Radiation Safety Institute of Canada
Institut de radioprotection du Canada

February 4, 2021

Understanding Radiation

Followed by STEPs Dance

Good Science in Plain Language®

Webinar Functionality

- Audio and video
  - Will be from the presenters only
  - Use computer or telephone (call in)
  - Computer seems to give the best sound quality
- Use the “Chat” feature to enter comments
- Use the “Questions” feature to ask questions
- Follow up email will be sent
  - Topics covered
  - Time of attendance
  - Q&A answers
  - Link to a copy of the slides
- It may be possible to change your Zoom view if the controls are hiding the closed captioning.

Outline

- What is radiation?
- Different types of radiation
- Activity and Half-life
- Units of radiation dose
- Health effects of exposure to radiation
- Dose limits
- Common radiation exposures
- Regulatory bodies in Canada

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Use of Radiation in Canada

- 160,000+ Canadians are monitored annually for workplace exposure to radiation
  - Only 16% are part of the nuclear power industry
- 84% come from
  - Health Care (technologists, nurses, doctors)
  - Industry (construction, manufacturing, mining, etc)
  - Education and Research Facilities
- But what IS radiation?

Radiation and Energy

- Radiation can be interpreted as a form of energy.
- Radiation will interact differently with matter depending upon how much energy it has.

Non-Ionizing (Low Energy) Radiation

Radiation that does not have enough energy to break bonds in matter.

Non-Ionizing Radiation

Radio waves

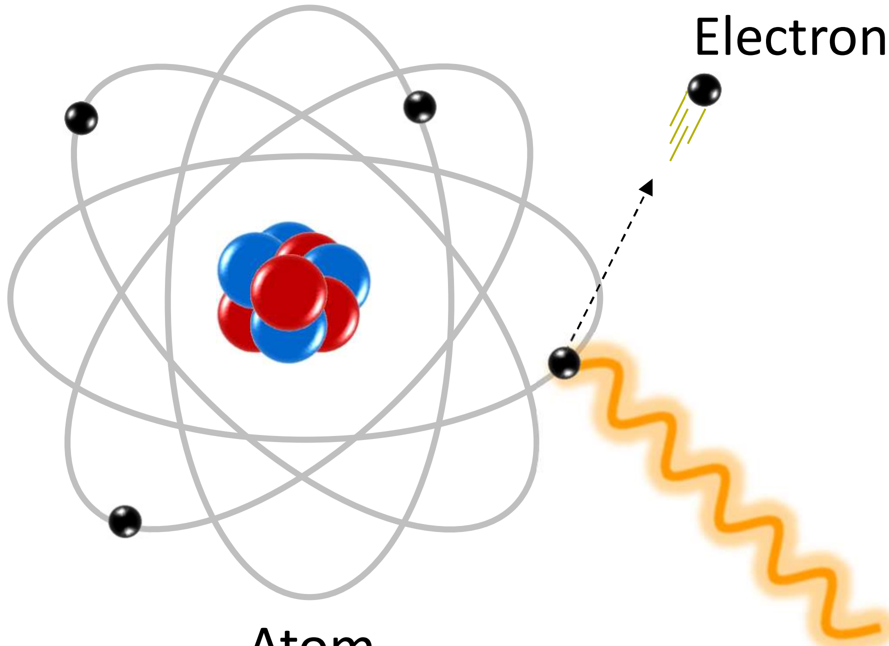
Infrared light

Visible light

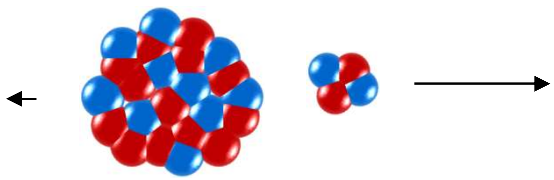
Microwaves

When radiation strikes matter, it interacts with the atoms of the matter.

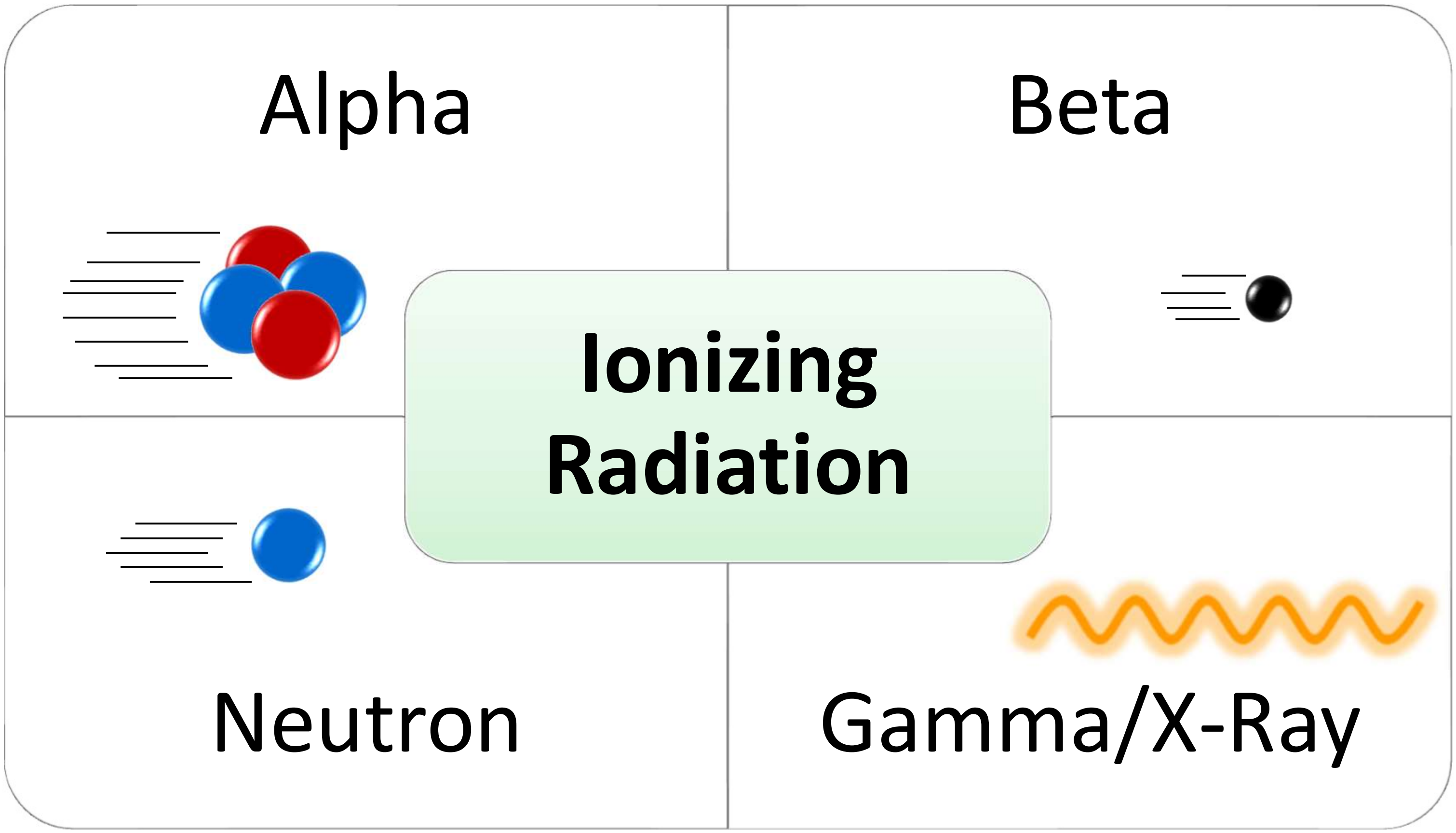
Radiation with enough energy can knock **electrons** out of orbit from the atoms it strikes.



Where does ionizing radiation come from?

Radioactive atoms	Man-made devices
	

Types of Ionizing Radiation



Alpha Radiation

- Alpha radiation is highly ionizing.
  – It can easily strip electrons from atoms.
- Alpha radiation does not travel far in matter:

Approximately **7 cm of air**

Stopped by a **piece of paper**

Can't penetrate the **dead outer layer of skin**

Beta Radiation

- Beta radiation is less ionizing than alpha radiation.
- It can travel farther in matter than alpha:

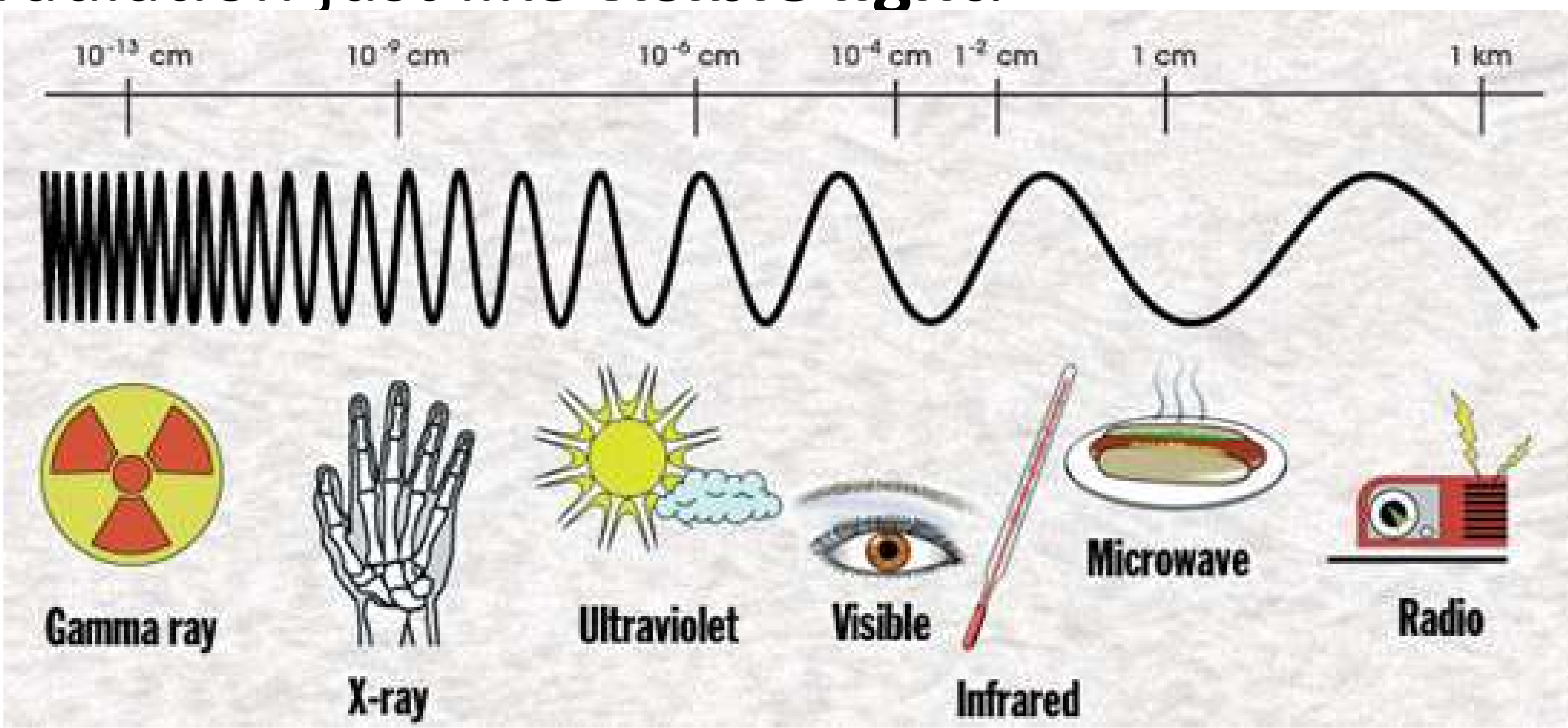
Approximately **200 cm of air**

Stopped by glass, plastic, or aluminium

Can penetrate skin and tissue, to about 0.2 cm

Gamma/X-Ray Radiation

Gamma rays and x-rays are electromagnetic radiation just like **visible light**.



Gamma/X-Ray Emission

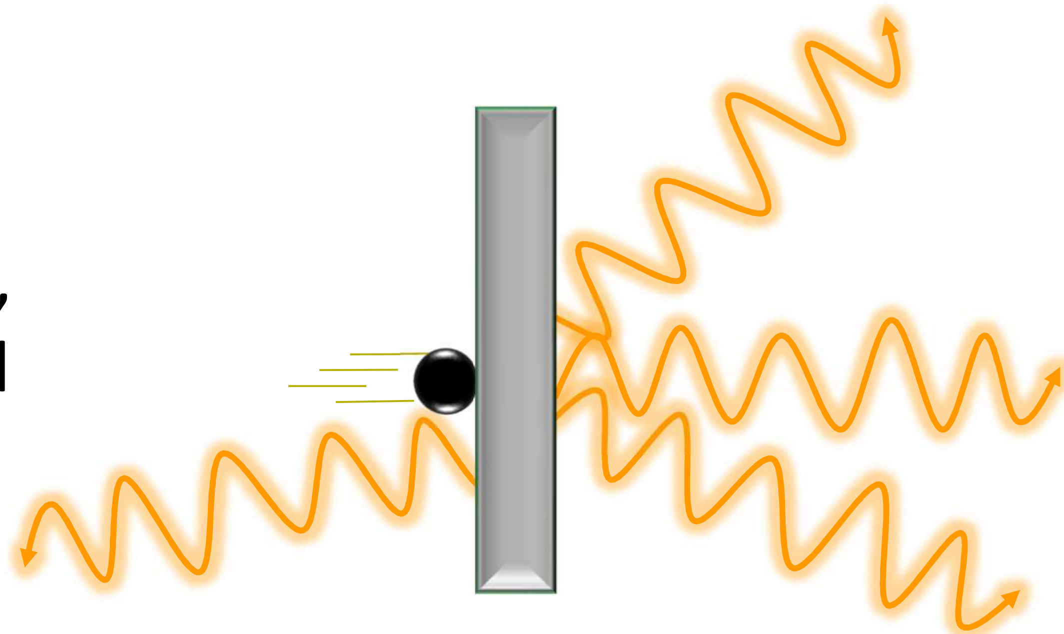
- Gamma rays are emitted from the nuclei of radioactive atoms.
  - The emission of a gamma ray is **always** preceded by either a beta or an alpha decay.

- X-rays are created by forcing electrons to hit a target.

How Are X-rays Produced?

- Get a fast moving (energetic) electrons to hit a target material.

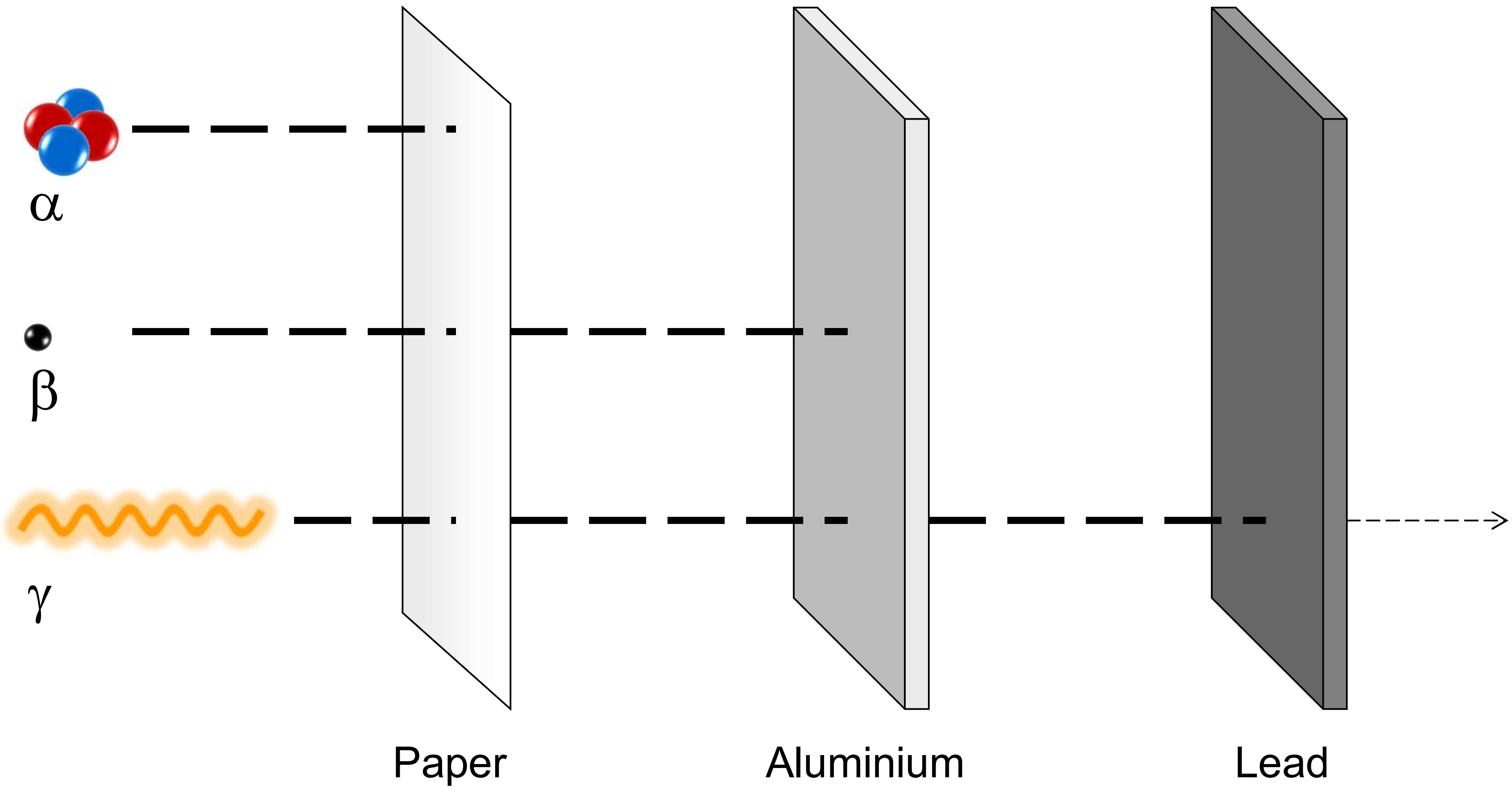
- They will slow down, releasing energy and creating x-rays.



Gamma Rays and X-Rays

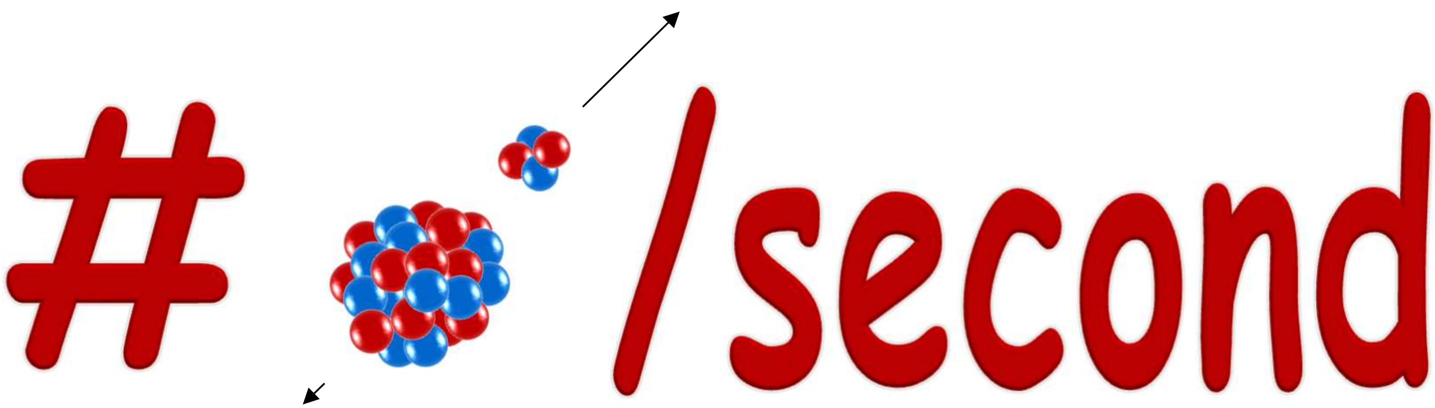
- Gamma rays and x-rays are **ionizing** radiation.
- They do not have a range.
  - They can theoretically travel forever.
- As they pass through matter, their ***intensity*** is reduced.

Radiation Penetrating Power

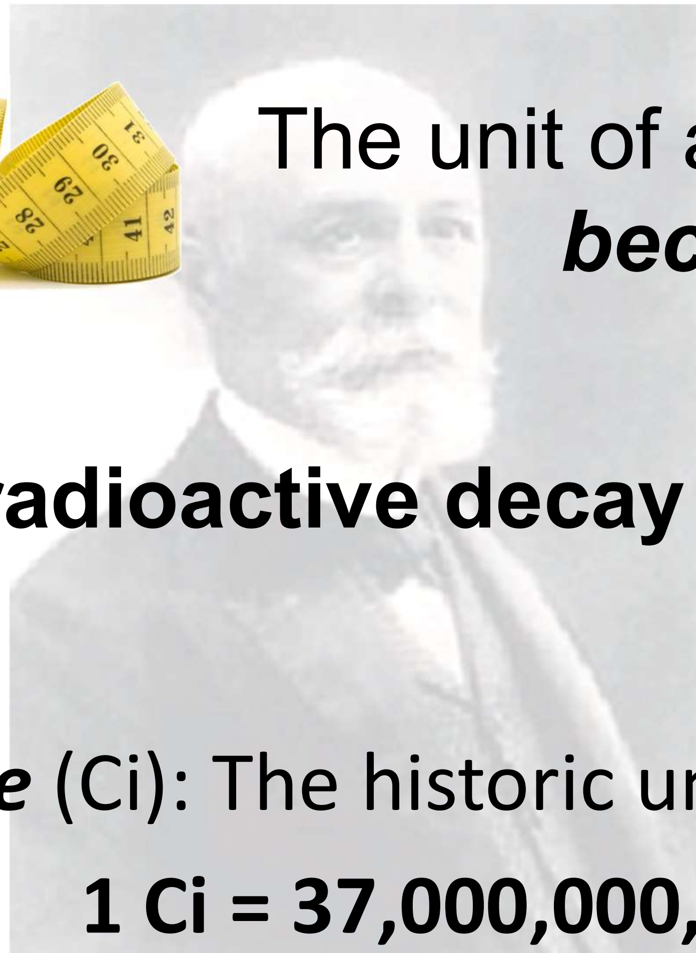


Activity

- ***Activity***: The rate of radioactive decay.
  - The number of radionuclide decays per unit of time.



Activity



The unit of activity is the ***becquerel*** (Bq).

1 Bq = 1 radioactive decay per second

Curie (Ci): The historic unit for activity.

1 Ci = 37,000,000,000 Bq

Half-Life

- ***Half-life***: The time required for a radioactive sample to lose 50% of its activity by radioactive decay.
  - Each radioactive atom has its own unique half-life, regardless of the quantity or form.
    - Solid, liquid, gas
    - Element or compound

Radiation Dose

- The effects of radiation depend on the amount of ***energy*** the radiation transfers to your body.
  - Energy is transferred when the radiation knocks electrons out of orbit

- This transfer of energy results in a radiation ***dose.***

Radiation Dose

- Absorbed dose is a measure of the amount of energy radiation deposits in the body, per unit mass.
- The unit of absorbed dose, is called ***gray*** (Gy).
- 1 Gy is a very large dose.
  - mGy or µGy are used more often

Equivalent Dose

- The *equivalent dose* is the *absorbed dose* multiplied by a radiation weighting factor
- The radiation weighting factor accounts for the different biological damage produced by different types of radiation
- Unit of equivalent dose:
  - *millisieverts (mSv)*

Equivalent Dose

- 1 unit of *absorbed dose* from **gamma**, **x-ray** and **beta** radiation produce approximately the **same** amount of damage in tissue

- 1 unit of *absorbed dose* from internal **alpha** radiation causes approximately **20 times** more damage to tissue than 1 unit of absorbed dose from gamma, x-ray or beta radiation

1 mGy of alpha = 20 mGy gamma = 20 mGy beta

- The concept of **equivalent dose** takes this into account

1 mSv of alpha = 1 mSv gamma = 1 mSv beta

Effective Dose

- The ***effective dose*** is the *equivalent dose* multiplied by a tissue weighting factor, to assess dose on the scale of the whole body

- The tissue weighting factor helps to account for the varying sensitivities to radiation exposure of the different tissues and organs

- The unit of effective dose is also the ***millisievert*** (mSv)

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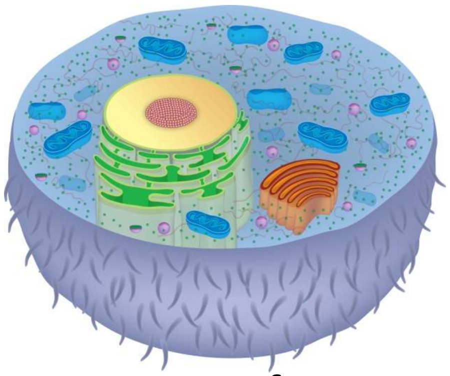
Interaction with the Body

- When radiation strikes living tissue, there are a number of possible outcomes:
  - No damage at all
  - Damage to cells that is repaired
  - Damage to cells that leads to cell death
    - Causes ***deterministic effects*** when exposed to large amounts of radiation in a short period of time
  - Damage to cell chromosomes that is incorrectly repaired ("mutated")
    - Probability increases with increased exposure to radiation
    - Main concern: mutation leading to cancer



Cancer

- Radiation exposure increases the ***likelihood*** of developing cancer.
- The greater the exposures the greater is the likelihood.
- But we cannot be certain that an effect will or will not occur.

Cancer

- We know that smoking causes lung cancer.
  - But, Joe smoked sixty a day and lived to be 95!
- Some people develop lung cancer in their life anyway.
  - Only some of these people are smokers.
- Smoking increases the likelihood of developing lung cancer.
  - This is a stochastic effect.

Cancer Risk from Radiation

- The risk of developing a fatal cancer as a result of exposure to radiation is approximately 4% per 1000 mSv.
  - Consider a person who worked for 50 years and received 20 mSv per year.
  - This person's total lifetime radiation dose is 1000 mSv.
  - This person will have an extra 4% chance of developing a fatal cancer.

Effective Dose Limits

Person	Period	Effective Dose (mSv)
Nuclear Energy Worker (NEW)	1-yr dosimetry period	50
	5-yr dosimetry period	100
Pregnant NEW	Balance of the pregnancy	4
A person who is not a nuclear energy worker	1 calendar year	1

- Radiation Protection Regulations, Section 13(1)

Chronic Exposure

- Exposure to low doses of radiation over months or years
  - Deterministic effects
    - Cataracts
  - Probabilistic effects
    - Cancer

Acute Exposure

- Exposure to a high dose delivered within seconds, minutes or days

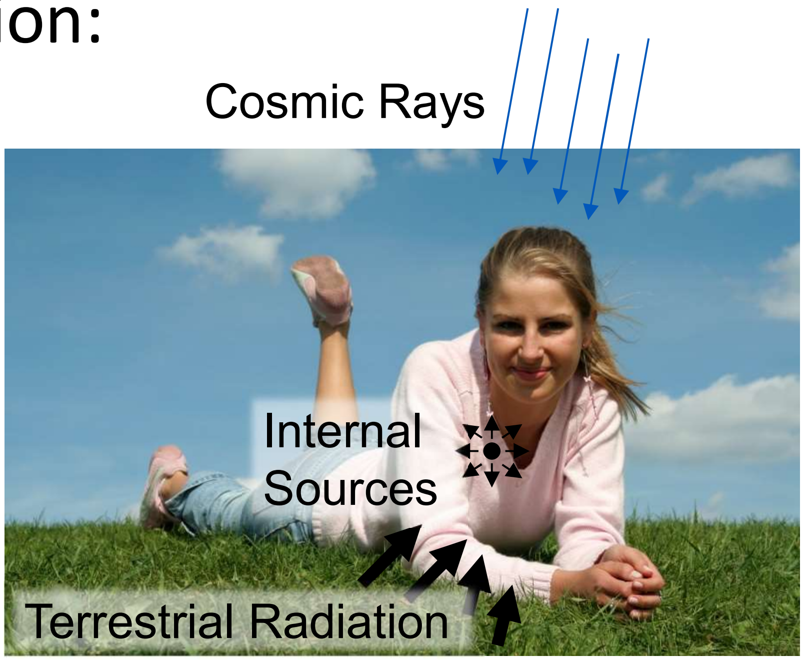
- Possible ***deterministic effects***
  - Blood changes
  - Nausea
  - Diarrhea
  - Hair-loss
  - Malaise
  - Death

Acute Exposure

Acute Dose (mGy)	Effect
< 250	No detectable effects
> 3,000	Chance of death 50% and above
> 6,000	Death an almost certainty, time between exposure and death depends on amount of dose

Radiation Exposure

- We are all exposed to radiation:
  - Cosmic radiation
    - sun, space
  - Terrestrial radiation
    - soil, rocks
  - Internally
    - Food, air (radon gas)
  - Medical treatment



- On average, we receive about 2 – 4 mSv per year from background radiation

Regulator

- The Canadian Nuclear Safety Commission (CNSC) regulates the possession and use of all radioactive substances and radiation devices in Canada
  - Owners of radiation sources and devices must have a licence from the CNSC
- X-ray systems are generally under provincial jurisdiction
  - For example, in Ontario the Ministry of Labour regulates the use of most X-rays.

Radiation Safety Institute of Canada

- The Radiation Safety Institute of Canada is an independent, not-for-profit organization specializing in radiation safety.

- For further information on all types of radiation contact us at:

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www.radiationsafety.ca