AL- Mustaqpal University

Science College

Dep. Biochemistry

First Stage

Biophysics

Lec 8

Radiations, sources, types

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Radiation occurs when energy is emitted by a source, then travels through a medium, such as air, until it is absorbed by matter. Radiation can be described as being one of two basic types: non ionizing and ionizing.

Non-ionizing radiation

People use and are exposed to non-ionizing radiation sources every day. This form of radiation does not carry enough energy to ionize atoms or molecules.

Microwave ovens, global positioning systems, cellular telephones, television stations, FM and AM radio, baby monitors, cordless phones, garage-door openers and ham radios all use non-ionizing radiation. Other forms include the earth's magnetic field and magnetic field exposure from proximity to transmission lines, household wiring and electrical appliances. These are defined as extremely low frequency (ELF) waves.

Ionizing radiation

Some types of radiation have enough energy that they can knock electrons out of their orbits around atoms, upsetting the electron/proton balance and giving the atom a positive charge. Electrically charged molecules and atoms are called ions. The radiation that can produce ions is called ionizing radiation.

There are many types of ionizing radiation. The following are some of the relevant ones:

Alpha radiation:

Alpha radiation consists of two protons and two neutrons; since they have no electrons, they carry a positive charge. Due to their size and charge, alpha particles are barely able to penetrate skin and can be stopped completely by a sheet of paper.

Beta radiation:

Beta radiation consists of fast-moving electrons ejected from the nucleus of an atom. Beta radiation has a negative charge and is about 1/7000th the size of an alpha particle, so it is more penetrating. However, it can still be stopped by a small amount of shielding, such as a sheet of plastic.

Gamma radiation:

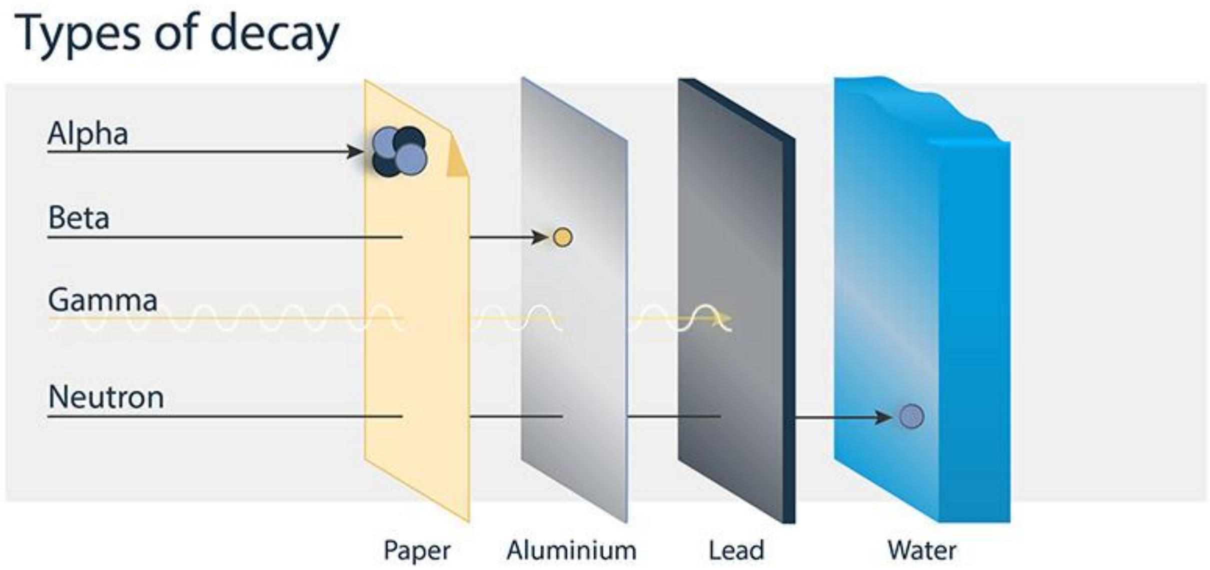
Gamma radiation is a very penetrating type of radiation. It is usually emitted immediately after the ejection of an alpha or beta particle from the nucleus of an atom. Because it has no mass or charge, it can pass through the human body, but it is absorbed by denser materials, such as concrete or lead.

X-rays:

X-rays are a form of radiation similar to gamma radiation, but they are produced mainly by artificial means rather than from radioactive substances.

Neutron radiation:

Neutron radiation occurs when neutrons are ejected from the nucleus by nuclear fission and other processes. The nuclear chain reaction is an example of nuclear fission, where a neutron being ejected from one fissioned atom causes another atom to fission, ejecting more neutrons. Unlike other radiations, neutron radiation is absorbed by materials with lots of hydrogen atoms, like paraffin wax and plastics.



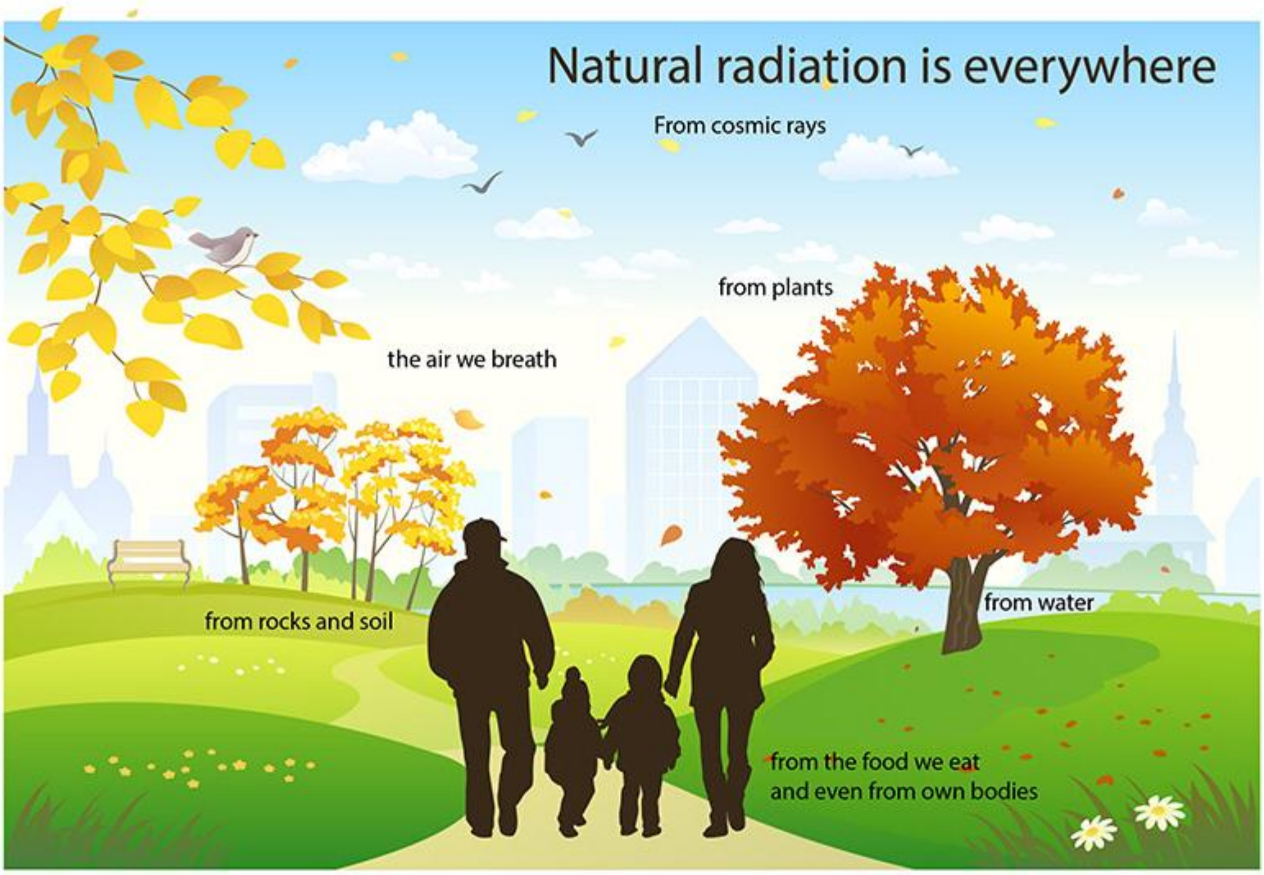
Sources of ionizing radiation

People are constantly exposed to small amounts of ionizing radiation from the environment as they carry out their normal daily activities; this is known as background radiation. We are also exposed through some medical treatments and through activities involving radioactive material.

Natural background radiation

Radiation has always been present and is all around us. Life has evolved in a world containing significant levels of ionizing radiation. Our bodies are adapted to it.

The following section outlines sources of natural background radiation. For information on dose levels from these sources, visit the Radiation Doses page and fact sheet on natural background radiation.



The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) identifies four major sources of public exposure to natural radiation:

- cosmic radiation
- terrestrial radiation
- inhalation
- ingestion

Exposure from cosmic radiation

The earth's outer atmosphere is continually bombarded by cosmic radiation. Usually, cosmic radiation consists of fast moving particles that exist in space and originate from a variety of sources, including the sun and other celestial events in the universe. Cosmic rays are mostly protons, but can be other particles or wave energy. Some ionizing radiation penetrates the earth's atmosphere and becomes absorbed by humans, which results in natural radiation exposure.

The doses due to natural sources of radiation vary depending on location and habits. Regions at higher altitudes receive more cosmic radiation.

Exposure from terrestrial radiation

The composition of the earth's crust is a major source of natural radiation. The main contributors are natural deposits of uranium, potassium and thorium which, in the process of natural decay, release small amounts of ionizing radiation. Uranium and thorium are “ubiquitous”, meaning they are found essentially everywhere. Traces of these minerals are also found in building materials, so exposure to natural radiation can occur indoors as well as outdoors.

Exposure through inhalation

Most of the variation in exposure to natural radiation results from inhalation of radioactive gases that are produced by radioactive minerals found in soil and bedrock. Radon is an odourless and colourless radioactive gas that is produced by the decay of **uranium-238** . It is an inert gas, meaning that it does not react with surrounding matter. Because radon does not react, it can readily move up through the ground and into the atmosphere.. Thoron is a radioactive gas produced by thorium. Radon and thoron levels vary considerably by location depending on the composition of soil and bedrock. Once released into the air, these gases normally dilute to harmless levels in the atmosphere, but sometimes they become trapped and accumulate inside buildings where they are inhaled by occupants. Radon gas poses a health risk not only to uranium miners but also to homeowners if it is left to accumulate in the home. On average, it is the largest source of natural radiation exposure.

Exposure through ingestion

Trace amounts of radioactive minerals are naturally found in the contents of food and drinking water. For instance, vegetables are typically cultivated in soil and ground water which contains radioactive minerals. Once ingested, these minerals result in internal exposure to natural radiation.

Naturally occurring radioactive isotopes, such as potassium-40 and carbon-14, have the same chemical and biological properties as their non-radioactive isotopes. These radioactive and non-radioactive elements are used in building and maintaining our bodies. Natural radioisotopes continually expose us to radiation.

The table below identifies the amount of radioactivity from potassium-40 contained in about 500 grams of different food products. A becquerel is a unit of radioactivity, equal to one transformation (decay) per second.

Table 1 : Potassium-40 content in food

Food	Becquerel (Bq) per 500 grams
Red meat	56
Carrot	63
White potato	63
Banana	65
Lima bean	86
Brazil nut	103

The human body also contains several radioactive isotopes. The table below contains a list of some of the isotopes naturally found in the body.

Table 2: Radioactive isotopes in the body (70 kg adult)

Isotope	Amount of radioactivity in Bq
Uranium	2.3
Thorium	0.21
Potassium-40	4,000
Radium 226	1.1
Carbon-14	3,700
Tritium	23
Polonium-210	40

Artificial sources of radiation

Atmospheric testing

The atmospheric testing of atomic weapons from the end of the Second World War until as late as 1980 released radioactive material, called fallout, into the air. As the fallout settled to the ground, it was incorporated into the environment. Much of the fallout had short half-lives and no longer exists, but some continues to decay to this day. People and the environment receive smaller and smaller doses from the fallout every year.

Medical sources

Radiation has many uses in medicine. The most well known use is in X-ray machines, which use radiation to find broken bones and diagnose disease. X-ray machines are regulated by state ministries of health and regional authorities. Another example is nuclear medicine, which uses radioactive isotopes to diagnose and treat diseases such as cancer. These applications of nuclear medicine, as well as the related equipment, are regulated by the CNSC. The CNSC also licenses those reactors and particle accelerators that produce isotopes destined for medical and industrial applications.

This image shows examples of medical sources of radiation including an x-ray, CT scan, nuclear medicine, and a particle accelerator that produce isotopes.

Industrial sources

Radiation has a variety of industrial uses that ranges from nuclear gauges used to build roads to density gauges that measure the flow of material through pipes in factories. It is also used in smoke detectors and some glow-in-the dark exit signs, and to estimate reserves in oil fields. Radiation is also used for sterilization in which large, heavily shielded irradiators are used. All of these uses are licensed by the CNSC.

This image shows examples of industrial sources of radiation including nuclear gauges, a smoke detector, and glow in the dark exit sign.

Nuclear fuel cycle

Nuclear power plants (NPPs) use uranium to drive a chain reaction that produces steam, which in turn drives turbines to produce electricity. As part of their normal activities, NPPs release regulated levels of radioactive material which can expose people to low doses of radiation. Similarly, uranium mines, fuel fabrication plants and radioactive waste facilities release some radioactivity that contributes to the dose of the public.

Striking a balance

Normally, there is little we can do to change or reduce ionizing radiation that comes from natural sources like the sun, soil or rocks. This kind of exposure, while never entirely free of risk, is generally quite low. However in some cases, natural sources of radioactivity, such as radon gas in the home, may be unacceptably high and need to be reduced. The ionizing radiation that comes from artificial sources and activities is controlled more carefully. In these settings, a balance is struck between the benefits that the radiation provides to society and the risks it imposes on people and the environment. Dose limits are set in order to restrict radiation exposures to both workers and members of the public. In addition, licensees are required to keep all radiation doses as low as reasonably achievable (ALARA), social and economic factors being taken into account. Also, there has to be a net benefit to the use of radiation. For example, radioactive isotopes are permitted in smoke detectors, because smoke detectors save lives.

Discussion

1. What is the primary difference between ionizing and non-ionizing radiation?

A) Ionizing radiation has a larger wavelength than non-ionizing radiation.

B) Non-ionizing radiation does not carry enough energy to ionize atoms.

C) Ionizing radiation cannot pass through solid objects.

D) Non-ionizing radiation can create ions by knocking off electrons.

E) Both types of radiation carry equal energy.

Correct Answer: B

2. Which of the following is an example of non-ionizing radiation?

A) X-rays

B) Alpha particles

C) Microwave ovens

D) Gamma rays

E) Neutron radiation

Correct Answer: C

3. What is a characteristic of alpha particles?

A) They are fast-moving electrons.

B) They carry no charge and no mass.

C) They consist of two protons and two neutrons.

D) They are the most penetrating type of radiation.

E) They are ejected during nuclear fission.

Correct Answer: C

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4. Beta radiation can be stopped by which material?

A) Concrete

B) Lead

C) A sheet of paper

D) A sheet of plastic

E) Glass

Correct Answer: D

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5. What type of radiation is absorbed by dense materials like lead?

A) Alpha radiation

B) Beta radiation

C) Gamma radiation

D) Non-ionizing radiation

E) Extremely low frequency (ELF) waves

Correct Answer: C

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6. Which form of radiation is commonly used in X-ray machines?

A) Alpha radiation

B) Gamma radiation

C) Beta radiation

D) X-rays

E) Neutron radiation

Correct Answer: D

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7. What is a source of neutron radiation?

A) Microwave ovens

B) Nuclear fission processes

C) Cosmic rays

D) FM radio stations

E) Household wiring

Correct Answer: B

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8. Which radioactive gas is the largest source of natural radiation exposure?

A) Uranium-238

B) Thorium

C) Radon

D) Carbon-14

E) Tritium

Correct Answer: C

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9. Cosmic radiation exposure increases with:

A) Higher altitude.

B) Proximity to nuclear power plants.

C) Lower altitude.

D) Proximity to the Earth's core.

E) Usage of electronic devices.

Correct Answer: A

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10. What is the main source of terrestrial radiation?

A) Cosmic rays

B) Earth's magnetic field

C) Natural deposits of uranium, thorium, and potassium

D) Radioactive fallout from weapons testing

E) Atmospheric radon gas

Correct Answer: C

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11. What property makes radon gas dangerous?

A) It is reactive with air and water.

B) It is radioactive and accumulates indoors.

C) It is found only in industrial settings.

D) It is absorbed directly through the skin.

E) It is brightly colored and visible in low light.

Correct Answer: B

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12. Which food has the highest amount of potassium-40 per 500 grams?

A) Banana

B) Carrot

C) Red meat

D) Brazil nut

E) Lima bean

Correct Answer: D

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13. Which radioactive isotope contributes the most to natural radioactivity in the human body?

A) Uranium

B) Carbon-14

C) Tritium

D) Potassium-40

E) Polonium-210

Correct Answer: D

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14. Which activity is the primary artificial source of radiation exposure?

A) Atmospheric testing of atomic weapons

B) Nuclear medicine procedures

C) Use of microwave ovens

D) Installation of garage door openers

E) Consumption of radioactive isotopes in food

Correct Answer: B

15. Which type of radiation is used in smoke detectors?

A) Beta radiation

B) Alpha radiation

C) Gamma radiation

D) X-rays

E) ELF waves

Correct Answer: B

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16. Which organization identifies major sources of public exposure to natural radiation?

A) CNSC

B) United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)

C) International Atomic Energy Agency (IAEA)

D) World Health Organization (WHO)

E) National Aeronautics and Space Administration (NASA)

Correct Answer: B

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17. Which material is most effective at absorbing neutron radiation?

A) Lead

B) Paraffin wax

C) Concrete

D) Glass

E) Aluminum

Correct Answer: B

18. What is the principle of ALARA in radiation protection?

A) Allowing Limited Access to Radiation Areas

B) Always Limiting Atom Reactions in Atmosphere

C) As Low As Reasonably Achievable

D) Avoiding Long-term Accumulation of Radiation

E) Assessing Levels of Atmospheric Radiation Anomalies

Correct Answer: C

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19. Fallout from atmospheric testing of atomic weapons continues to decay because:

A) It has long half-lives.

B) It is constantly replenished.

C) It reacts with cosmic rays.

D) It is shielded by atmospheric gases.

E) It forms new isotopes over time.

Correct Answer: A

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20. Which radiation source is carefully regulated to protect the public?

A) Cosmic radiation

B) Inhalation of radon gas

C) Radiation from X-ray machines

D) Potassium-40 in food

E) Terrestrial radiation

Correct Answer: C

21. What percentage of the human body's radioactive isotopes is due to carbon-14 ?

A) 1%

B) 10%

C) Approximately 48%

D) Approximately 92%

E) Less than 5%

Correct Answer: C

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22. What is the primary health risk of radon gas accumulation in homes?

A) Skin burns

B) Inhalation of radioactive particles

C) Damage to household appliances

D) Chemical explosions

E) Visual impairments

Correct Answer: B

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23. What natural process generates cosmic rays?

A) Nuclear fission in power plants

B) Solar and celestial events

C) Decay of potassium-40

D) Earth's magnetic field fluctuations

E) Industrial processes

Correct Answer: B

24. What is the primary purpose of radiation in industrial settings?

A) Sterilization and material measurement

B) Enhancing product colors

C) Generating solar energy

D) Increasing electrical conductivity

E) Decreasing weight of materials

Correct Answer: A

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25. Why is the use of radioactive isotopes in smoke detectors justified?

A) It poses no health risks at all.

B) It provides essential household lighting.

C) It offers a net benefit by saving lives.

D) It generates power for other devices.

E) It neutralizes harmful airborne particles.

Correct Answer: C