U.S. EPA Radiation Education Activities:

Vocabulary Materials

United States Environmental Protection Agency

U.S. EPA Radiation Education Activities: **Vocabulary Activities**

By conducting a vocabulary activity before beginning an activity or series of activities, students will have a shared base knowledge. Teachers can use all of the vocabulary words in this packet, or only those identified for each activity. Alternatively, you can provide students with the terms and definitions at the beginning of the activity or when introducing the words.

This document contains vocabulary activity suggestions, radiation definitions, and the vocabulary words and images to use with the vocabulary activities.

Common Core State Standards (CCSS)

The concepts in this activity align with the following CCSS English Language Arts Standards for Literacy in History/Social Studies, Science, & Technical Subjects:

- Key Ideas and Details: CCSS.ELA-LITERACY.RST.6-12.2
- Craft and Structure: CCSS.ELA-LITERACY.RST.6-12.4
- Vocabulary Acquisition and Use: CCSS.ELA-LITERACY.L.6-12.6

Activity Suggestions

- **Identifying images.**
  - Print the applicable images from the *Vocabulary Materials* document.
  - Display the images around the room or spread them out in an open area on the floor.
  - Pronounce the vocabulary words one at a time. NOTE: You can provide the definition of the given word at this time or after students have identified the words.
  - Have students take turns identifying the words in an active manner. Suggestions include having students move to and identify the correct image, use a flashlight to point to the correct image (being careful to avoid light in another person's eyes), drive a remote control car to the correct image or throw a bean bag to land on the correct image.
- **Matching words and images.**
  - Print the applicable words and images from the *Vocabulary Materials* document.
  - Give each student a vocabulary word or image. Options: Fold or ball up the copies and let each student select one. Have students trade their copy with another student once or twice. NOTE: You may need to participate to have an even number of participants.
  - Direct students to find the person with the matching word or image.
  - Review the matches to confirm they are correct.
  - Pronounce each word and provide a definition.
- **Spelling the words.**
  - Print the applicable words and images from the *Vocabulary Materials* document.
  - Display the words and images at the front of the classroom.
  - Pronounce each word and provide a definition.
  - Conduct a spelling activity:
    - Have students create a word scramble or word find activity; trade papers and complete the activity.
    - Play spelling basketball. Divide the class into two teams. Pronounce a vocabulary word. Have a student (alternating between teams) spell or write the word on the board. Students that spell the word correctly are given an opportunity to shoot a basket (use a trash can) with a ball of paper (ball) from a designated distance (or varying distances for a different number of points). The team that scores the most points wins. You can have students provide a definition for extra points.
- **Creating definitions.**
  - Print the applicable words and images from the *Vocabulary Materials* document.
  - Display the words and images at the front of the classroom.
  - Pronounce the vocabulary words.
  - Have students work in pairs or small groups to hypothesize and create a definition for each vocabulary word.
  - Options: Direct one student from each pair/group to rotate and join another pair/group or have two pairs/groups join together. Direct the newly formed groups to compare their definitions and modify them if desired.
  - Review each pair/group's definitions, have students discuss what they agree/disagree with and confirm the accurate definition.

Radiation Definitions

Acute exposure: Exposure to a large, single dose of radiation, or a series of moderate doses received during a short period of time. Large acute doses can result from accidental or emergency exposures or from specific medical procedures (radiation therapy).

Alpha particle: A positively charged particle made up of two neutrons and two protons emitted by certain radioactive nuclei. Alpha particles cannot penetrate most matter. A piece of paper or the dead outer layers of skin is sufficient to stop alpha particles. Radioactive material that emits alpha particles (alpha emitters) can be very harmful when inhaled, swallowed, or absorbed into the blood stream.

Americium: A man-made element; a silvery metal. Trace quantities of americium are widely used in smoke detectors and as neutron sources in neutron moisture gauges.

Atom: Extremely small particles of which we, and everything around us, are made. Atoms consist of a nucleus, containing protons and neutrons, surrounded by electrons.

Beta particle: An electron or positron emitted by certain radioactive nuclei. Beta particles can be stopped by a layer or two of clothing or by a few millimeters of a substance such as aluminum. They are capable of penetrating the skin and causing radiation damage, such as skin burns. As with alpha emitters, beta emitters are most hazardous when they are inhaled or ingested.

Chain reaction: A reaction that initiates its own repetition. In a fission chain reaction, a fissionable nucleus absorbs a neutron and fissions (splits) spontaneously, releasing additional neutrons. These, in turn, can be absorbed by other fissionable nuclei, releasing still more neutrons. A fission chain reaction is self-sustaining when the number of neutrons released in a given time equals or exceeds the number of neutrons lost by absorption in non-fissionable material or by escape from the system.

Chronic exposure: Continuous or intermittent exposure to low doses of radiation over a long period of time. There is a delay between the exposure and the observed health effect.

Cosmic radiation: Radiation from space, like a steady drizzle of rain. This shower of cosmic radiation is created by charged “sub-atomic particles” (parts of atoms) that originate in our galaxy and the sun. The particles interact with Earth’s atmosphere and magnetic field to create cosmic radiation.

DNA (deoxyribonucleic acid): The "blueprints" that carry our genetic information. DNA ensures that a perfect copy of the original cell is created when our body repairs or replaces cells.

Decay chain: The series of decays or steps that certain unstable (radioactive) atoms go through before reaching a stable form. For example, the decay chain that begins with uranium–238 culminates in lead–206, after forming uranium–234, thorium–230, radium–226 and radon–222.

Direct exposure: Exposure from radioactive material outside of your body.

Dose: The quantity of energy absorbed by a person exposed to radiation.

Dosimeter: A small portable instrument (e.g., a film badge, thermoluminescent dosimeter or pocket dosimeter) for measuring and recording the total accumulated personal dose of ionizing radiation.

Dosimetry: The monitoring of individuals to accurately determine their radiation dose equivalent.

Electromagnetic spectrum: Energy that travels in the form of waves or high-speed particles. The electromagnetic spectrum extends from low to high frequencies of energy including radio waves, microwaves, infrared light, visible light, ultraviolet light, x-rays and gamma rays. The electromagnetic spectrum is divided into two major categories: ionizing radiation and non-ionizing radiation.

Electron: Particles that orbit the nucleus as a cloud. They are negatively charged and balance the positive electrical charge of the protons in the nucleus. Interactions with electrons in the outer orbits affect an atom's chemical properties.

Exposure pathways: The way in which people are exposed to radiation or other contaminants. The three basic pathways are inhalation (contaminants are taken into the lungs), ingestion (contaminants are swallowed) and direct (external) exposure (contaminants cause damage from outside the body).

Fission: The splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

Fusion: The union of atomic nuclei to form heavier nuclei resulting in the release of enormous quantities of energy when certain light elements unite.

Gamma rays: High-energy electromagnetic radiation emitted by certain radioactive elements when their nuclei transition from a higher to a lower energy state. These rays have high energy and a short wavelength. Gamma rays are very penetrating. Several feet of concrete or a few inches of lead may be required to stop gamma rays. While gamma rays can easily pass completely through the human body, a fraction of the energy will always be absorbed by tissue.

Geiger counter: A radiation detection and measuring instrument. It consists of a gas-filled tube containing electrodes, between which there is an electrical voltage, but no current flowing. When ionizing radiation passes through the tube, a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second measures the intensity of the radiation field. It is the most commonly used portable radiation detection instrument.

Half-life: The amount of time it takes for half of the radioactive atoms in a sample to decay into a more stable form. Every radioactive atom has a different half-life. Half-lives vary from billionths of a billionth of a second to billions of years.

Health physics: A scientific field that focuses on radiation protection of humans and the environment. Health physics uses physics, biology, chemistry, statistics and electronic instrumentation to help protect individuals from any damaging effects of radiation.

Ingestion: Eating or drinking radioactive material.

Inhalation: Breathing in radioactive material.

Ion: An atom that has too many or too few electrons, causing it to have an electrical charge, and therefore, be chemically active.

Ionizing radiation: Energy given off as either particles or rays from the unstable nucleus of an atom. The most energetic form of radiation; capable of removing electrons from atoms and damaging living cells and the DNA of those cells. Ionizing radiation includes x-rays, gamma rays and alpha and beta particles.

Isotope: A form of an element that has the same atomic number (same number of protons), but a different atomic mass due to the presence of a different number of neutrons.

Man-made radiation: Radiation that is produced for medical, manufacturing and consumer purposes.

Meson: A subatomic particle that holds nucleons together in the atomic nucleus.

Monitoring: The use of sampling and detection equipment to determine the levels of radiation or other toxic materials in land, air or water.

Natural (background) radiation: The radiation present in the natural environment; includes cosmic, terrestrial and internal radiation.

Neutron: A small particle, with no electrical charge, typically found within an atom's nucleus. A neutron has about the same mass as a proton.

Non-ionizing radiation: Radiation that has lower energy levels and longer wavelengths than ionizing radiation. It has enough energy to move atoms, but not enough to alter them chemically. It can be strong enough to heat tissue and cause harmful biological effects. Examples include radio waves, microwaves, visible light and infrared from a heat lamp.

Nuclear energy: The heat energy produced by the process of nuclear reaction (fission or fusion) within a nuclear reactor or by radioactive decay.

Nuclear fallout: The slow descent of minute particles of radioactive debris in the atmosphere following a nuclear explosion.

Nucleus: The central part of an atom that contains protons and neutrons. The nucleus is the heaviest part of the atom.

Photon: A "packet" of electromagnetic energy. Photons have no mass and travel at the speed of light. Gamma and X-rays are photons.

Proton: A small particle, typically found within an atom's nucleus, that possesses a positive electrical charge. The number of protons is unique for each chemical element.

Radiation: Radiation is energy that travels in the form of waves and makes up the electromagnetic spectrum. The electromagnetic spectrum is divided into two major categories: ionizing radiation and non-ionizing radiation. All matter is composed of atoms. Some atoms are unstable. As unstable atoms change to become more stable, they give off invisible energy waves or particles called ionizing radiation.

Radiation exposure: Exposure occurs when a person is near a radiation source. Receiving an x-ray is an example of exposure. Though the radiation penetrates the body, it does not remain on the skin or in the body.

Radiation exposure pathways: The way in which people are exposed to radiation or other contaminants. The three basic pathways are inhalation (contaminants are taken into the lungs), ingestion (contaminants are swallowed) and direct (external) exposure (contaminants cause damage from outside the body).

Radiation protection: Basic radiation protection concepts can be applied separately or in combination to help limit people's exposure to increased radiation levels, including time: limiting time near the radiation source, distance: increasing the distance from a radiation source, and shielding: placing material or a barrier between a person and a radiation source.

Radioactive atom: An atom with an unstable nucleus that emits ionizing radiation (alpha particles, beta particles or gamma rays) as it decays and attempts to become stable.

Radioactive contamination: A deposit of radioactive material on the surfaces of structures, areas, objects or people. It may also be airborne, external or internal (inside components or people).

Radioactive decay: The process in which an unstable (radioactive) nucleus emits radiation and changes to a more stable isotope or element. A number of different particles can be emitted by decay. The most typical are alpha or beta particles, often accompanied by gamma radiation.

Radioactive materials: Materials that emit ionizing radiation (alpha particles, beta particles and gamma rays).

Radioactivity: The property of some atoms that causes them to spontaneously give off energy as particles or rays. Radioactive atoms emit ionizing radiation when they decay and transform to a new element.

Radium: A naturally occurring radioactive (unstable) element that forms when uranium or thorium decay. Elevated levels of radium (Ra; atomic number 88) can contaminate water supplies. Radium also poses a risk when it decays to form radon, a radioactive gas.

Radon: A naturally occurring (colorless and odorless) radioactive gas found in soils, rock and water throughout the United States. Radon (Rn; atomic number 86) causes lung cancer and is a threat to health because it tends to collect in homes, sometimes to very high concentrations. As a result, radon is the largest source of exposure to naturally occurring radiation.

Rem: The United States' unit of a measurement for radiation dose is the rem (Roentgen Equivalent Man). Doses are most commonly reported in millirem (mrem). A millirem is one thousandth of a rem (1000 mrem = 1 rem). Countries that use the metric system measure radiation dose in units of sieverts (Sv). A millisievert is one thousandth of a sievert (1000 mSv = 1 Sv). Converting sieverts to rems is easy. One sievert equals 100 rem (1 Sv = 100 rem). One millisievert equals one hundred millrems (1 mSv = 100 millrems).

Strong nuclear force: A powerful force between nucleons: proton-to-proton, neutron-neutron, and proton-neutron. It extends only a very short distance, about the diameter of a proton or neutron.

Shelter-in-place: Selecting a small, interior room, with no or few windows, and taking refuge there.

Terrestrial radiation: Radiation that is emitted by naturally occurring radioactive materials in the earth.

Tritium: Tritium (chemical symbol H–3) is a radioactive isotope of the element hydrogen (chemical symbol H).

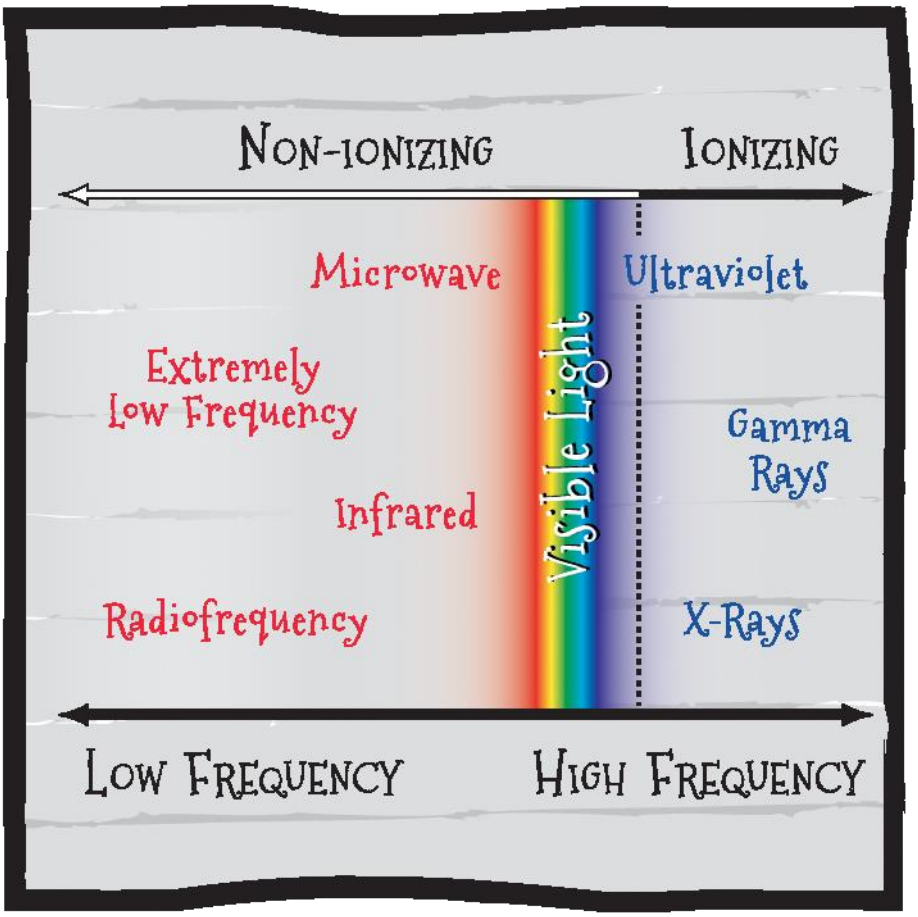
Unstable nucleus: An atom is unstable (radioactive) if the forces among the particles that make up the nucleus are unbalanced (has an excess of internal energy).

Uranium: A radioactive (unstable) element generally found in the environment. As uranium (U; atomic number 92) decays, it releases radiation and forms other elements (like radium and radon) until it becomes a stable element (lead).

X-rays: X-rays and gamma rays differ in origin, but have essentially the same properties. All x-rays are less energetic than the most energetic gamma rays. Most diagnostic medical x-rays are stopped by a few millimeters of lead.

Electromagnetic Spectrum

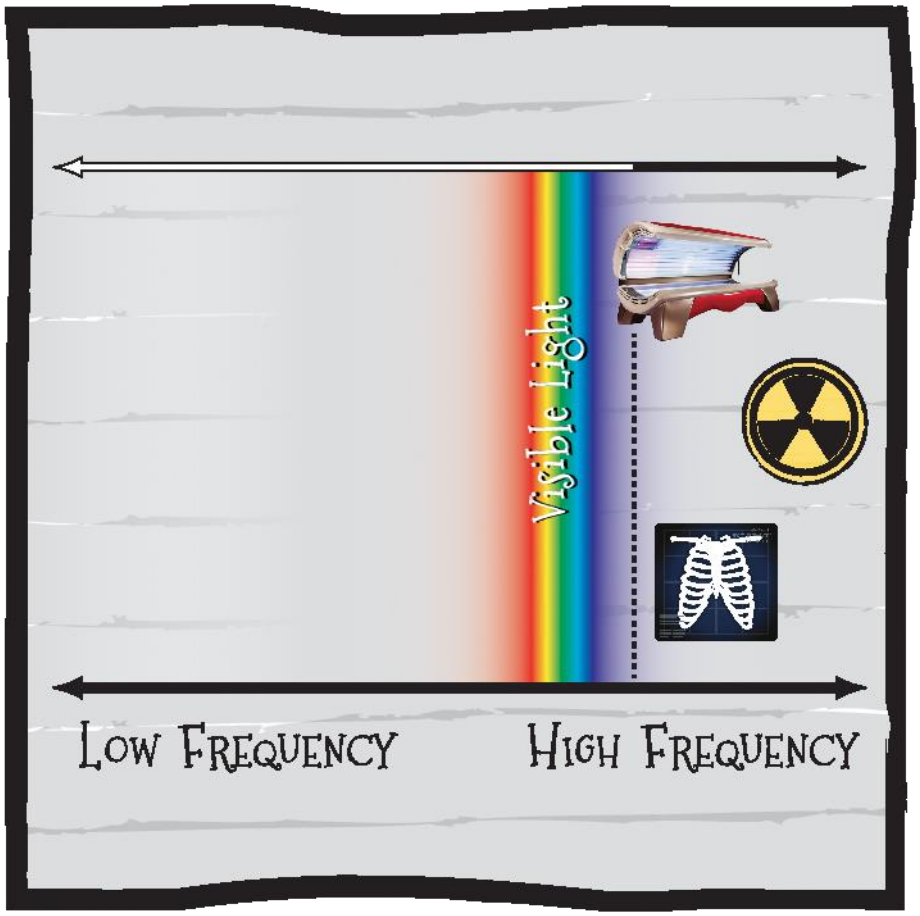
Radiation


Non-ionizing
Ionizing
Microwave
Ultraviolet
Extremely
Low Frequency
Visible Light
Gamma
Rays
Infrared
Radiofrequency
X-Rays
Low Frequency
High Frequency

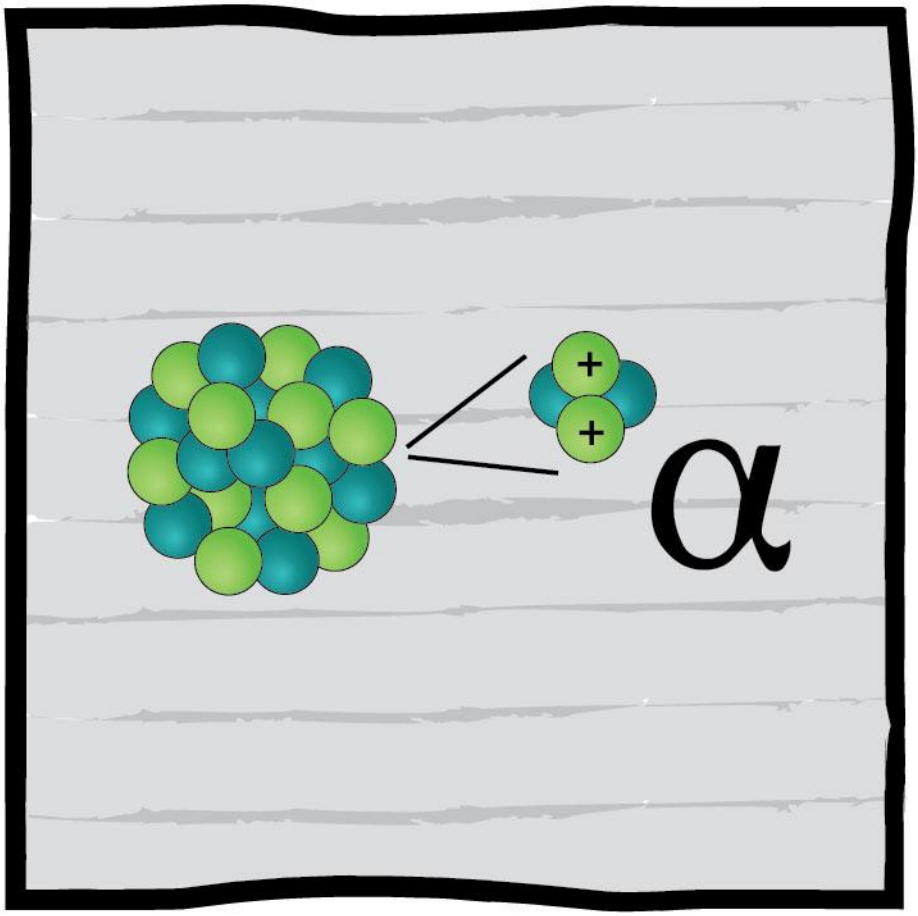
Non-Ionizing Radiation


Visible Light
Low Frequency
High Frequency

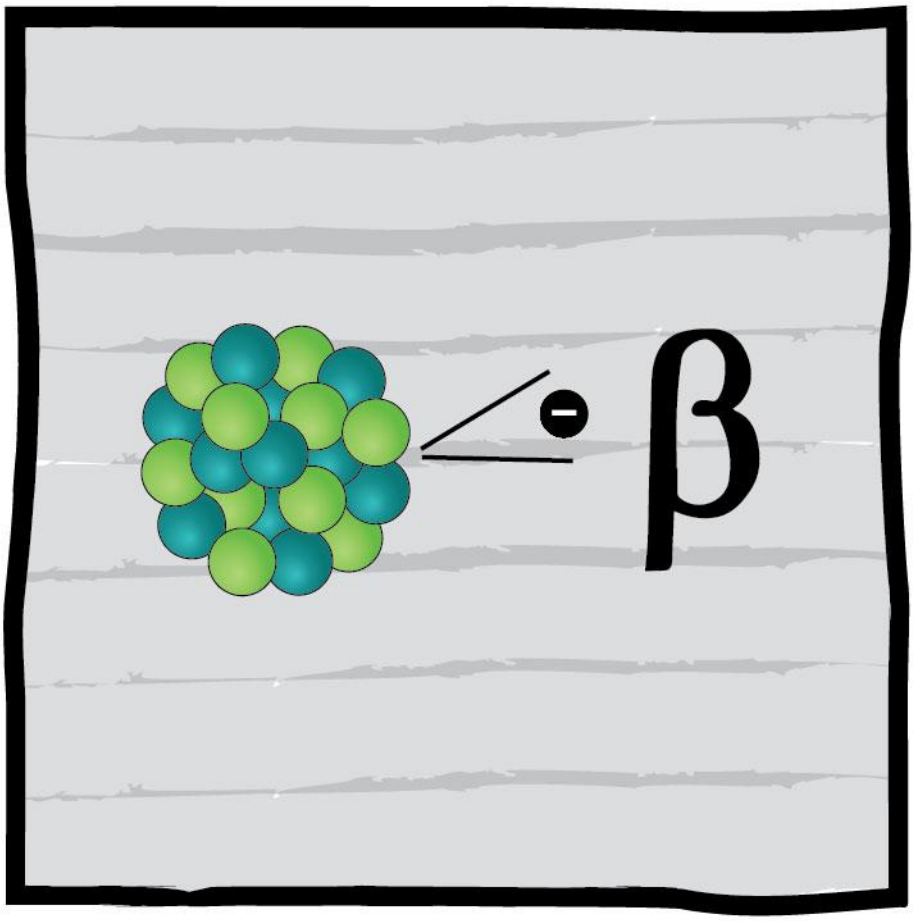
Ionizing Radiation


Visible Light
Low Frequency
High Frequency

Alpha Particle

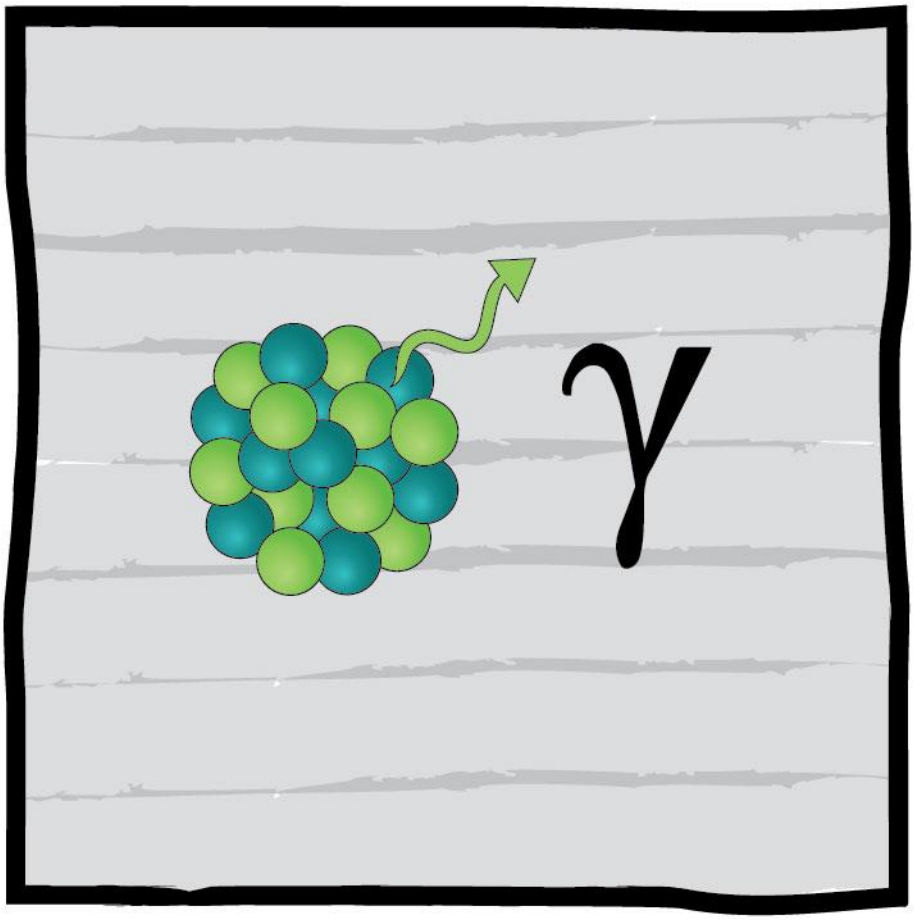

+
+
α

Beta Particle


β

Gamma Rays

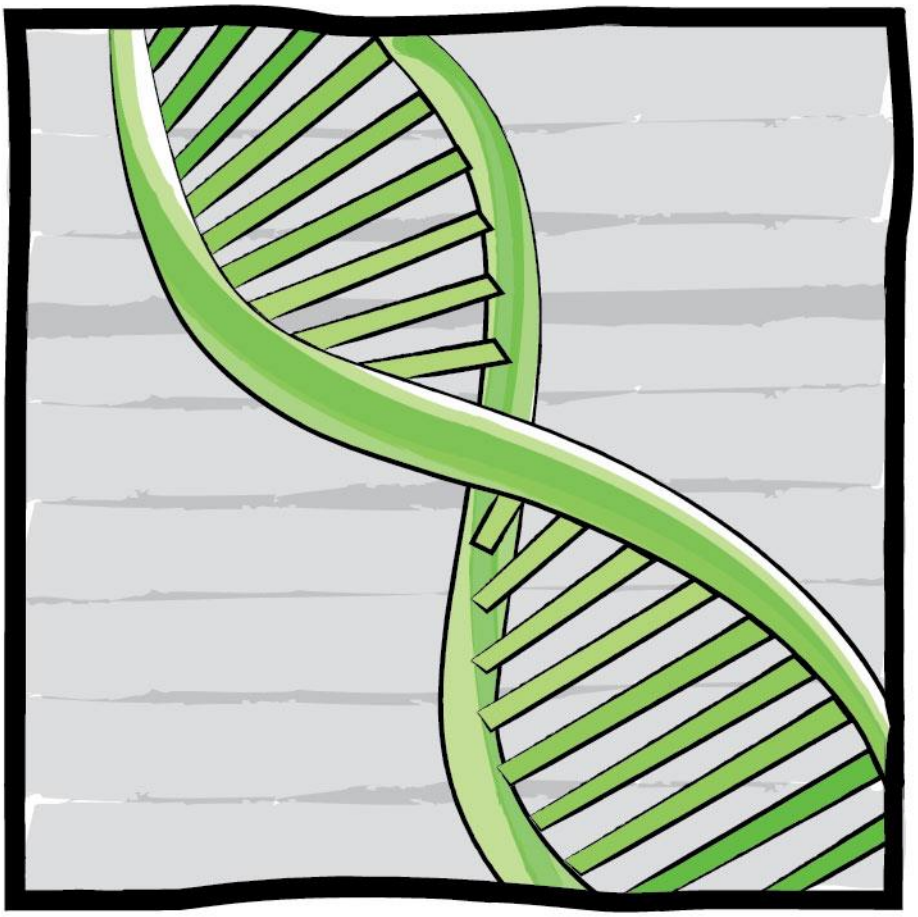
Photon


γ

X-rays


02/09/2012

DNA
(deoxyribonucleic
acid)



Natural (Background) Radiation

Cosmic Radiation

Terrestrial Radiation

Man-made Radiation

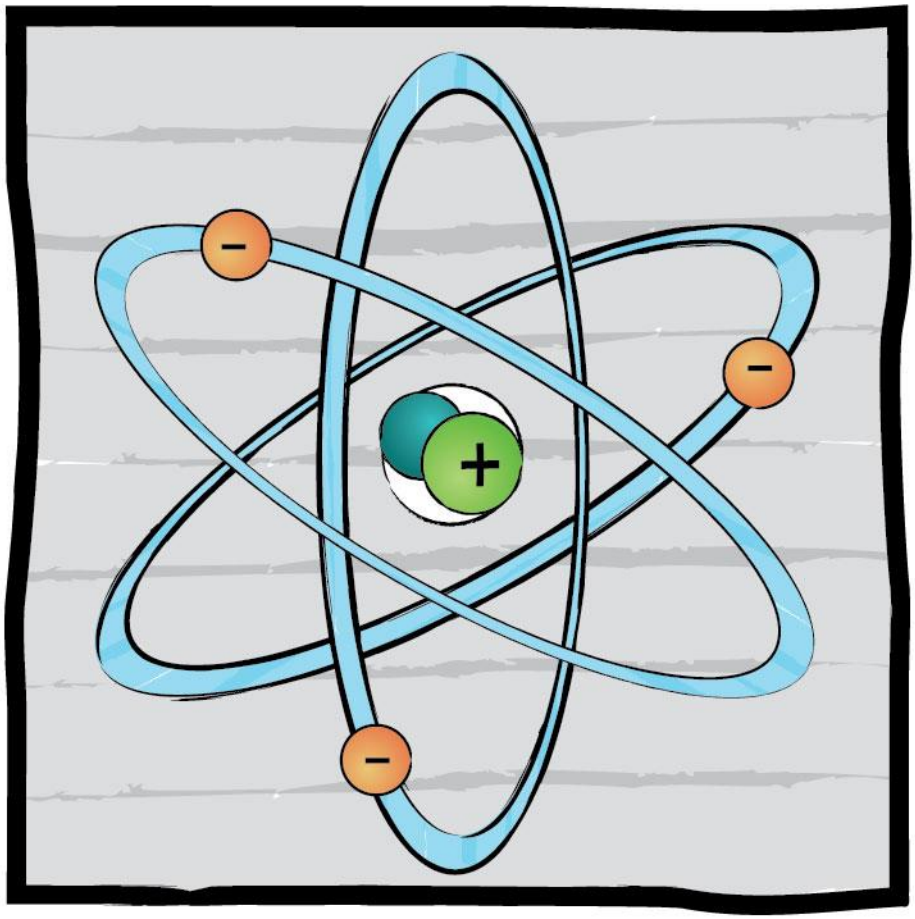
Nuclear Energy

Atom

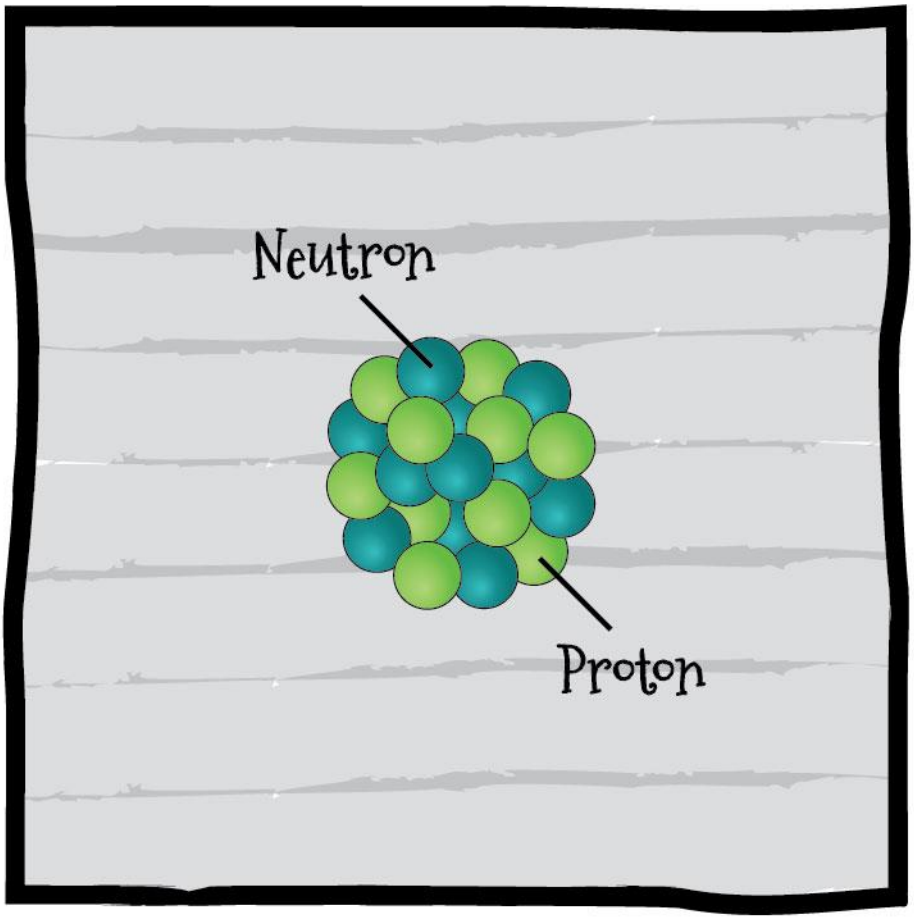
Neutron

Proton

Electron

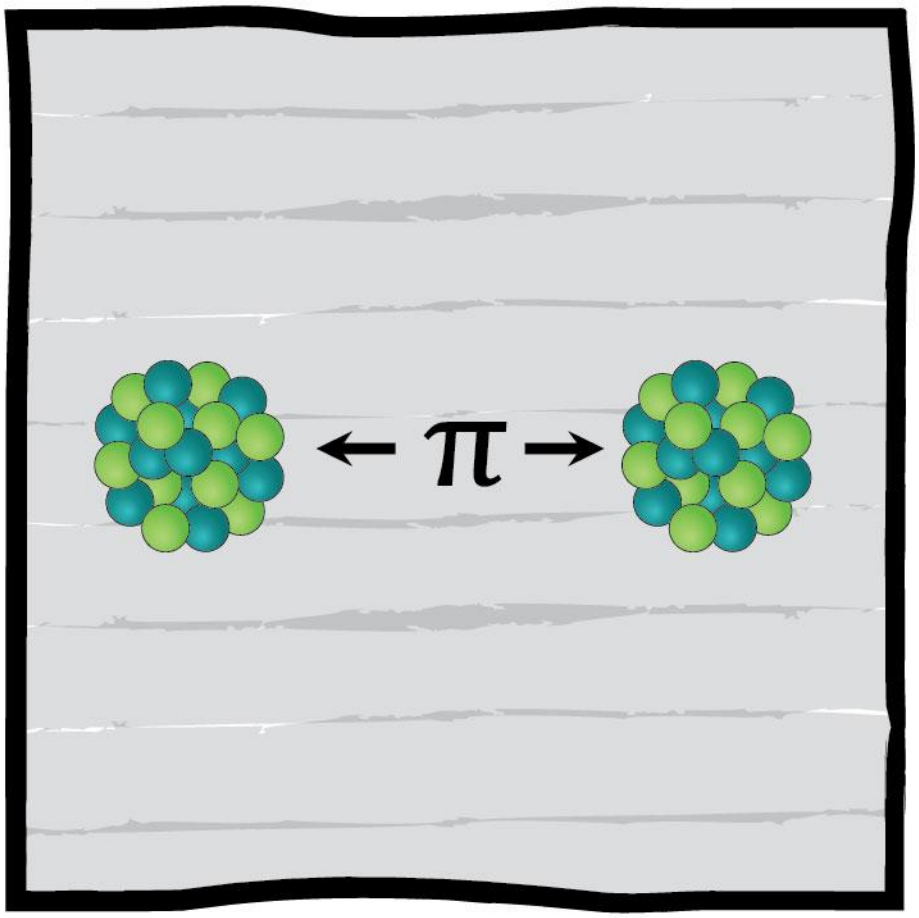


Nucleus


Neutron
Proton

Meson

Strong Nuclear Force

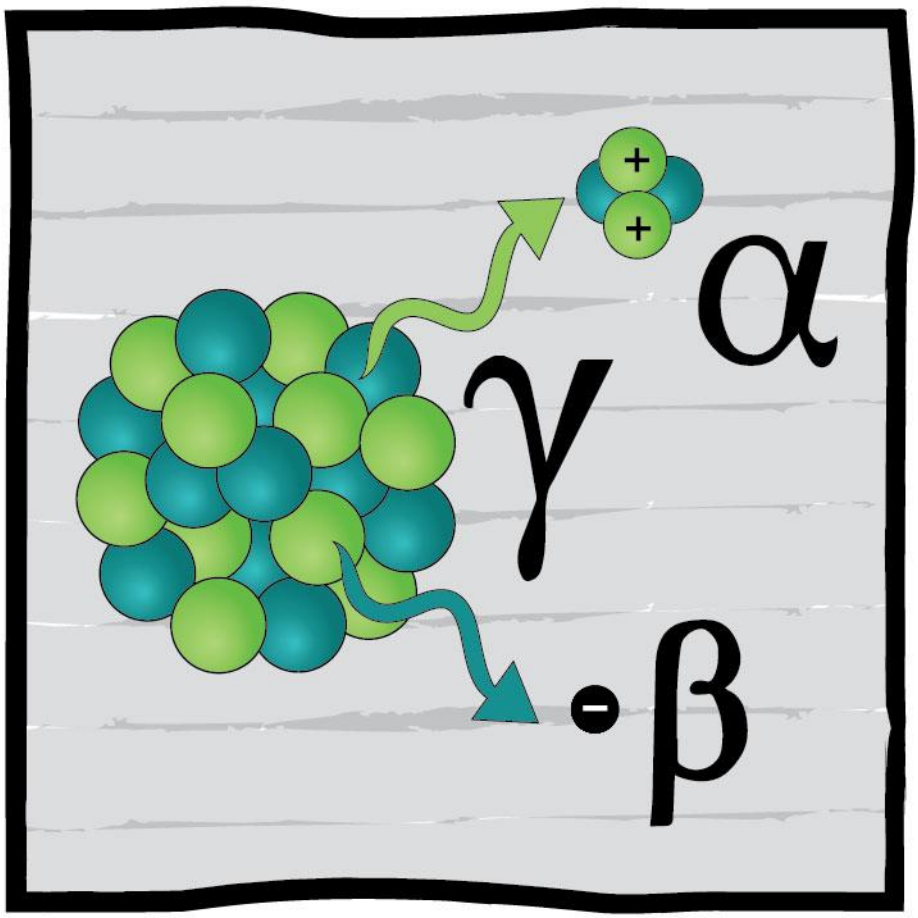

π

Radioactive Atom

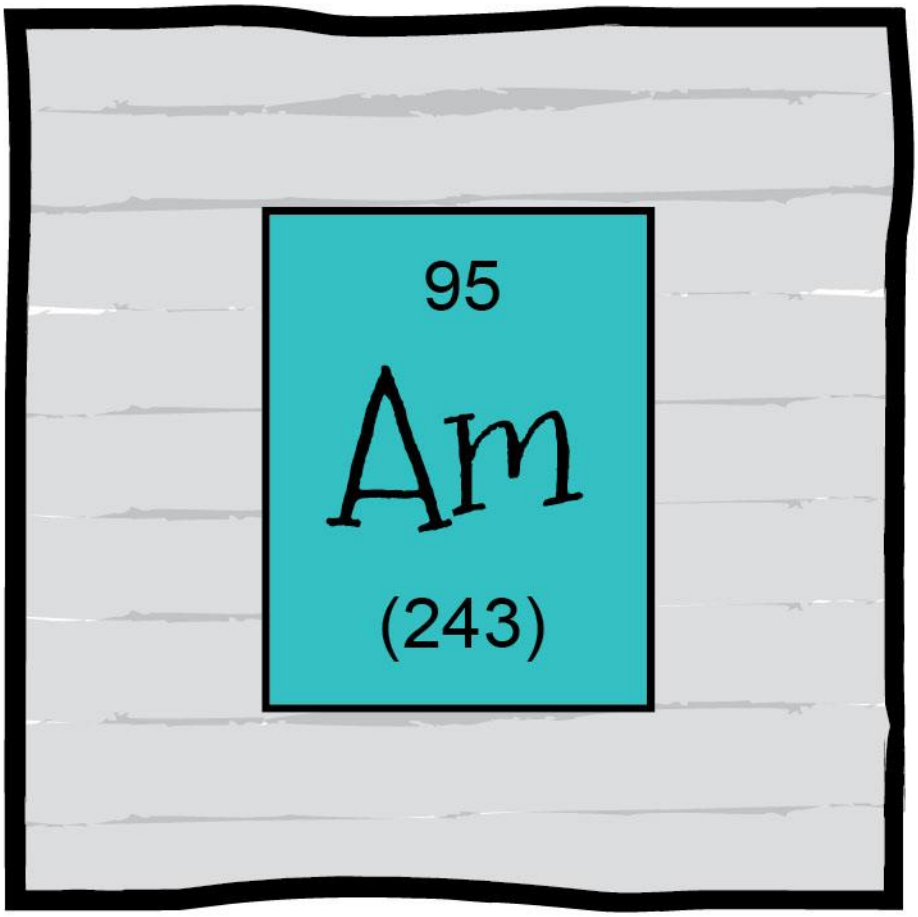
Radioactive Decay

Radioactivity

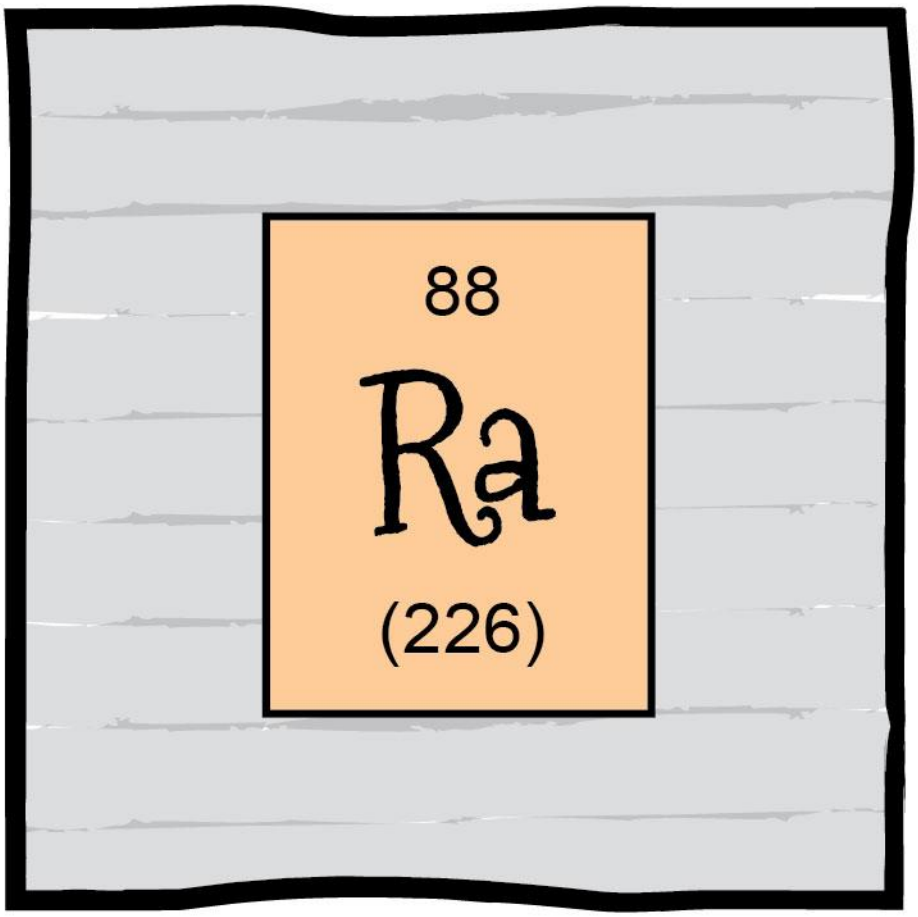
Unstable Nucleus


+
+
α
γ
-
β

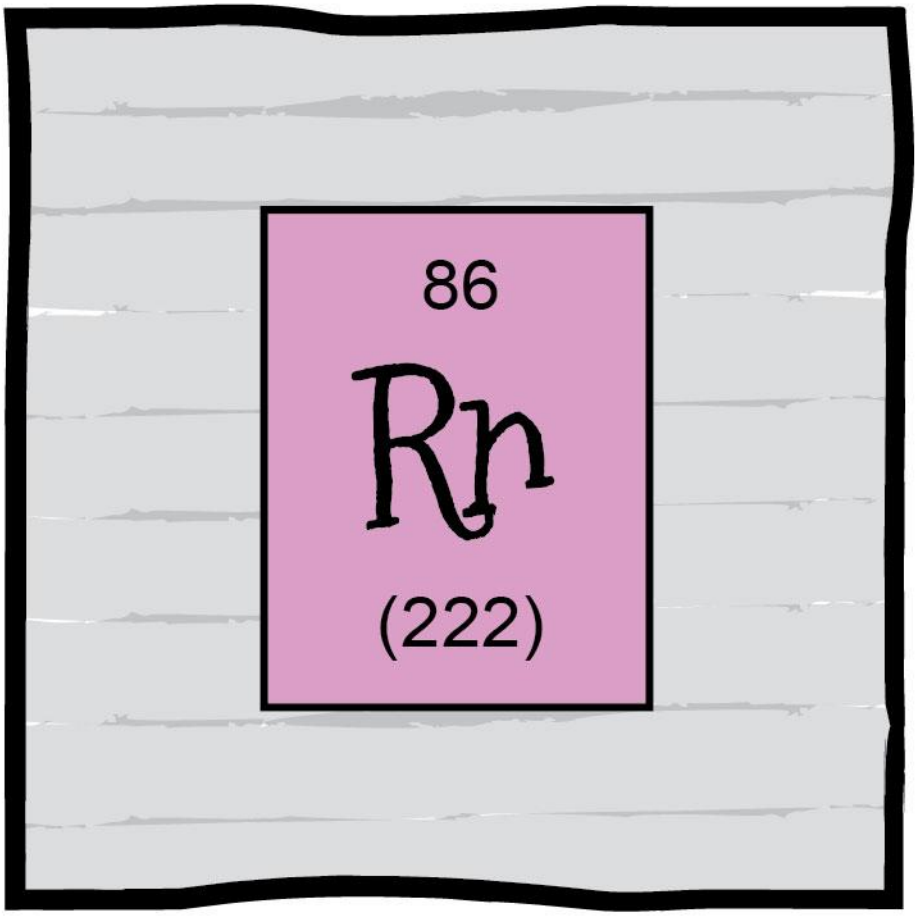
Americium


95
Am
(243)

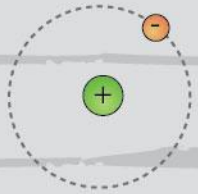
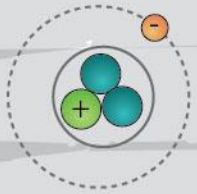
Radium


88
Ra
(226)

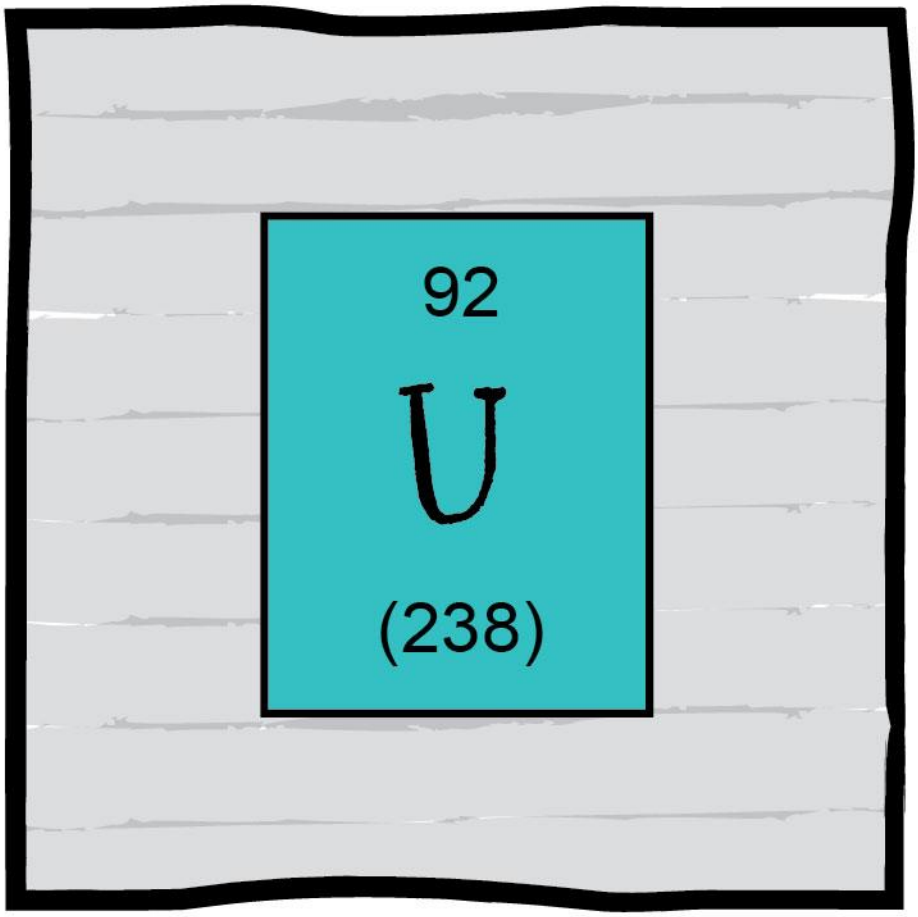
Radon


86
Rn
(222)

Tritium

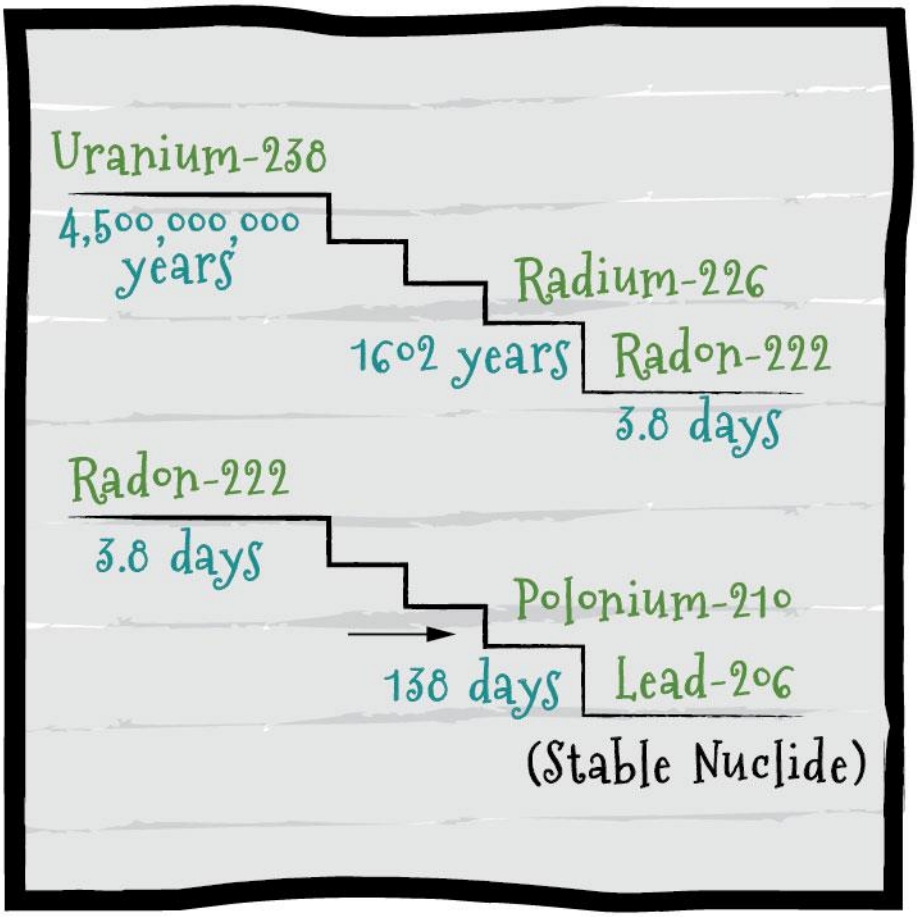
Hydrogen-1 (1P + 0N)	Hydrogen-3 (1P + 2N)
Atomic Weight = 1	Atomic Weight = 3
	
1 proton 0 neutrons	1 proton 2 neutrons

Uranium


92
U
(238)

Decay Chain

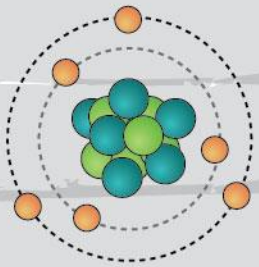
Half-life


Uranium-238
4,500,000,000 years
Radium-226
1602 years
Radon-222
3.8 days
Radon-222
3.8 days
Polonium-210
138 days
Lead-206
(Stable Nuclide)

Ion

Neutral Atom

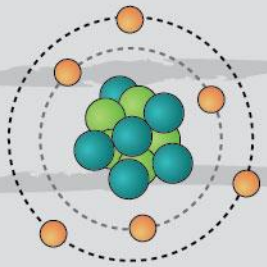
protons (+)
= electrons (-)



6 protons
6 electrons

Negatively Charged Atom

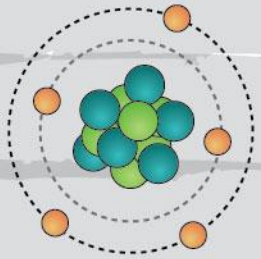
electrons (-) >
protons (+)



5 protons
6 electrons

Charged Positively Atom

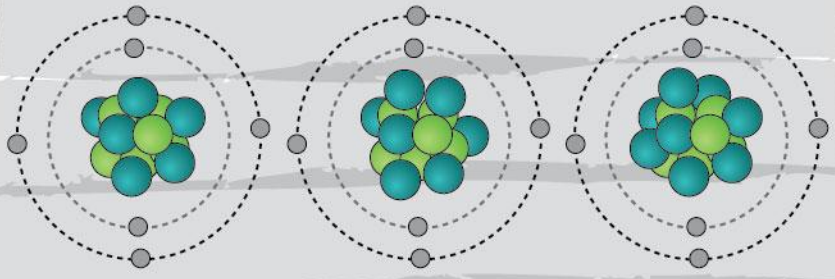
protons (+) >
electrons (-)



6 protons
5 electrons

Isotope

Carbon-12	Carbon-13	Carbon-14
(6P+6N)	(6P+7N)	(6P+8N)
Atomic Weight = 12	Atomic Weight = 13	Atomic Weight = 14

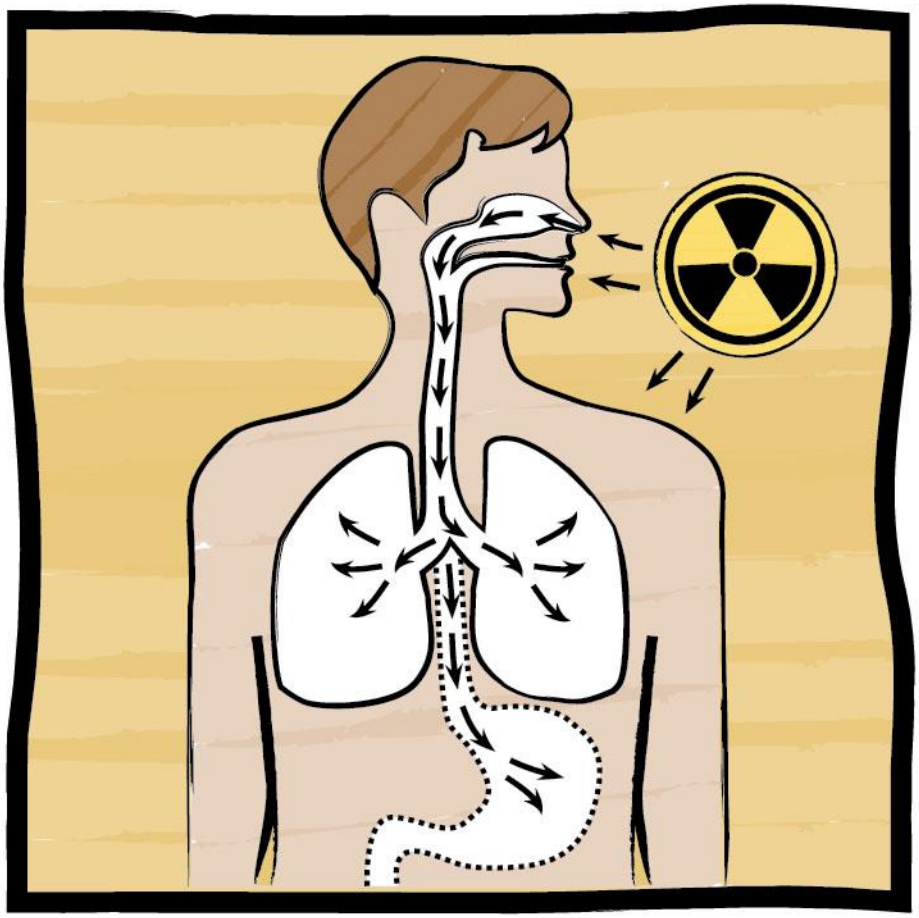


6 protons	6 protons	6 protons
6 neutrons	7 neutrons	8 neutrons

Radioactive Materials

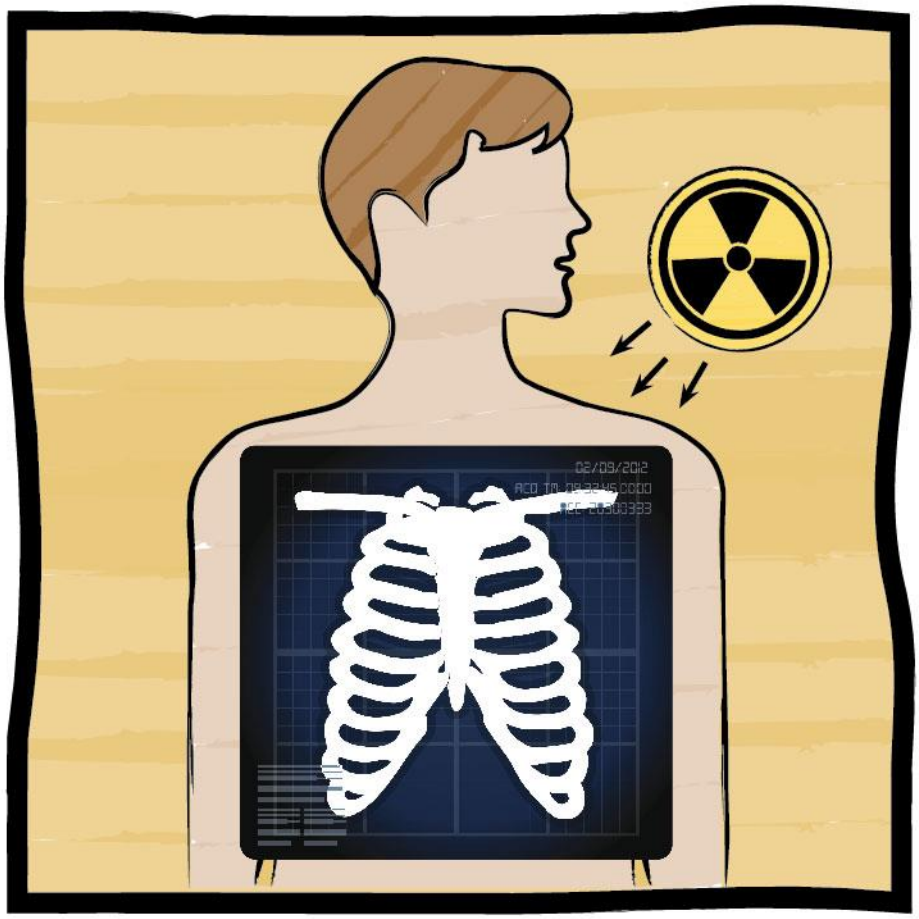
Image provided by: **U.S. Department of Energy (DoE), Los Alamos National Laboratory**

Exposure Pathways



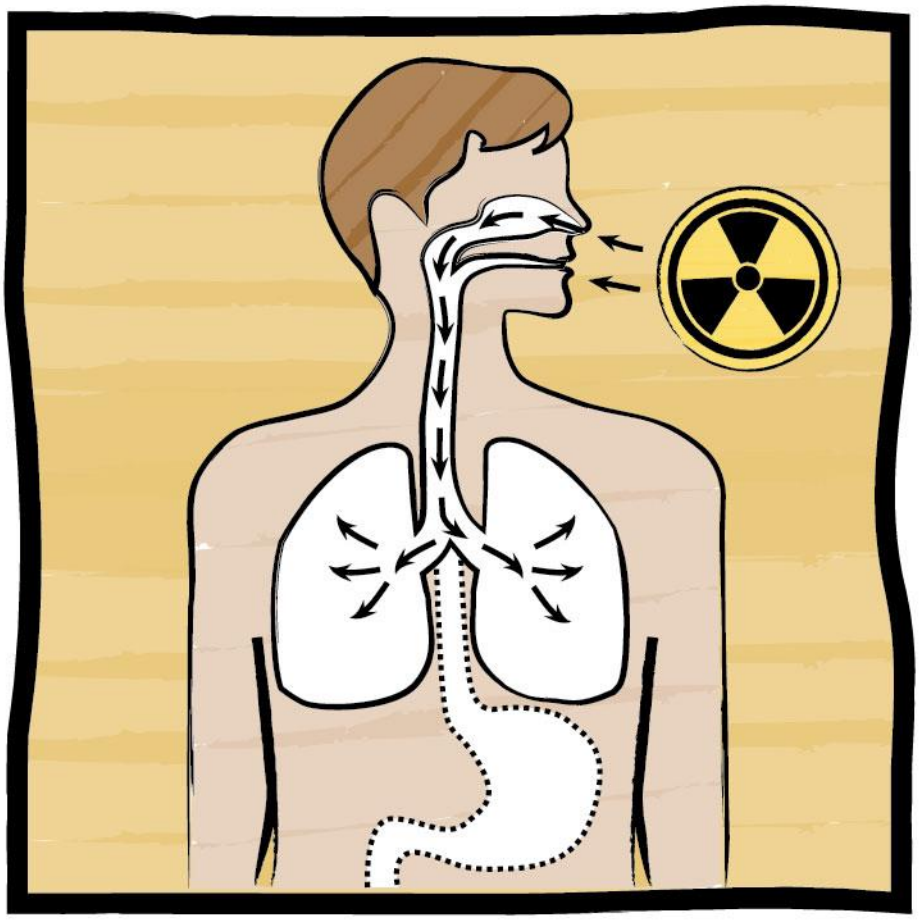
Radiation Exposure

Direct Exposure



Inhalation

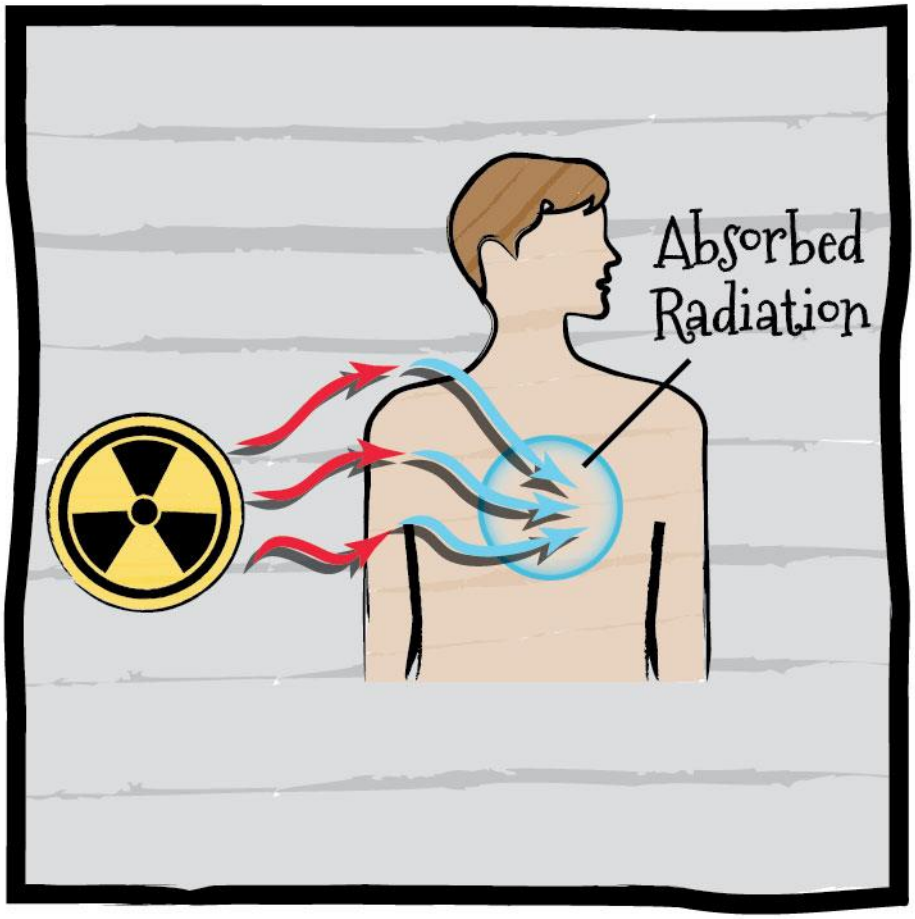
Ingestion



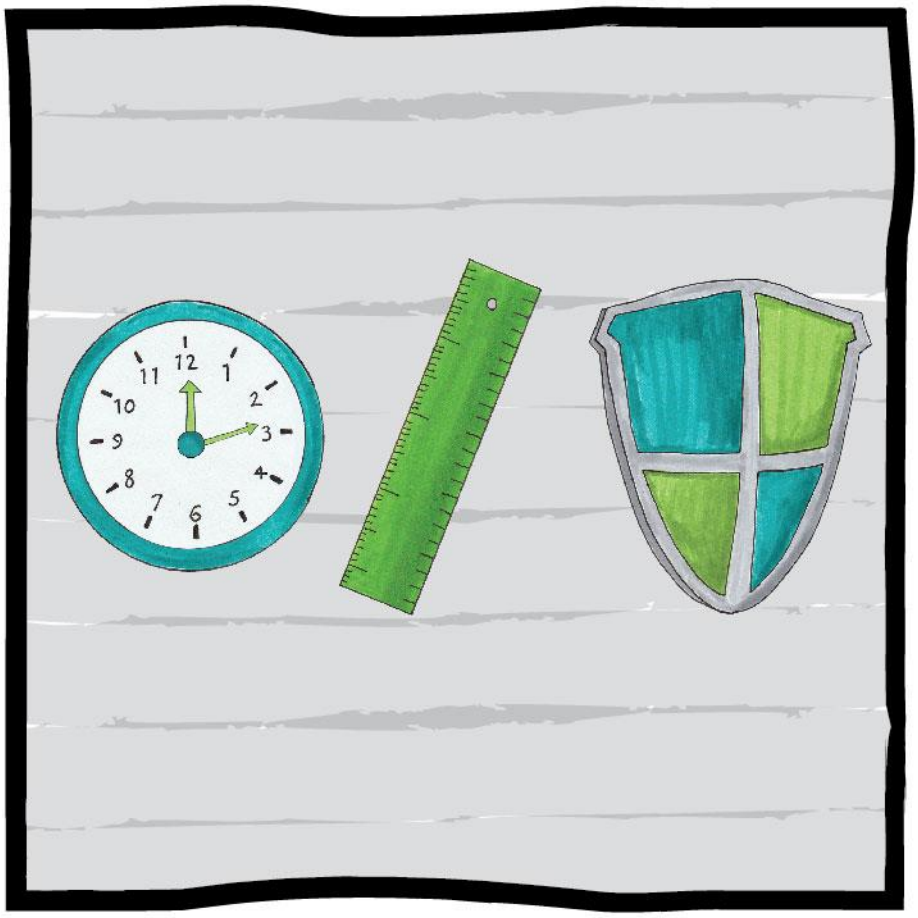
Radioactive Contamination

Dose

Rem
(Roentgen Equivalent
Man)


Absorbed
Radiation

Radiation Protection


12
1
2
3
4
5
6
7
8
9
10
11

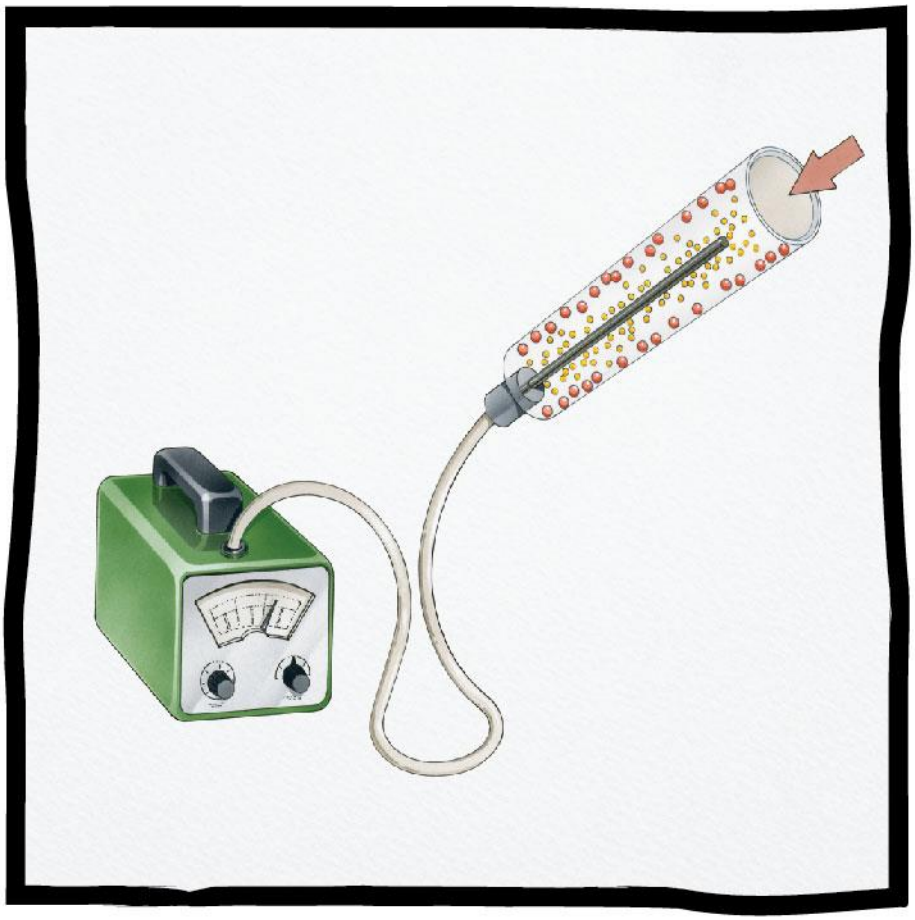
Dosimeter


AA0003263488
Stevenson , K 290501
075-0123 Billing Date: 04/2007
Stevenson , K 290501
075-0123 Return Date: 04/2007

Dosimetry

Image provided by: **U.S. Department of Energy (DoE), Oak Ridge National Laboratory**

Geiger Counter



Health Physics

Monitoring

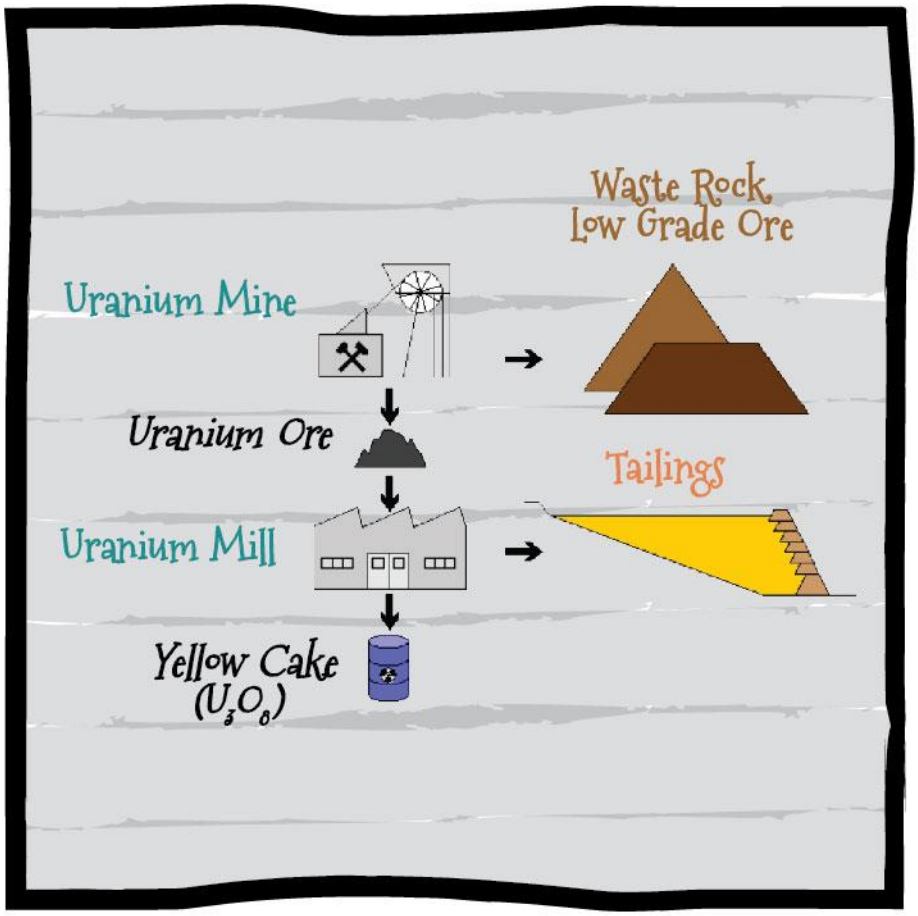
Open-pit Uranium Mining

Image provided by: **U.S. Geological Survey (USGS)**

Underground Uranium Mining

Uranium Milling

Uranium Mine Tailings


Waste Rock
Low Grade Ore
Uranium Mine
Uranium Ore
Tailings
Uranium Mill
Yellow Cake
(U_3O_8)

Heap Leaching

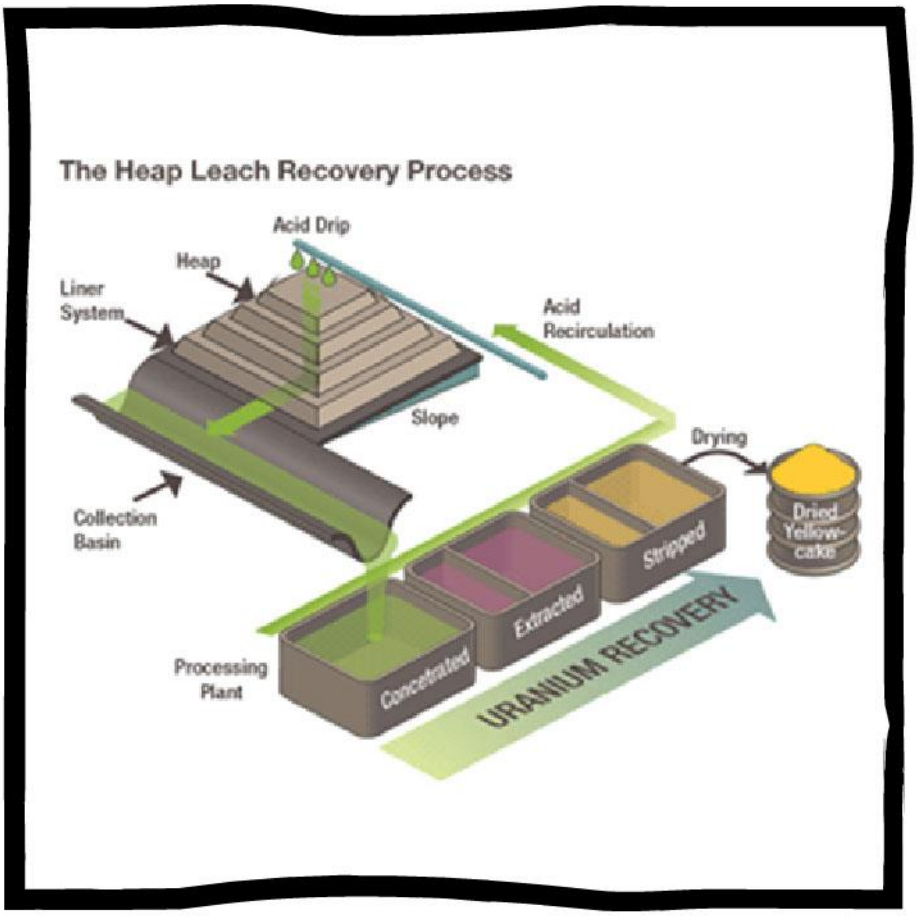


Image provided by: **Nuclear Regulatory Commission (NRC)**

In-situ Leaching

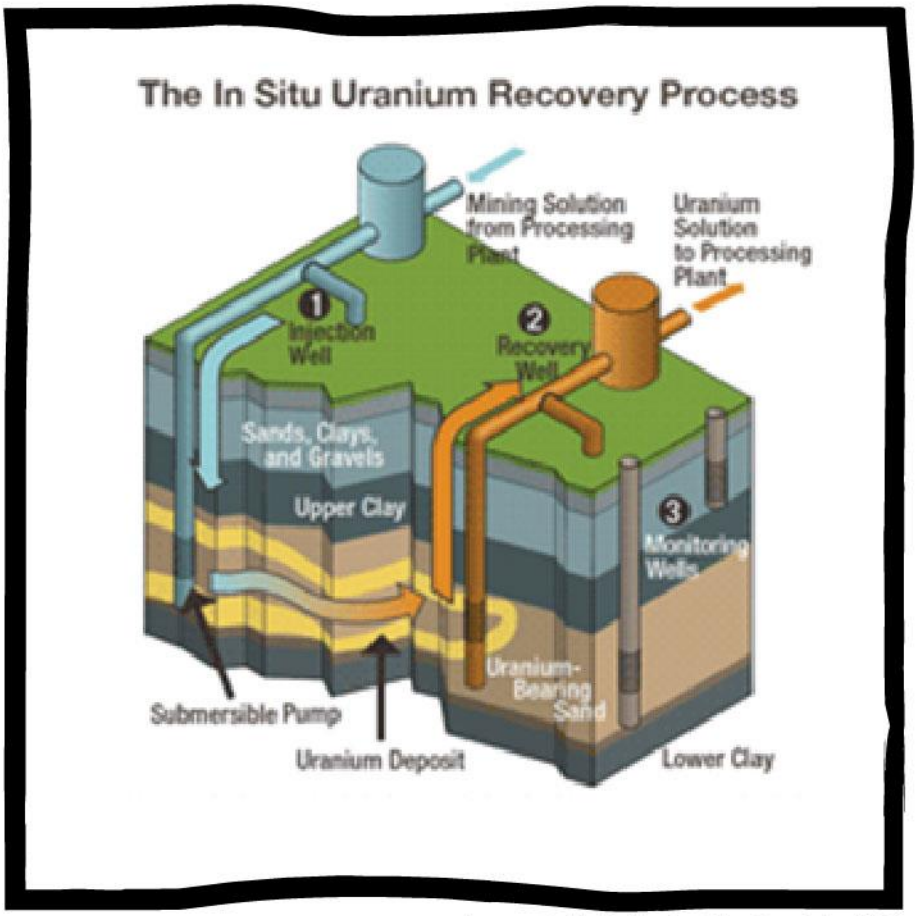


Image provided by: **Nuclear Regulatory Commission (NRC)**