Warm-Up | Nuclear Radiation

Lesson Objectives

By the end of this lesson, you should be able to:

- Explain that alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and describe the effects of each kind of radiation on living things.
- Describe how radiation is measured and detected.
- Describe applications of radiation.

Science Practice: Describe careers that involve working with radioactive substances.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

becquerel	a unit of measurement for radioactivity; 1 becquerel (Bq) is equivalent to one decay of an atomic nucleus per second
cloud chamber	a particle detector used to detect radiation in a sealed chamber
film badge	a badge made of photographic film that is used to measure a worker's exposure to radiation
Geiger counter	a device used to measure radiation by detecting alpha or beta particles, or gamma rays
gray	a unit of measurement for absorbed radiation; 1 gray (Gy) is equivalent to the absorption of 1 joule of radiation by 1 kilogram of living tissue
rad	a unit of measurement for absorbed radiation; 1 rad is equivalent to 0.01 Gy

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Words to Know

rem	a unit of measurement for the biological effects of radiation
scintillation counter	a device used to measure radiation by measuring quantities of light emitted from a sensor
sievert	a unit of measurement for effective dose of radiation in biological tissue; 1 sievert (Sv) is equivalent to 1 joule per kilogram, which is equivalent to 1 gray (Gy)

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Lesson Question How does radiation affect living things, and how is it detected?

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The Types of Radiation

Radiation effects depend on:

- the type of radiation [(energy)].
- the pathway of [exposure] (ability to permeate).

All forms of radiation can cause [cancer] and other health problems.

Summary of Alpha, Beta, and Gamma Radiation

Radiation Type	Form	Exposure Information	Penetration Information
Alpha	Fast-moving particle	External exposure – [low] risk; Internal exposure – high risk; increased risk of [cancer]	Alpha particles also cannot penetrate most matter they encounter.
Beta	[Fast-moving] particle	Rare acute exposure; chronic health problems from long-term exposure	Beta particles travel several feet in open [air] and are easily stopped by solid materials.
Gamma	Photon	Primary hazard during radiological emergencies	Gamma rays travel at the speed of [light] and exist only as long as they have energy.

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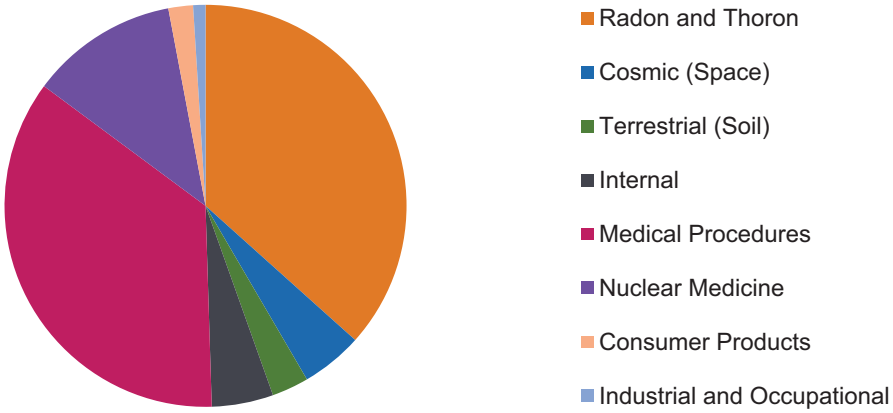
Sources of Radiation Exposure



Biological effects of radiation on living cells may result in three outcomes:

- Injured or damaged cells could [repair] themselves, resulting in no residual damage.
- The cells could die and be [replaced] through normal biological processes.
- The cells could [incorrectly] repair themselves, resulting in biophysical changes.

Biological Effects of Radiation

Low	High
< 50 rem	[>] 50 rem
Damage to cells	Death of cells, [tissues], organs
[Body] repairs damage.	[Cancers], Acute Radiation Syndrome, and death may result.

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General Units of Radiation

	Radioactivity	Absorbed Dose	Dose Equivalent
Common unit	curie (Ci)	rad	rem
SI unit	becquerel (Bq)	gray (Gy)	sievert (Sv)

Radiation Emission Measurement

1 becquerel (Bq) = 1 nuclear decay/sec

1 curie (Ci) = 37 $\times 10^9$ nuclear decays/sec

- The number of disintegrations of radioactive atoms in a radioactive material over a period of time
- The amount of radioactive materials released into the environment

Dose Measurement

1 gray (Gy) = 1 J/kg

1 rad = 0.01 Gy

- Radiation dose absorbed by living tissue
- Amount of energy deposited per unit of mass of human tissue

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Biological Risk Measurement

1 sievert (Sv) = 1 J of radiation/kg

1 Sv = 1 Gy

rem = [rad] × Q

- Measures biological risk and exposure to radiation
- Radiation weighting factor [(Q)]: the ability to transfer energy to the body
  - 1 for photons
  - 1 for [electrons]
  - 2 for protons
  - 20 for alpha particles, fission fragments, and heavy [ions]
  - 2 to 20 for neutrons, depending on the energy level

Summary: SI Units of Measurement for Radiation

Name	Units	Explanation
Becquerel (Bq)	one disintegration per second	Number of disintegrations of radioactive atoms over a period of time
Gray (Gy)	1 Gy = one joule of energy per kilogram of matter	Radiation dose absorbed by *any* material
Sievert (Sv)	1 Sv = one [joule] of energy per kilogram of matter	Radiation dose absorbed by *biological* [tissue]

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Radiation Detection Instruments

A [Geiger] **counter** is a device used to measure radiation by detecting alpha or beta particles or gamma rays.

A [scintillation] **counter** is a device used to measure radiation by measuring quantities of light emitted from a sensor.

A [film] **badge** is a badge made of photographic film, which can be used to measure a worker's exposure to radiation.

A [cloud] **chamber** is a particle detector used to detect radiation in a sealed chamber.

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Applications of Radiation

- Irradiation to kill germs
- [Smoke] detectors
- Nuclear power
- [Medical] diagnostics, such as X-rays
- Medical treatments

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Radiation Treatments for Cancer

- They emit powerful [X-ray] energy.
- Treatments stop cancerous [cells] from multiplying by:
  - shrinking tumors.
  - killing [tumors].
  - stopping the growth of cancer cells.
  - decreasing [pressure] and pain.
- Side effects include fatigue and sunburnlike injuries.
- They are delivered [internally] or externally.

Chemistry Careers in Radiation

Nuclear chemists study:

- [radioactive] elements.
- [nuclear] reactions.
- absorption of radiation.
- production and use of radioactive sources.
- nuclear power.
- the presence or level of radionuclides.

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Lesson Question

How does radiation affect living things, and how is it detected?

Answer

(Sample answer) There are three types of radiations: alpha, beta, and gamma radiations. These radiations can have no effect on living things, small effects such as killing cells, or large effects such as causing biophysical changes such as cancer. Instruments such as film badges, cloud chambers, Geiger counters, and scintillation counters are used to detect the radiations.

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Radiation Exposure and Cancer

- The relationship between radiation exposure and the development of cancer is based on populations exposed to relatively high levels of ionizing radiation.
- Cancers associated with [high-dose] exposure (greater than 50 rem) include leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma, and stomach cancers.
- The time between exposure and development of cancer is known as the [latent] period, which can last for many years.
- Cancers that may develop as a result of radiation exposure are indistinguishable from those that occur naturally or as a result of exposure to other [carcinogens].

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Radiation Measurement and Detection

SI Units of Measure

- Becquerel (Bq)
- Gray (Gy)
- Sievert (Sv)

Conventional Units of Measure

- Curie (Ci)
- Rad
- Rem

Instruments

- Geiger counters
- Scintillation counters
- Film badges
- Cloud chambers

Applications of Radiation

- Irradiation to kill germs
- Smoke detectors
- Nuclear power
- Medical diagnostics, such as X-rays
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Use this space to write any questions or thoughts about this lesson.