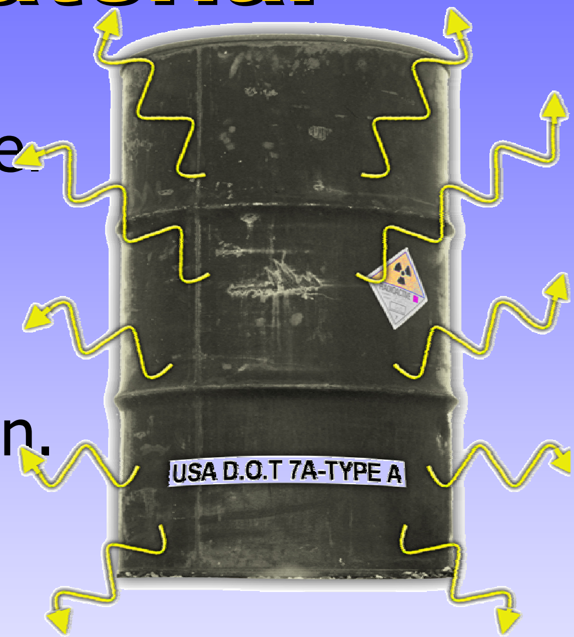
- When radiation's energy is deposited into our body's tissues, that is a dose of radiation.
- The more energy deposited into the body, the higher the dose.
- **Rem** is a unit of measure for radiation dose.
- Small doses expressed in **mrem = 1/1000 rem**.
- **Rad** & **R** (Roentgens) are similar units that are often equated to the Rem.

Typical Doses

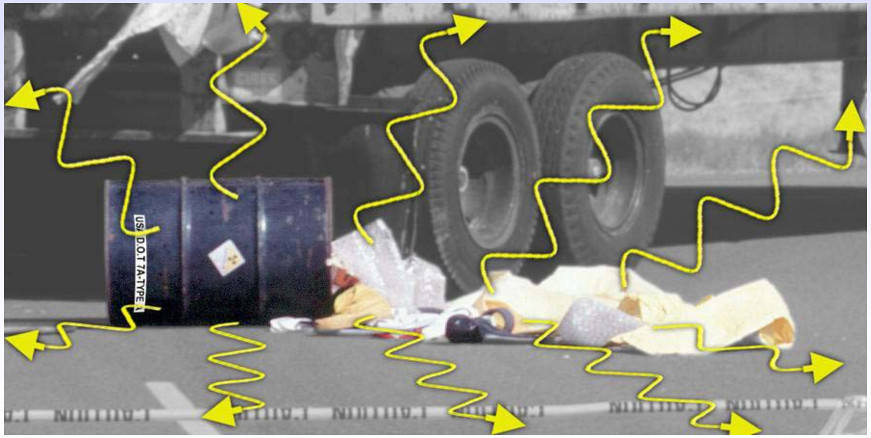
Average Dose to US Public from All sources	360 mrem/year
Average Dose to US Public From Natural Sources	300 mrem/year
Average Dose to US Public From Medical Uses	53 mrem/year
Coal Burning Power Plant	0.2 mrem/year
Average dose to US Public from Weapons Fallout	< 1 mrem/year
Average Dose to US Public From Nuclear Power	< 0.1 mrem/year
Occupational Dose Limit for Radiation Workers	5,000 mrem/yr

Coast to coast Airplane roundtrip	5 mrem
Chest X ray	8 mrem
Dental X ray	10 mrem
Head/neck X ray	20 mrem
Shoe Fitting Fluoroscope (not in use now)	170 mrem
CT (head and body)	1,100 mrem
Therapeutic thyroid treatment (dose to the whole body)	7,000 mrem

Radiation is a type of energy; Contamination is material

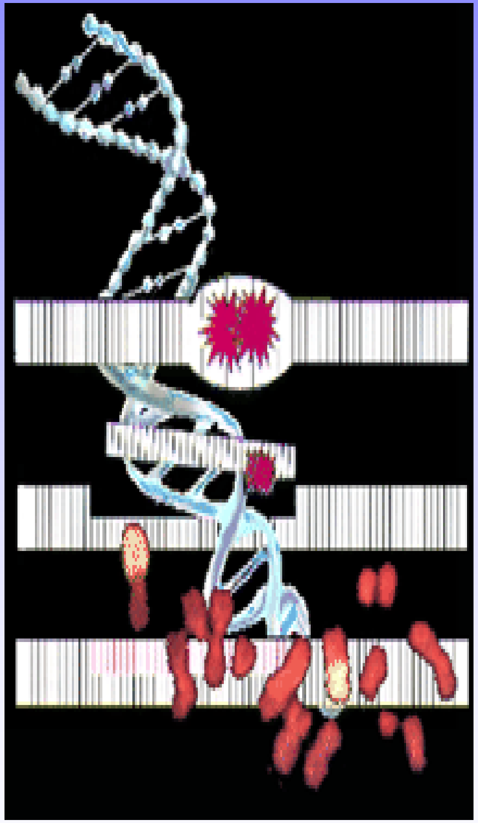


- Exposure to ***Radiation*** will not contaminate you or make you radioactive.
- ***Contamination*** is Radioactive Material spilled someplace you don't want it.
- Radioactive contamination emits radiation.
- Contact with ***Contamination*** can contaminate you with the material.



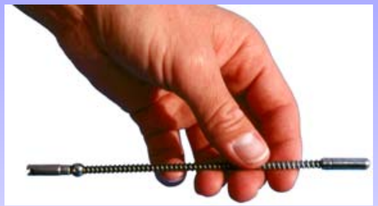
Our Bodies Are Resilient

- **DNA damage is most important and can lead to cell malfunction or death.**
- **Our body has ~ 60 trillion cells**
  - **Each cell takes "a hit" about every 10 seconds, resulting in tens of millions of DNA breaks per cell each year.**
  - **BACKGROUND RADIATION causes only a very small fraction of these breaks (~ 5 DNA breaks per cell each year).**
- **Our bodies have a highly efficient DNA repair mechanisms**

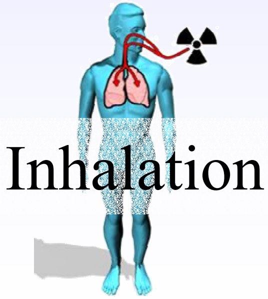


Types of Exposure & Health Effects

- **Acute Dose**
  - Large radiation dose in a short period of time
  - Large doses may result in observable health effects
    - Early: Nausea & vomiting
    - Hair loss, fatigue, & medical complications
    - Burns and wounds heal slowly
  - Examples: medical exposures and accidental exposure to sealed sources



- **Chronic Dose**
  - Radiation dose received over a long period of time
  - Body more easily repairs damage from chronic doses
  - Does not usually result in observable effects
  - Examples: Background Radiation and Internal Deposition



Dividing Cells are the Most Radiosensitive

- Rapidly dividing cells are more susceptible to radiation damage.
- Examples of radiosensitive cells are
  - Blood forming cells
  - The intestinal lining
  - Hair follicles
  - A fetus

This is why the fetus has a exposure limit (over gestation period) of 500 mrem (or 1/10th of the annual adult limit)

At HIGH Doses, We KNOW Radiation Causes Harm

- High Dose effects seen in:
  - Radium dial painters
  - Early radiologists
  - Atomic bomb survivors
  - Populations near Chernobyl
  - Medical treatments
  - Criticality Accidents
- In addition to radiation sickness, increased cancer rates were also evident from high level exposures.

Effects of ACUTE Exposures

Dose (Rads*)	Effects
25-50	First sign of physical effects (drop in white blood cell count)
100	Threshold for vomiting (within a few hours of exposure)
320 - 360	~ 50% die within 60 days (with minimal supportive care)
480 - 540	~50 % die within 60 days (with supportive medical care)
1,000	~ 100% die within 30 days

*** For common external exposures 1 Rad ~ 1Rem = 1,000 mrem**

At LOW Doses, We PRESUME Radiation Causes Harm

- No physical effects have been observed
- Although somewhat controversial, this increased risk of cancer is presumed to be proportional to the dose (no matter how small).

The Bad News:	Radiation is a carcinogen and a mutagen
The Good News:	Radiation is a **very weak** carcinogen and mutagen!

*** Similar to those received by Atomic Bomb Survivors (≥10 rem)**

Long-term Effects of Radiation

- **Radiation is assumed to increase one's risk of cancer**
  - The "normal" chance of dying of cancer is ~ 23% (~460 out of 2,000).
  - Each rem is assumed to increase that risk by 0.05% (~1 chance in 2,000).

The occupational radiation dose limit to the whole body is 5 rem/yr

Conclusion (1 of 2):

Understanding Radiation and it's Effects

- Radiation is energy given off by unstable atoms and some machines.
- Radioactive Material contains unstable atoms that give off radiation when they "decay."
- Contamination is Radioactive Material spread someplace where you don't want it.

Conclusion (2 of 2):

Understanding Radiation and it's Effects

- Radiation damages our cell's DNA, fortunately our body has very efficient repair mechanisms.
- Large acute doses of radiation can cause sickness or even death. The severity of the effects are proportional to the dose.
- All exposures to presumed to increase the risk of cancer. The amount of "increased risk" is proportional to exposure.

Very Small DOSE = Very Small RISK

References

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Uranium Information Centre

Melbourne, Australia

http://www.uic.com.au/index.htm

DOE; Transportation Emergency Preparedness Program (TEPP)

http://www.em.doe.gov/otem/program.html