NUCLEAR REACTIONS

Unit Introduction

In Unit 12, you learned about nuclear energy. In this unit, you will take a closer look—much closer, actually—at the atomic changes involved in nuclear reactions. Recall the concepts of nuclear fission and nuclear fusion. You will revisit these processes and gain a new understanding at the molecular level. You will also explore the positive and negative effects of radiation.

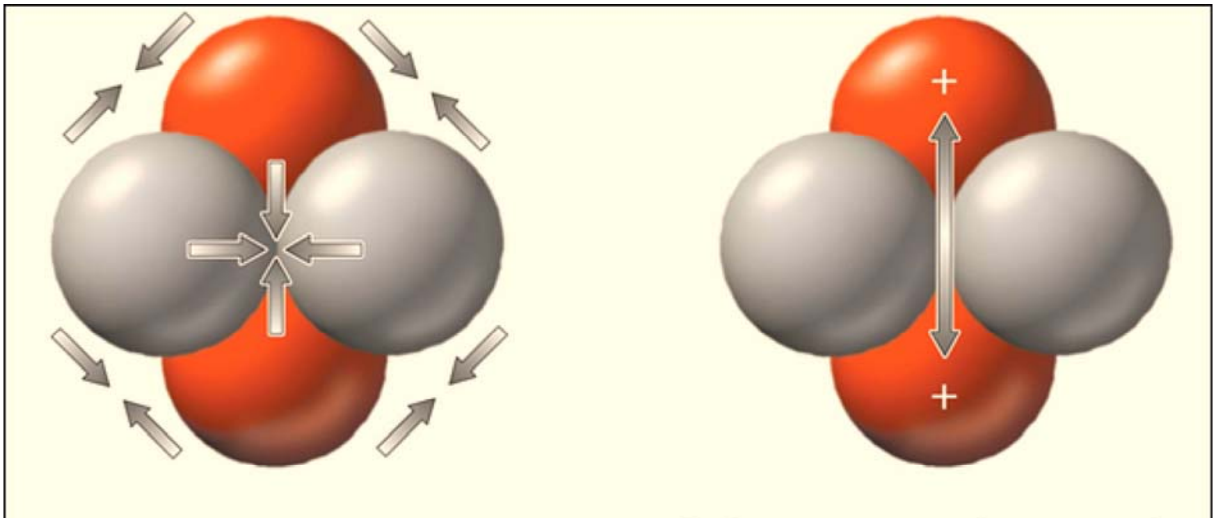
Nuclear Reactions

The study of radioactivity and nuclear reactions requires a thorough understanding of the atomic nucleus. Since there can be different ***isotopes*** (atoms whose nuclei have the same number of protons but different numbers of neutrons) of the same element, a system was developed to identify different forms of the same element.

A ***nuclide*** is an atom that has a specific atomic number and atomic mass. Carbon is an element that has more than one isotope. One of the nuclides is carbon-12, and it is called carbon-12 because it has an atomic mass of 12. You will notice that the nuclide number (12) and atomic mass (12) are the same. Carbon-12 is a stable nuclide, meaning it is not radioactive.

What makes some nuclides stable, while others are radioactive? The stable nuclides generally have the same number of protons and neutrons. Carbon-12 has 6 protons and 6 neutrons making it a stable form of carbon.

Another factor that makes an atom stable is the balance of attractive nuclear forces and repulsive electrical forces. ***Nuclear forces*** are the attractive forces between protons and neutrons in the nucleus of an atom. ***Electrical forces*** are the repulsive forces among protons in the nucleus.

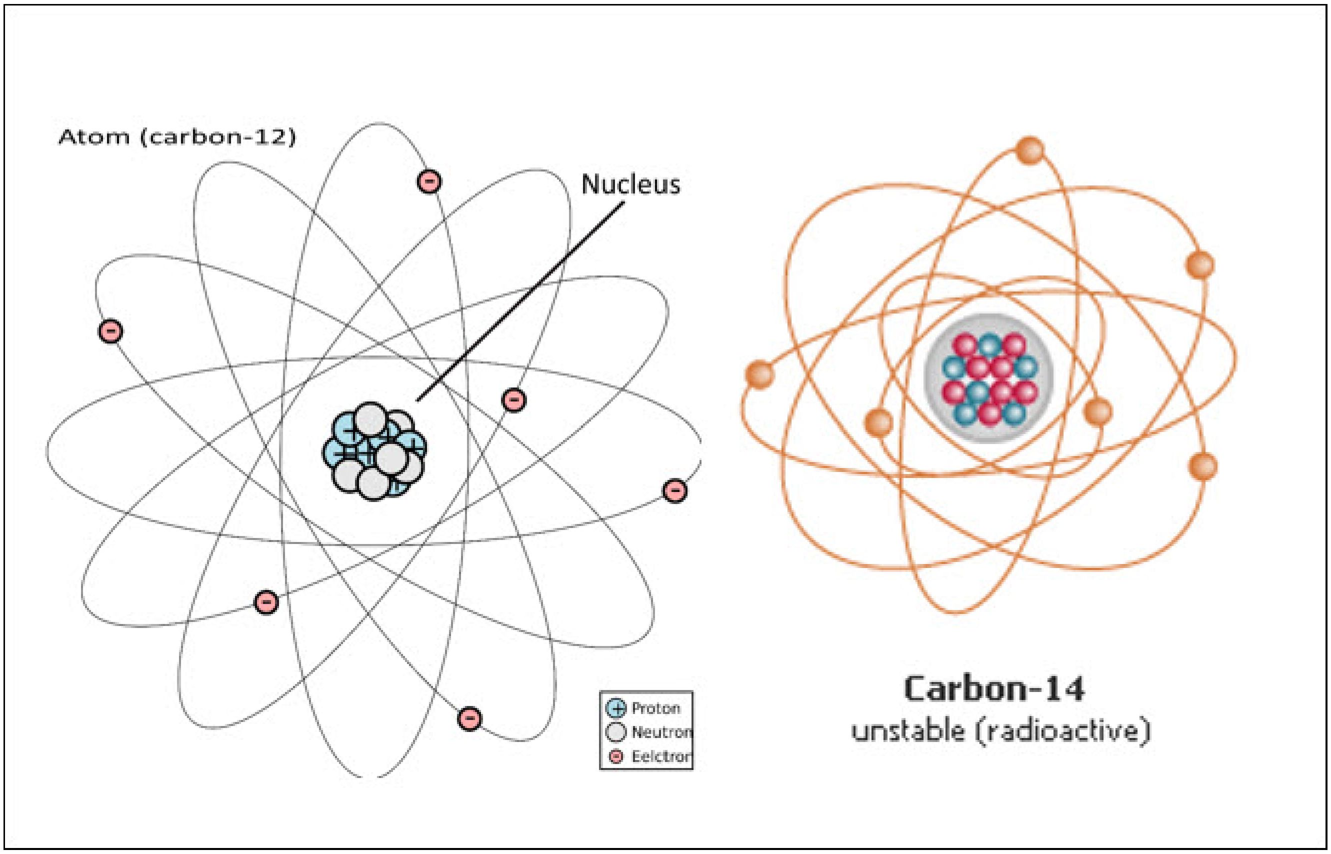


All nucleons, both protons and neutrons, attract one another by the strong nuclear force.

Only protons repel one another by the electric force.

Nuclear forces are weak across long distances, but within the short distances between protons and neutrons in the nucleus, they are quite strong in holding the nucleus together. In a stable nuclide, there is a balance between nuclear forces and electrical forces. When these forces are unbalanced in an atom's nucleus, this is known as a ***radioactive*** nuclide.

Another form of carbon is carbon-14, an isotope of carbon, which has 8 neutrons and 6 protons. The number of protons and neutrons is not equal, and neither are the nuclear and electrical forces in the nucleus of a carbon-14 atom. This leads to an unstable nuclide which is radioactive.



Watch the following video, which gives more information about nuclear stability.

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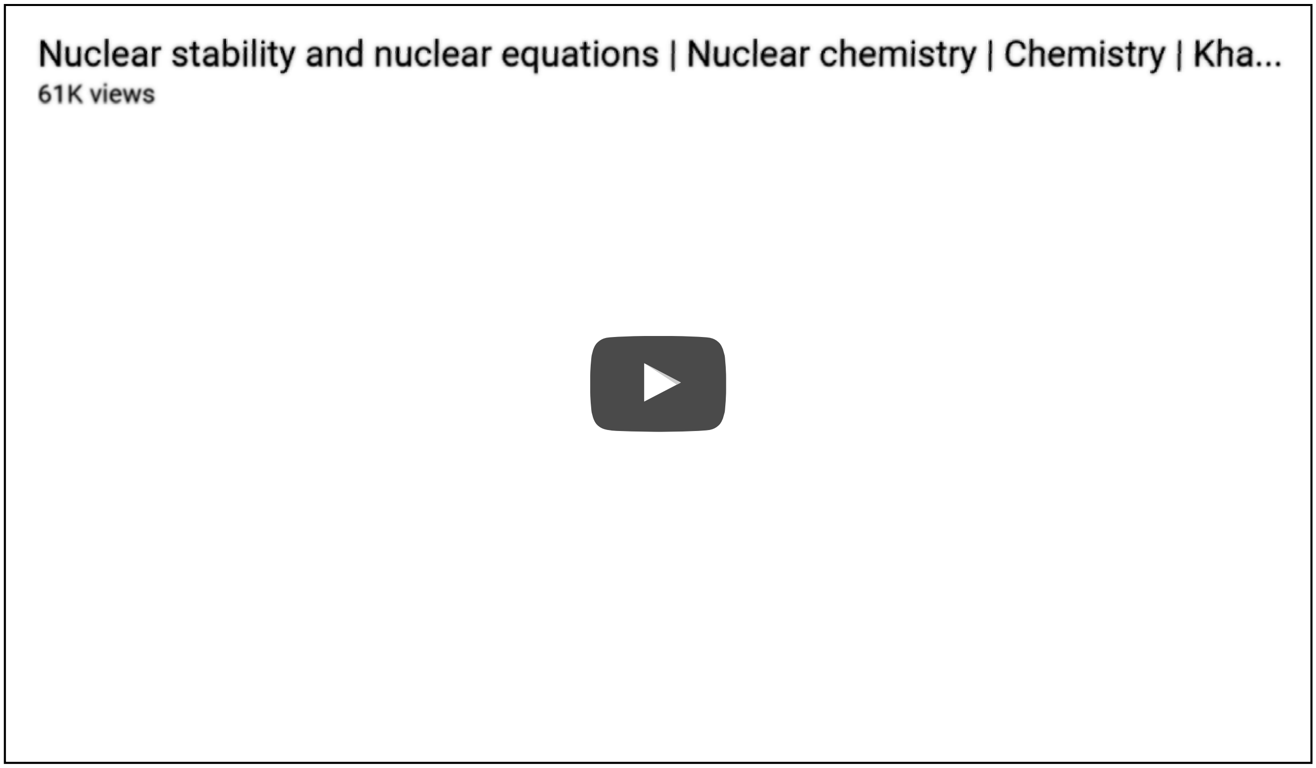
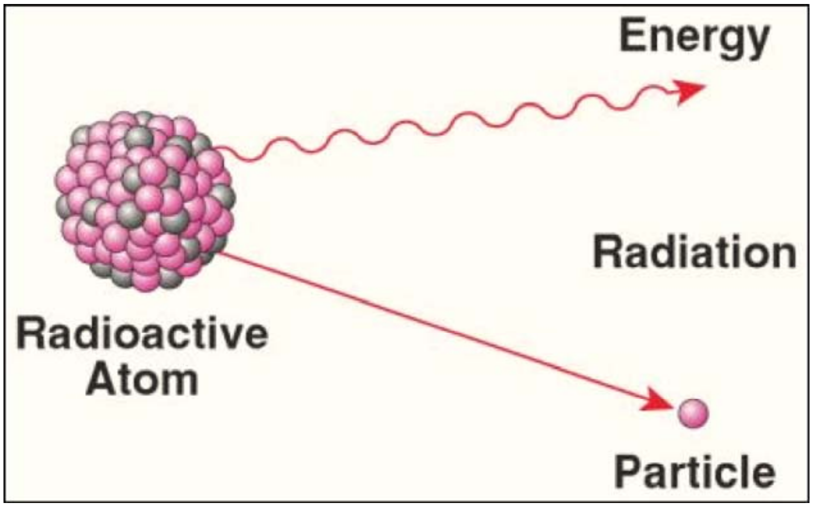
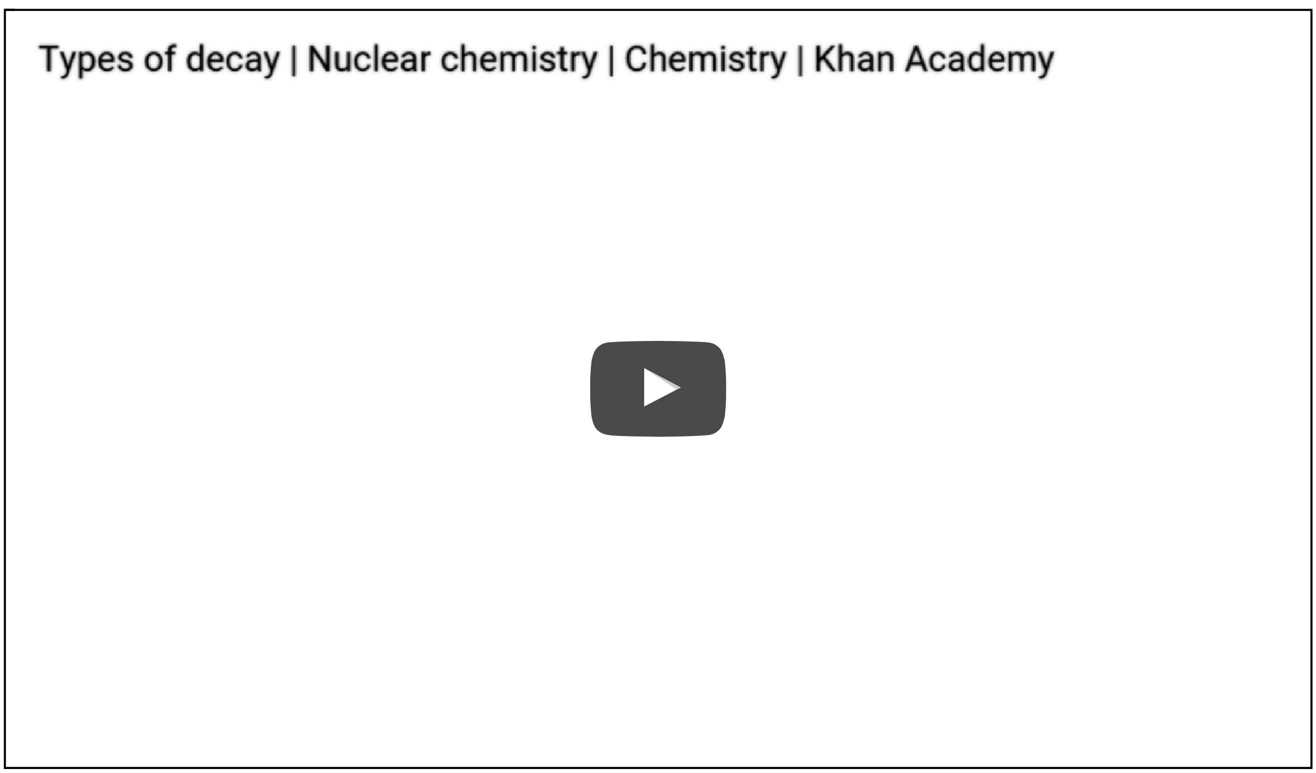


Radioactive Decay

Nuclear reactions are reactions of matter that involve changes to the nucleus and release a great amount of energy. When an unstable radioactive isotope breaks down over time, its nucleus changes, which results in the formation of a more stable substance. This change or breakdown over time is known as ***radioactive decay***.

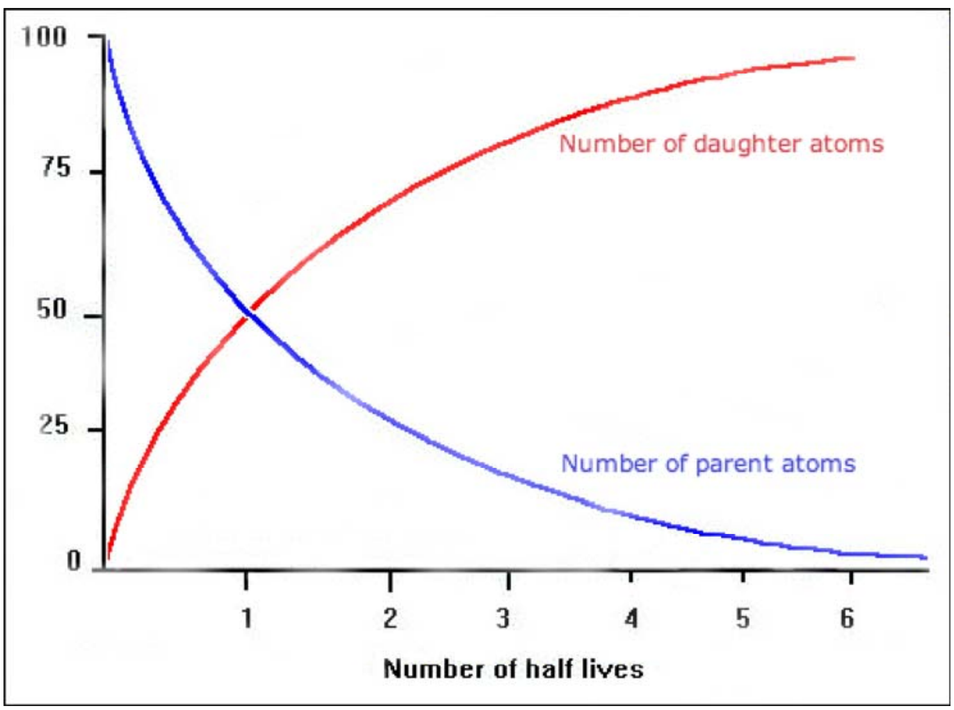


Now, watch the following video clip on types of radioactive decay. Complete the guided notes as you watch. Submit your completed work as question #15 in the assessment portion of the unit.



Printable: TYPES OF DECAY VIDEO NOTES

Radioactive decay of a radioisotope over time can be graphed. The amount of time it takes for half of a sample of a certain radioisotope to break down into a more stable element is known as its ***half-life***. A half-life is unique and constant for each radioisotope. For example, the half-life of uranium is different from the half-life of carbon-14. When you graph the radioactive decay across several half-lives, you see a certain shape on the graph. The following image shows the classic pattern of radioactive decay on a half-life graph. The blue line represents the radioisotope, or "parent" material, and the red line represents the more stable element, or "daughter" material.

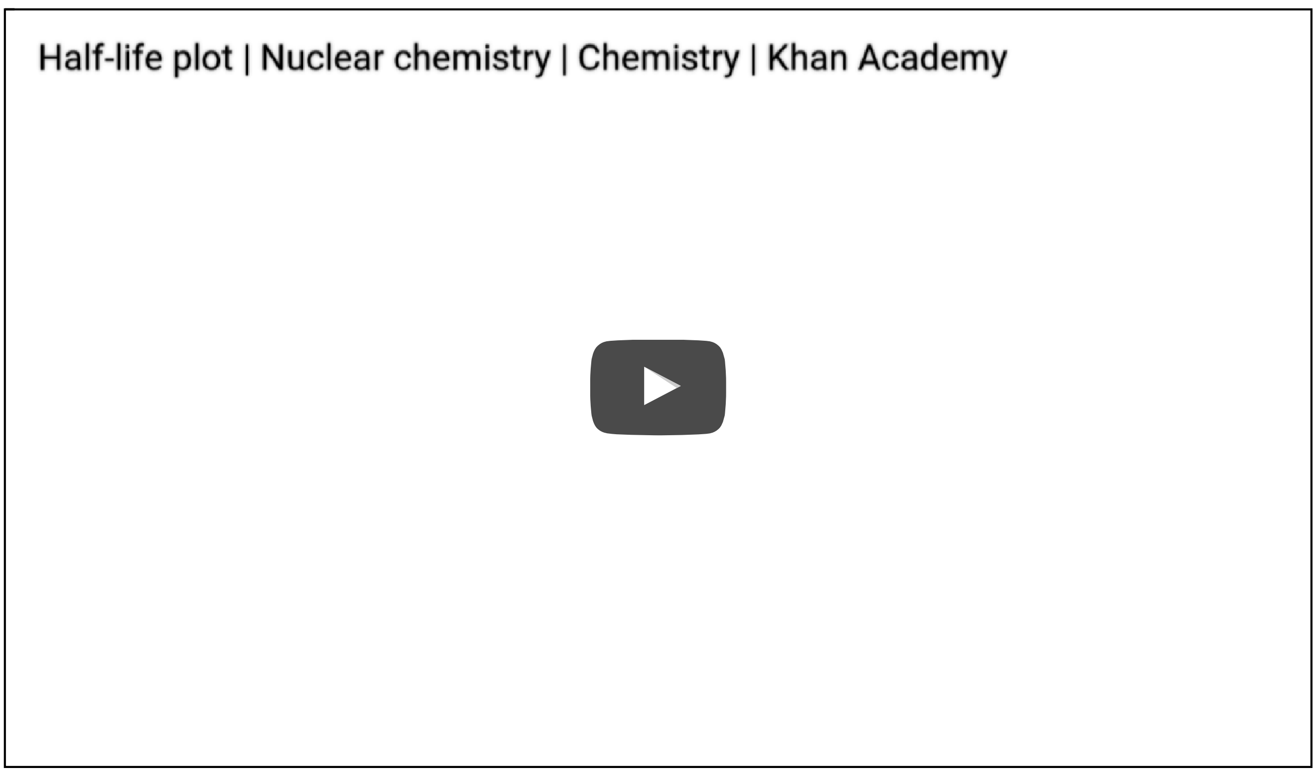


When a radioactive substance undergoes radioactive decay, will the amount of the radioisotope ever reach zero? The answer is no. That is because it is breaking down by half, over each half life. Half of 100 is 50, half of 50 is 25, and so on. Half of any number is never zero. The amount will get smaller and smaller and approach zero, but never be zero.

The following article is an excellent resource which has more information about radioactive decay and half-lives.

KHANACADEMY

Once you've read the last article, watch this video clip which shows you how to plot half-lives on a rate of decay graph. As you watch the video clip, construct your own decay graph along with the video narrator. Submit your work as question #16 in the assessment portion of the unit.



Radioactive Dating

Half-life values of certain radioisotopes are used in radioactive dating. ***Radioactive dating*** is used to find the age of fossils and rock in Earth's layers. Carbon-14 is a radioisotope found in living things. It has a half-life of 5,370 years. If a fossil has half as much carbon-14 as a new bone, for instance, an age of 5,370 years can be assigned to the fossil, since one half life has passed.

Lab: Simulating Radioactivity

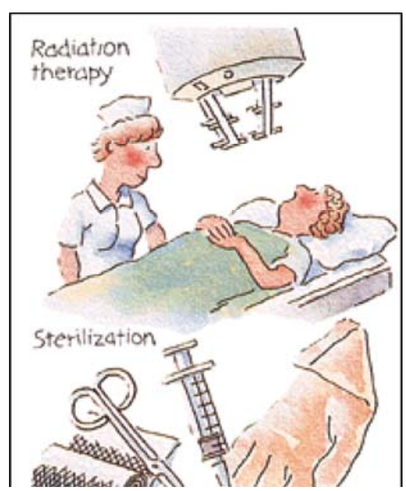
Complete Part I of the following SAS activity to simulate radioactivity. The directions say to use pennies, but you can choose whether you use pennies, M&M's or Skittles. (The key here is having a two-sided object to count—since the candies have one printed side and one plain side, just as a coin has heads and tails, they will all work for this activity.) If you don't have 100 pennies/candies, start with another quantity you do have, such as 50. You do not need to complete Part II. Complete pages 1, 2, and the top half of page 3 of the attached document and submit your work as question #17 in the assessment portion of the unit.

Printable: SIMULATING RADIOACTIVITY DOCUMENT

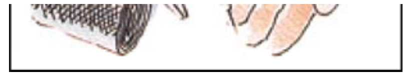
Nuclear Fission and Nuclear Fusion

As you recall from Unit 12, nuclear fission and nuclear fusion are both types of nuclear reactions that release great amounts of energy. Fission involves the splitting of large nuclei into smaller nuclei. Fission is how nuclear power plants produce energy. Fusion is the joining of smaller nuclei to create larger nuclei. This is how all the elements beyond helium were created.

Radiation and Its Applications



Radiation has many positive applications, as well as many negative consequences. Whether its use is considered positive or negative largely depends on the amount of radiation that is used. It can be deadly if exposure occurs in excessive amounts. The degree of damage caused by radiation depends on many factors – dose, dose rate, type of radiation, the part of the body exposed, age and health, for example. Embryos including the human fetus are particularly sensitive to radiation damage.

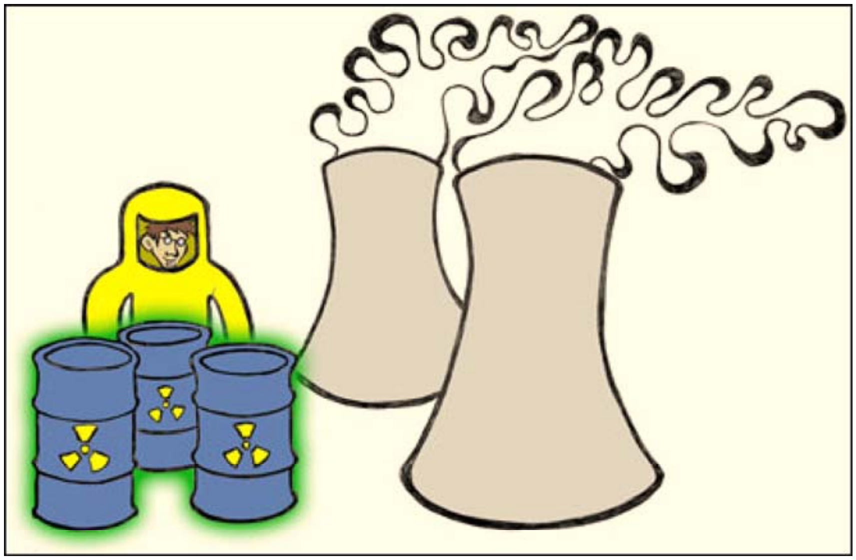


Radioactive substances can be placed in the soil surrounding a plant and traced with a Geiger counter throughout the plant as the plant absorbs minerals from the soil. Scientists can use this technique to trace an element's path through plants and animals to better understand where nutrients go and how they are utilized by plants and animals.

Radiation can be used beneficially to kill cancer cells. Radiation can also be used to detect tumors and diseased organs. Another application is to sterilize medical equipment.

X-ray images of bones and teeth are produced using radiation.

There are many industrial uses for radiation, as well as harnessing energy of nuclear fuel in nuclear power plants.



The use of radioactive products can be very dangerous, such as in a nuclear energy plant failure or explosion, or in the use of nuclear weapons. Radiation has the power to destroy as well as to heal.

Now, read the following articles on the risks and benefits of radiation.

https://hps.org/hpspublications/articles/risk-benefitinfosheet.html

http://www.americanscientist.org/issues/feature/2017/2/risks-and-benefits-of-radiation/1

QUIZLET VOCABULARY

Quizlet

Now answer questions 1 through 17.