Unit 2: Uses of Radiation

Time: One hours

Objectives

A. Teacher:

1. To stimulate students interest in the biological effect of radiation.
2. To help students become more literate in the benefits and hazards of radiation.
3. To inform youngsters about the NRC's role in regulating radioactive materials.

B. At the conclusion of this unit the student should be able to —

1. Discuss the uses of radiation in science, industry, and medicine.
2. Identify the different man-made radiation sources that result in exposure to members of the public.

Investigation and Building Background

1. Introduce term:

Probably, and because of rather widespread uses of isotopes, etc., in medicine, students will have broadly varying views of the uses of radioactive materials.

2. Resources:

1. **Natural and Man Made Radiation Sources** , "Nuclear Reactor Concepts" Workshop Manual, U.S. NRC.
2. **Backgrounder on Medical Use of Radioactive Materials**.
3. *The Harnessed Atom* (available for **download**). Pages 89-97 will provide general information on the uses of radiation.
4. *Energy from the Atom* (available through the **American Nuclear Society**). Pages 2-31 to 2-33 will provide some insight into nuclear medicine.

3. Experiment:

No experiments or demonstrations are scheduled with this unit.

4. Generalizing:

While the Earth and all things on it are constantly being bombarded by radiation from space, there are two distinct groups exposed to man-made radiation: members of the public and radiation workers. The most significant source of man-made radiation exposure to the public is from medical procedures. Radiation workers, on the other hand, are exposed according to their occupations and to the sources with which they work.

Questions

How can we use radioactive isotopes to detect illness?

How can we use radiation to detect a weakness in the construction of buildings?

Have you ever had a bone x-rayed? Teeth x-rayed? How did this help your doctor or dentist treat you?

Do you think the additional radiation received when people have medical x-rays, about 40 millirems per year, is worth the benefits they receive?

Are there advantages to using radiation instead of pesticides to control pests, such as insects?

References

"Nuclear Power and Radiation," Workshop Manual, U.S. NRC, Office of Public Affairs.

The Harnessed Atom, Teacher's Edition, U.S. Department of Energy.

Lesson Plan

Greeting...

Although scientists have only known about radiation since the 1890s, they have developed a wide variety of uses for this natural force. Today, to benefit mankind, radiation is used in science, medicine, and industry, as well as for generating electricity. Radiation has useful applications in such areas as agriculture, medicine, space exploration, architect/engineering, industry/manufacturing, government, geology (including mining), ecology, and education.

Radiation is used by doctors to diagnose illness and helps archaeologists find the age of ancient artifacts. Electricity produced by nuclear fission — splitting the atom — is one of its greatest uses. A reliable source of electricity is needed to give us light, help to groom and feed us, and to keep our homes and businesses running. Let me give you some specific examples of how the radiation has been used to —

- Diagnose and treat illnesses
- Kill bacteria and preserve food without chemicals and refrigeration
- Process sludge for fertilizer and soil conditioner
- Locate underground natural resources and tell a dry hole from a gusher
- Make smoke detectors, nonstick frypans, and ice cream
- Grow stronger crops
- Power satellites and provide future electrical needs for space laboratories with people on board
- Design instruments, techniques, and equipment; measure air pollution
- Prove the age of works of art and assist in determining their authenticity

Radiation in Medicine

X-rays are a type of radiation that can pass through our skin. Our bones are denser than our skin, so when x-rayed, bones and other dense materials cast shadows that can be detected on photographic film. The effect is similar to placing a pencil behind a piece of paper and holding them in front of a light. The shadow of the pencil is revealed because most light has enough energy to pass through the paper, while the denser pencil stops all the light. The difference is that we need film to see the x-rays for us.

Today, doctors and dentists use x-rays to see structures inside our bodies. This allows them to spot broken bones and dental problems. X-ray machines have now been connected to computers in the development of machines called CAT scanners. These instruments provide doctors with color TV pictures that show the shape of internal organs.

Approximately 10 million nuclear medicine procedures are performed in the United States annually. Diagnostic x-rays and or radiation therapy were administered to about seven out of every 10 Americans. Medical procedures using radiation have saved thousands of lives through the detection and treatment of conditions ranging from hyperthyroidisdm to bone cancer.

In such procedures, doctors administer slightly radioactive substances to patients, which are attracted to certain internal organs such as the pancreas, kidney, thyroid, liver, or brain, to diagnose clinical conditions. Moreover, radiation is often used to treat certain types of cancer. Radioactive iodine, specifically iodine-131, is being used frequently to treat thyroid cancer, a disease which strikes about 11,000 Americans every year.

Radiation in Science

Radiation is used in science in many ways. Just as doctors can label substances inside people's bodies, scientists can label substances that pass through plants, animals, or our world. This allows us to study such things as the paths that different types of air and water pollution take through the environment.

It has also helped us learn more about a wide variety of things, such as what types of soil different plants need to grow, the size of newly discovered oil fields, and the track of ocean currents.

Scientists use radioactive substances to find the age of ancient objects by a process called carbon dating. For example, in the upper levels of our atmosphere, cosmic rays hit nitrogen atoms and form a naturally radioactive isotope called carbon-14. Carbon is found in all living things, and a small percentage of this carbon is carbon-14. When a plant or animal dies, it no longer takes in new carbon and the carbon-14 it contains begins the process of radioactive decay.

However, new isotopes of carbon-14 continue to be formed in our atmosphere, and after a few years the percent of radioactivity in an old object is less than it is in a newer one. By measuring this difference, scientists are able to determine how old certain objects are. The measuring process is called carbon dating.

Radiation Used To Solve Crimes

How is radiation used to solve crimes? I am sure that you already know that detectives often search the scene of a crime for traces of paint, glass, hair, gunpowder, or blood. But you may not know that after such evidence is collected, it is often exposed to radiation and then analyzed to find out its exact makeup.

If material is exposed to streams of neutrons, some of the neutrons can be absorbed into the nucleus of the exposed material. This makes these materials slightly radioactive because they are unstable and decay with time. Scientists are then able to read the exact chemical signatures of these substances. This laboratory process, called activation analysis, is precise enough to tell if a single hair found at a crime scene came from a certain person.

Activation analysis is also used to find out the chemical makeup of materials when scientists only have small samples, as well as to prove that older works of art are not made of modern materials.

Radiation in Industry

We could talk all day about the many and varied uses of radiation in industry and not complete the list. To make a long story short, we'll just concentrate on a few. Exposure to some types of radiation (for example, x-rays) can kill germs without harming the items that are being disinfected or making them radioactive. For example, when treated with radiation, foods take much longer to spoil, and medical equipment such as bandages, hypodermic syringes, and surgical instruments don't have to be exposed to toxic chemicals or extreme heat to be sterilized. Although we now use chlorine, a toxic and difficult-to-handle chemical, we may use radiation in the future to disinfect our drinking water and even kill all the germs in our sewage. Ultraviolet light already is used to disinfect drinking water in some homes.

The agricultural industry makes use of radiation to improve food production. Plant seeds, for example, have been exposed to radiation to bring about new and better types of plants. Besides making plants stronger, radiation can also be used to control insect populations, thereby decreasing the use of pesticides.

Engineers use radioactive substances to measure the thickness of materials and an x-ray process called radiography to find hard to detect defects in many types of metals and machines. Radiography is also used to check such things as the flow of oil in sealed engines and the rate and way various materials wear out. And we've already talked about the use of the radioactive element uranium, which is used as a fuel to make electricity for our cities, farms, towns, factories, etc.

In outer space, radioactive materials are also used to power space craft. Such materials have also been used to supply electricity to satellites sent on missions to the outermost regions of our solar system.

Radiation has been used to help clean up toxic pollutants, such as exhaust gases from coal-fired power stations and industry. Sulphur dioxides and nitrogen oxides, for example, can be removed by electron beam radiation.

As you can see, radiation and radioactive materials have played and will continue to play a very significant role in our lives. Let's sum up this discussion with a walk through the life of a typical family for one day and learn about some of the uses of radiation.

Dad gets up in the morning and puts on a clean shirt. His polyester-cotton blend shirt is made from chemically treated fabric that has been irradiated (treated with radiation) before being exposed to a soil-releasing agent. The radiation makes the chemicals bind to the fabric, keeping his shirt fresh and pressed all day. The shirt is not radioactive.

In the kitchen, Jenny is frying an egg. That nonstick pan she is using has been treated with gamma rays, and the thickness of the eggshell was measured by a gauge containing radioactive material before going into the egg carton. Thin, breakable eggs were screened out. The turkey Mom is taking out of the refrigerator for tonight's dinner was covered with irradiated polyethylene shrink wrap. Once polyethylene has been irradiated, it can be heated above its usual melting point and wrapped around the turkey to provide an airtight cover.

As Dad drives to work, he passes reflective signs that have been treated with radioactive tritium and phosphorescent paint. During lunch, brother Bob has some ice cream. The amount of air whipped into that ice cream was measured by a radioisotopic gauge. After you and your family return home this evening, some of you may have soda and others may sit and relax. Nuclear science is at work here: The soda bottle was carefully filled — a radiation detector prevented spillover. And your family is safe at home because the ionizing smoke detector, using a tiny bit of americium-241, will keep watch over you while you sleep.

Answers to Questions from "The Uses of Radiation" Unit Outline:

1. **Q: How can we use radioactive isotopes to detect illness?**

   A: By replacing a few regular atoms with radioactive isotopes in substances like hormones, food, or drugs we are able to trace the path they take through our bodies. Instruments can be used to trace the isotope through the body, or parts of the body, to find problems.

2. **Q: How can we use radiation to detect a weakness in the construction of buildings?**

   A: X-rays can be used to see into many metals and machines to help find flaws that cannot be seen on the outside. This type of examination is called radiography.

3. **Q: Have you ever had a bone x-rayed? Teeth x-rayed? How did this help your doctor or dentist treat you?**

   A: The doctor or dentist is able to see exactly what the problem is and then knows how to treat it.

4. **Q: Do you think the additional radiation received when people have medical x-rays, about 40 millirems per year, is worth the benefits they receive?**

   A: Answers will vary.

5. **Q: Are there advantages to using radiation instead of pesticides to control pests, such as insects?**

   A: Radiation can be used to control pests by sterilizing male insects that have been raised in captivity and then released into the environment. They will not be able to produce offspring. Therefore, the numbers of insects will be reduced. Another advantage is that there will be fewer chemicals added to the environment.