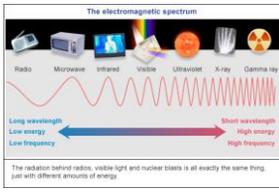
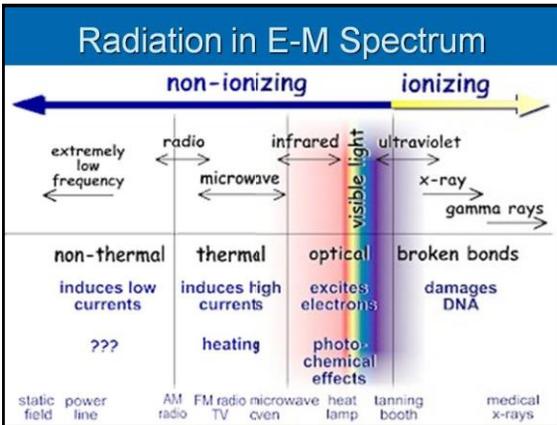




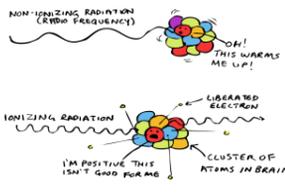
Radiation is...

- Everywhere around us, all the time!
- The emission of energy as electromagnetic waves or as moving subatomic particles

Non-Ionizing Radiation

- Refers to electromagnetic radiation that, instead of producing charged ions when passing through matter, has enough energy only to excite the atoms (cause them to vibrate and heat)



- Types of non-ionizing radiation include UV light, visible light, infrared light, microwaves and radio waves.

Non-Ionizing Radiation

Used in many common tasks:

- Microwave radiation - for telecommunications and heating food.
- Radio waves - radio broadcasting.
- UV light – sterilization of drinking water and surfaces.

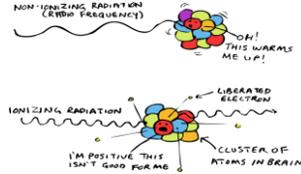


Non-Ionizing Radiation

- Though non-ionizing radiation does not cause a chemical change, observable effects include:
 - Infrared or laser light can cause burns to skin and damage to eyes
 - Ultraviolet light can kill single-celled organisms. In humans, UVB can cause sunburn, cataracts, and skin cancer. (This type of energy affects DNA.)

Ionizing Radiation

- Refers to emitted waves or particles that have enough energy to **remove electrons** from atoms (creating two charged ions) or to **break chemical bonds**.



- All forms of ionizing radiation can destroy or **cause damage** to DNA in cells.

Ionizing Radiation

- Almost **80%** of ionizing radiation that we are exposed to occurs **naturally**
- Cosmic rays** - radiation that reaches the Earth from space
- Rocks and soil** - some rocks are radioactive and give off radioactive radon gas
- Living things** - plants absorb radioactive materials from the soil and these pass up the food chain

Reality Check:

Are bananas radioactive & unsafe to eat?

Origin: There seems to be an internet rumour circling that bananas are radioactive.



Reality Check:

Are bananas radioactive & unsafe to eat?

Reality: Bananas are high in potassium which means they contain potassium-40, a radioactive isotope. So **yes, bananas are radioactive** but that doesn't mean they are unsafe to eat.



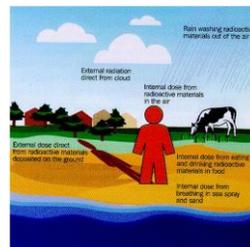
Reality Check:

Are bananas radioactive & unsafe to eat?

Reality: In fact, the term "banana equivalent dose" has come into pretty common use as a reference point for communicating radiation exposure.



Ionizing Radiation



- Referred to as **background radiation**, there is not much we can do avoid exposure to radiation in food, air, soil, etc.
- After all, we cannot stop eating, drinking or breathing to avoid it!

Ionizing Radiation

- However, human activity has added to background radiation by creating and using artificial sources of radiation.
- Many applications of radiation have benefitted humanity (nuclear medicine, food preservation, nuclear power).



Ionizing Radiation

- Radiation from the nuclear industry, including military testing and accidents, accounts for less than 1% of all radiation people are routinely exposed to.



Reality Check:

Does radiation have a green glow?

Origin: Comic book 'logic' wants us to believe that if you are exposed to radiation you will have a green glow and become radioactive.



Reality Check:

Does radiation have a green glow?

Origin: This likely comes from the early 20th century when green glow-in-the-dark watches contained paint that was radium-based.



Reality Check:

Does radiation have a green glow?

Origin: Factory workers spent many months licking their paintbrushes to get a sharp enough tip to paint the tiny numbers on the watch faces. The result was radiation-related illnesses.



Reality Check:

Does radiation have a green glow?

Reality: The radium-based paint used for those watches contained a phosphor (a metallic element with luminescence properties) that caused the green glow.

While radium is both radioactive and phosphorescent, only the phosphorescence causes the green glow. Radiation itself is not detectable by simply looking at an object.

Measuring Ionizing Radiation

- Radioactivity is not detectable by any of the human senses.



FIGURE 15.—Man being bombarded by "invisible" rays.

Measuring Ionizing Radiation

- But we can count every time a substance emits a radioactive particle or a gamma ray.
- To do so, we use the effects radiation has on matter:
 - Radiation ionizes matter.
 - Radiation causes some materials to scintillate (flash light).

Measuring Ionizing Radiation

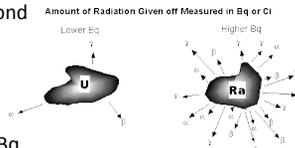
- E.g. Geiger counters detect electricity created by these ions and produce a click, move a needle on a dial or move a number on a counter.
- This shows how 'active' the sample is (how many decays occur per unit time).



Measuring Ionizing Radiation

- Standard unit is the becquerel (Bq).

– 1 Bq = 1 decay per second



- This is a tiny amount.

- banana = 15 Bq
- human body = 20,000 Bq
- 1 mg U-238 = 10 Bq
- 1 mg Am-241 = 100,000,000 Bq

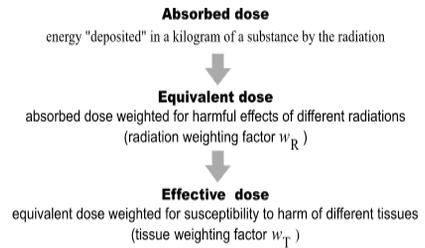
Most Radioactive Places on Earth

- <https://www.youtube.com/watch?v=TRL7o2kPqW0>

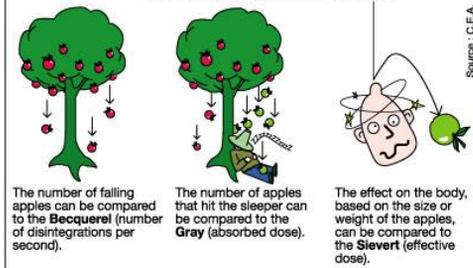
Measuring Ionizing Radiation

- Geiger counters *do not* measure how dangerous a given amount of radiation might be for humans.
- Rather, scientists need to calculate the 'dose' of radiation absorbed and account for the type of radiation and sensitivity of tissue/organs involved.

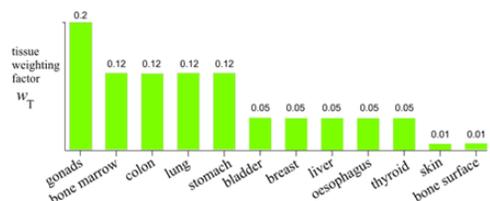
Dose Quantities



Units of measure for radioactivity



Tissue/Organ Sensitivity



Measuring Ionizing Radiation

- The most important radiation unit is the sievert (Sv), often seen as mSv.
- The sievert *estimates* the effective dose of radiation to the body.
 - E.g. The risk of cancer due to radiation exposure is linked to 100 mSv or higher in adults.

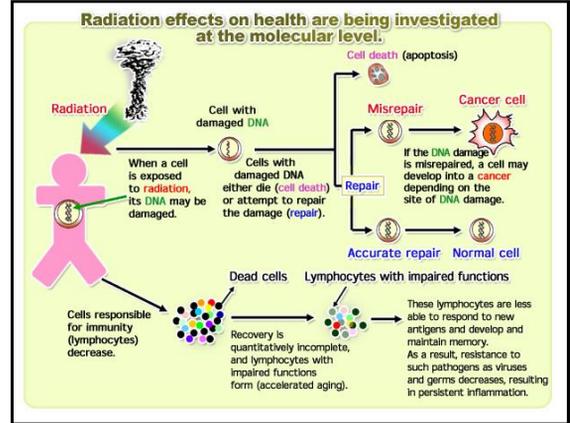
Effects of Ionizing Radiation

The extent of the damage depends upon the amount and duration of the exposure, as well as the organs exposed.

- Cell DNA undamaged by the dose
- Cell DNA are damaged but repair the damage and operate normally

Effects of Ionizing Radiation

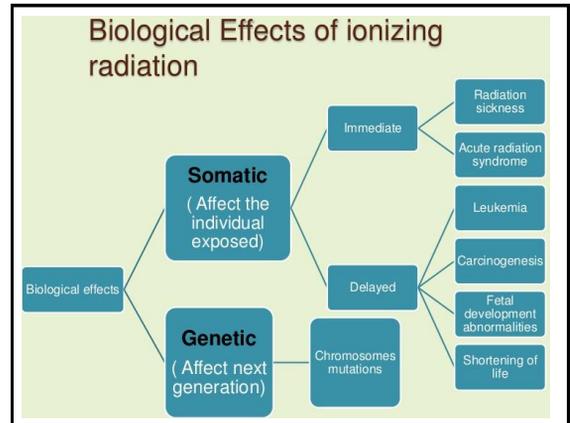
- C. Cell DNA damaged and incorrectly repair themselves, resulting in cancer.
- D. Cells die as a result of the damage



Effects of Ionizing Radiation

The biophysical changes caused by radiation exposure are divided into two categories:

- Somatic – physical effects that can be immediate or delayed
- Genetic – birth defects due to irradiation of reproductive cells before conception



RADIATION DOSES AND EFFECTS

