Activity I: Radiation Exposure on Earth

In Activity I, students will use worksheets to determine their average annual radiation dose here on Earth.

Background

Radiation is a form of energy that is emitted or transmitted in the form of rays, electromagnetic waves, and/or particles. In some cases, radiation can be seen (visible light) or felt (infrared radiation), while other forms like x-rays and gamma rays are not visible and can only be observed directly or indirectly with special equipment. Although radiation can have negative effects both on biological and mechanical systems, it can also be carefully used to learn more about each of those systems.

On Earth we are protected from much of the electromagnetic radiation that comes from space by Earth's atmosphere and magnetic field. Most radiation is unable to reach the surface of the Earth except at limited wavelengths, such as the visible spectrum, radio waves, some ultraviolet wavelengths, and some high-energy ionizing radiation. As we rise through the atmosphere, climb a high mountain, take a plane flight, or go to the International Space Station (ISS) or to the Moon, we rapidly lose the protection of the atmosphere and magnetic field.

Please see the introduction for more background about radiation.

Objectives:

By the end of this lesson, the students will be able to:

- Explain that radiation exposure on Earth is determined mainly by where people live, how people live (lifestyle), and by the medical procedures people have experienced.
- Determine their average annual radiation dose here on Earth.
- Describe some medical procedures that increase their radiation exposure.
- Explain the difference between acute and chronic radiation exposure.
- Compare their radiation exposure to an astronaut's radiation exposure.

Research Question:

How does your radiation exposure compare to an astronaut's radiation exposure, and why are they different?

Discussion Questions:

Regarding a human-tended lunar outpost, have students discuss in detail how and why radiation might affect the total duration astronauts can stay on the Moon. Other possible topics for discussion include:

- What are the different kinds of radiation?
- What units are used to describe radiation exposure?
- What is your annual radiation exposure?
- How does your radiation exposure compare to an Apollo 14 astronaut (use chart)?
- Are you exposed to radiation when watching TV?
- How does your altitude (height above sea level) affect your radiation exposure?
- What are some examples of medical procedures that are high in radiation?
- Does where you live on the Earth affect your radiation exposure?
- Does the Earth give off radiation?
- How can you reduce the amount of radiation you are exposed to?
- Why is radiation exposure more for ISS astronauts than for Space Shuttle astronauts?
- What kind of health effects due to radiation might Moon and Mars explorers experience?

National Education Standards[22]:

Unifying Concepts and Processes
- Systems, order, and organization
- Evidence, models, and explanation

Science in Personal and Social Perspectives
- Natural hazards
- Personal health
- Science and technology in society

Physical Science
- Transfer of energy

Earth and Space Science
- Structure of the Earth system

Materials:

Provide to the students the spaceflight radiation examples chart (Chart I), the acute radiation exposure chart that gives examples of health effects (Chart II), a short glossary of terms, and the Radiation Exposure on Earth worksheet. Show the comparison of radiation examples (Chart III and graphs) to students so they can visualize the differences between them.
Note: 1 Sv = 1,000 mSv.

Time allotment: 90 – 120 minutes

References:

1. The chart for calculating a personal radiation dose was derived in part from the American Nuclear Society's brochure titled Personal Radiation Dose.

   The primary sources for this information are National Council on Radiation Protection and Measurements Reports: #92 Public Radiation Exposure from Nuclear Power Generation in the United States (1987); #93 Ionizing Radiation Exposure of the Population of the United States (1987); #94 Exposure of the Population in the United States and Canada from Natural Background Radiation (1987); #95 Radiation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources, (1987); and #100 Exposure of the U.S. Population from Diagnostic Medical Radiation (1989).

2. The Environmental Protection Agency has established Radiation Protection Programs that are responsible for preparing regulations and guidance on protective limits. Health effects are the central focus in establishing the limits. This site explains the topics that the EPA considers.
   http://www.epa.gov/radiation/understand/health_effects.htm

3. For more information about radiation health affects, also see:
   http://srag.jsc.nasa.gov/SpaceRadiation/FAQ/FAQ.cfm

Going Further:

For additional research opportunities, have students investigate:
- Case studies of radiation exposure in people from the workplace, cell phones, nuclear explosions, radon, or nuclear power plant meltdowns.
- The concept of "half-life."
- NASA's use of radiation facilities at Brookhaven National Lab and Loma Linda University.
- The history of the discovery of radiation, and the scientists Marie Curie and Pierre Curie.

22 National Science Education Standards, Center for Science, Mathematics, and Engineering Education (CSMEE), National Academy of Sciences, National Academy Press, Washington, DC., 1996, ISBN 0-309-05326-9.

Chart I. Spaceflight Radiation Examples	
Human Spaceflight Mission Type	**Radiation Dose**
Space Shuttle Mission 41-C (8-day mission orbiting the Earth at 460 km)	5.59 mSv
Apollo 14 (9-day mission to the Moon)	11.4 mSv
Skylab 4 (87-day mission orbiting the Earth at 473 km)	178 mSv
International Space Station (ISS) Mission (up to 6 months orbiting Earth at 353 km)	160 mSv
Estimated Mars mission (3 years)	1200 mSv

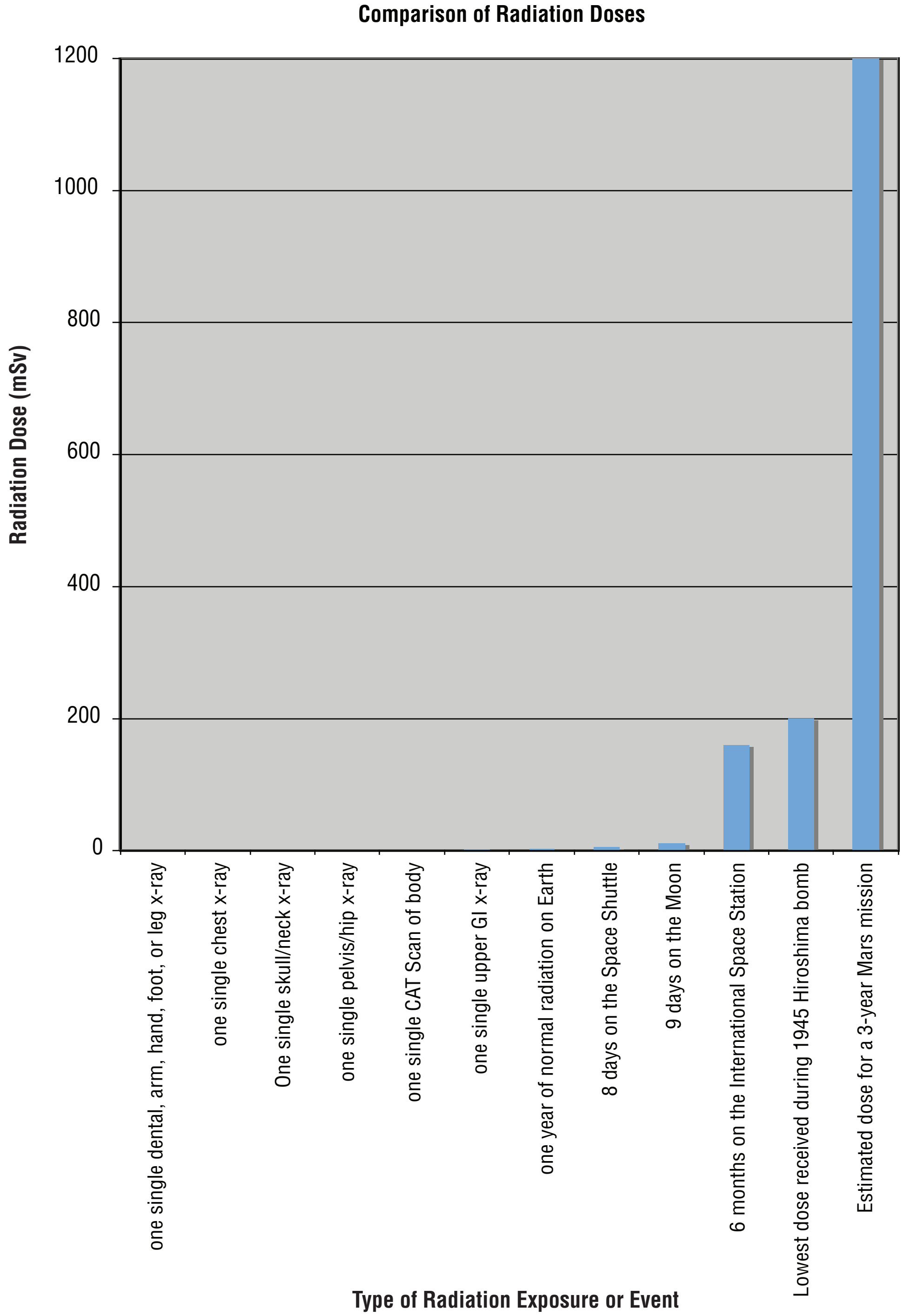
Note: units of exposure on this chart are in milliSieverts (mSv). 1 Sv = 1000 mSv.

Chart II. Examples of Health Effects from Acute Radiation Exposure		
Exposure (mSv)	**Acute Health Effects***	**Time to Onset (without treatment)**
Less than 100	No detectable health effects	
Above 100	Cell and chromosomal (DNA) damage	hours
Above 1,000	Nausea, vomiting, diarrhea: prodromic syndrome	1 to 2 days
Above 1,500	Damage to blood-forming organs: hematopoietic syndrome; possible death	≈1 month
3,000	50% death from hematopoietic syndrome	in 30 to 60 days
10,000	Destruction of intestinal lining	
	Internal bleeding	
	Death	1-2 weeks
20,000	Damage to central nervous system	
	Loss of consciousness	minutes
	Death	hours to days

Note: units of exposure on this chart are in Sieverts (Sv). 1 Sv = 1,000 mSv.
* The acute effects in this table are cumulative. For example, a dose that causes damage to bone marrow will produce changes in blood chemistry and be accompanied by nausea. At a certain threshold every individual will experience these kinds of effects, which include nausea, skin reddening, sterility, and cataract formation.

Chart III. Comparison of Radiation Doses	
Description	**Exposure (mSv)**
A single dental, arm, hand, foot, or leg x-ray	0.01
A single chest x-ray	0.06
A single skull/neck x-ray	0.2
A single pelvis/hip x-ray	0.65
A single CAT scan of body	1.1
A single upper GI x-ray	2.45
One year of normal radiation on Earth (approximate)	3.0
8 days on the Space Shuttle	5.59
9 days on the Moon	11.4
6 months on the International Space Station	160
Lowest dose received during 1945 Hiroshima bomb	200
Estimated dose for a 3-year round trip for a Mars Mission	1,200

Note: The items in Chart III are plotted in Graph 1 (see next page).



Graph 1: A comparison of radiation doses.