

# Activity 1: History of Radiation Protection

## Objectives

Students will:

- Learn about and create a timeline of the history of radiation protection.
- Research and discover how radiation protection practices were developed.

## Next Generation Science Standards

The concepts in this activity can be used to support the following science standard:

- PS4. Waves and Electromagnetic Radiation.

## 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:

- Comprehension and Collaboration: CCSS.ELA-LITERACY.SL.6-12.1
- Integration of Knowledge and Ideas: CCSS.ELA-LITERACY.RST.6-12.7
- Research to Build and Present Knowledge: CCSS.ELA-LITERACY.WHST.6-12.9

The concepts in this activity align with the following CCSS Mathematics Standards:

- CCSS.MATH.PRACTICE.MP4 Model with mathematics.
- CCSS.MATH.CONTENT.6.NS.C.7. Understand ordering and absolute value of rational numbers.
- CCSS.MATH.CONTENT.6.SP.B.4. Display numerical data in plots on a number line, including dot plots, histograms, and box plots.
- CCSS.MATH.CONTENT.HSS.ID.A.1. Represent data with plots on the real number line (dot plots, histograms, and box plots).

## Materials and Resources

- *Radiation Protection: Teacher Background Information.*
- *Vocabulary Materials.*
- Materials to create a timeline:
  - *History of Radiation Protection Timeline Cards (Option A).*
  - Paper or poster board and colored pencils, pens, markers or other art supplies (Option B).
  - Student computers and a printer (Option B).
- *Significant Discoveries and the History of Radiation Protection Handout (one per student, pair or group).*
  - *History of Radiation Protection Worksheet (one per student, pair or group) and the History of Radiation Protection Teacher Answer Key.*

## Time

45-60 minutes, not including optional activities or extensions.

## Vocabulary

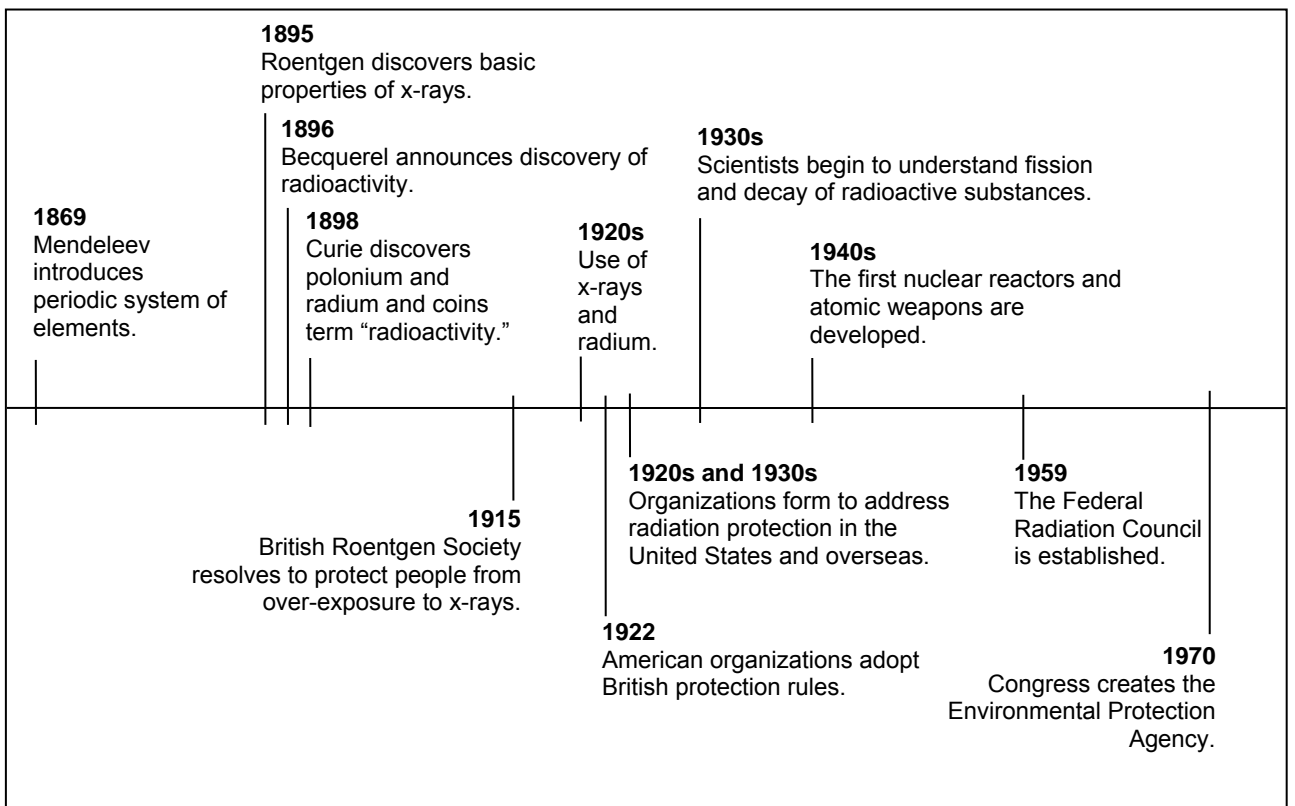
- Ionizing radiation
- Radiation
- Radiation exposure
- Radiation protection
- Radioactive decay
- Radium
- X-rays

## Directions

1. Start with a vocabulary activity if students are not familiar with radiation and the terms used in this activity, or provide students with the terms and definitions.
2. Ask students to provide examples of how people might prevent or reduce their exposure to radiation if, for example, they live in a home with high radon levels, work in a lab or industry that requires them to handle or work around radioactive materials, or when receiving an x-ray. Radiation protection involves three main concepts:
  - Time: limiting the time spent near a radiation source.
  - Distance: increasing the distance from a radiation source.
  - Shielding: using a barrier to prevent or reduce the risk of exposure. Examples include lead aprons or other protective equipment and thick walls or shields.
  - Devices and systems are also available to detect, monitor and reduce people's exposure to radiation.
3. Have students hypothesize how scientists discovered the risks of radiation exposure and ways to protect people from exposure to radiation.
4. Select and complete one of the timeline activities using the *Significant Discoveries and the History of Radiation Protection Handout*.
  - **Option A: Class Timeline Activity**  
Ask for 12 volunteers. Provide each volunteer with a card from the *History of Radiation Protection Timeline Cards*. Ask the volunteers to organize themselves, or let the class direct and organize the volunteers, in chronological order. They can do this first or while one or more students take turns reading the *Significant Discoveries and the History of Radiation Protection Handout*. Post the timeline cards on a wall in chronological order so students can complete the *History of Radiation Protection Worksheet*.
  - **Option B: Individual or Small Group Timeline Activity**  
Have students read the *Significant Discoveries and the History of Radiation Protection Handout* and create a paper- or computer-based timeline. A Sample Timeline is provided on Page 12.
5. Distribute the *History of Radiation Protection Worksheet*. Have students answer the questions in pairs or small groups.
6. Discuss their responses using the *History of Radiation Protection Teacher Answer Key*.
7. Conclude by having students share one or two things they learned about the history and personal benefits of radiation protection with a classmate.

8. Optional activities or extensions: Have students investigate related topics and summarize their findings in a report, science journal entry, skit or presentation, or an educational blog or wiki. Topics could include:
- Illnesses and deaths of early scientists, physicians, patients and industrial workers (e.g., the radium dial workers or uranium miners) related to their radiation exposure and any early protection measures established as a result of their deaths.
  - Early radiation protection standards (e.g., dose/exposure limits and methods of reducing exposure time and frequency) compared to today's standards.
  - Early research on the biological effects of radiation and how the information compares to our understanding of the effects today.
  - Events that led to the development of the health physicist career in 1942 and the duties, educational requirements and career options for a health physicist today.

### Sample Timeline



# Significant Discoveries and the History of Radiation Protection Handout

Philosophers and scientists have been interested in the basic building blocks of our physical universe since ancient times. In fact, the ancient Greeks were the first to believe that all matter in the universe must be made of tiny building blocks — or atoms. Beginning with the earliest scholars of science throughout history and into this century, scientists have been driven to learn more about the atom and how to control it.



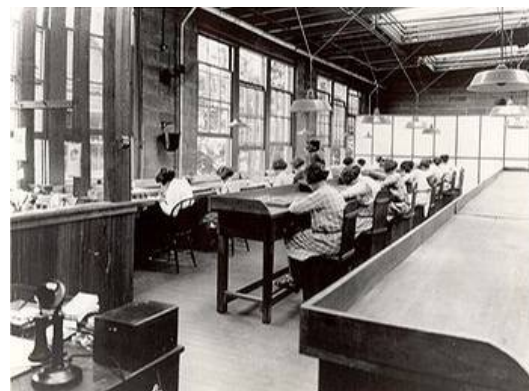
## Significant Discoveries

Scientists truly began to make advances in the study of atomic structure and radiation during the late part of the 19th century. Dmitri Mendeleev introduced the periodic system of elements in 1869. In December 1895, Wilhelm Roentgen accidentally discovered the basic properties of x-rays when he captured an x-ray image of his wife's hand. This led to further discoveries in the properties of ionizing radiation and the possibility of using radiation in medicine. In 1896, Henri Becquerel announced the discovery of radioactivity to the Academy of Sciences in Paris after he discovered the radioactive properties of uranium. Marie and Pierre Curie studied the radioactivity of uranium for several years, and discovered the elements polonium and radium after chemically extracting uranium from the ore. Marie Curie reported their discovery and coined the term "radioactivity" in 1898. By the early 1900s the study of radiation was a widely accepted scientific endeavor.



## New Dangers Come with Discoveries

These discoveries did not come without a price. Scientists learned that radiation was not only a source of energy and medicine; it could also be a potential threat to human health if not handled properly. In fact, early pioneers in radiation research died from radiation-induced illnesses from too much exposure.



For instance, Thomas Edison's assistant died from a radiation-induced tumor as a result of too much x-ray exposure. As new uses for radioactive elements were discovered, potentially fatal incidents of overexposure increased.

During World War I, radium paint (a mixture of radium and phosphor) was used on military aircraft instruments to make them glow in the dark so they would be more visible to pilots flying at night. After the war was over, the industry that supported this technology changed its focus to paint glow-in-the-dark clocks and watch faces. The young women who painted these items would form a fine point on their paint brushes by pulling the freshly-dipped brushes between their lips before applying the paint onto the watch faces. Unknowingly, they were swallowing small amounts of radium and damaging their bodies. Several of the women died of unexplained anemia and disease complications with their mouth, teeth and jaw. The dentist who treated one of the women connected the issues with the radium dial painting.

## Meeting the Need for Radiation Protection

By 1915, the British Roentgen Society had adopted a resolution to protect people from overexposure to x-rays. This was one of the first organized efforts in radiation protection.

American organizations had adopted the British protection rules by 1922. Awareness and education continued to grow. Throughout the 1920s and 1930s more guidelines were developed, scientists were studying the effects of radiation on living organisms, and various organizations were formed to address radiation protection in the United States and overseas.

By the 1930s, physicists were beginning to understand fission and radioactive decay, which led to the research and development of the first nuclear reactors and atomic weapons in the 1940s. Until that time, radiation protection was primarily a non-governmental function. After World War II, the development of the atomic bomb and nuclear reactors caused the federal government to establish policies dealing with human exposure to radiation. In 1959, the Federal Radiation Council was established to:

- Advise the President of the United States on radiological issues that affected public health.
- Provide guidance to all federal agencies in setting radiation protection standards.
- Work with the states on radiation issues.

In 1970, Congress created the U.S. Environmental Protection Agency (EPA) to serve as the primary federal agency to protect people and the environment from harmful and avoidable exposure to radiation. EPA's Radiation Protection Division carries out this responsibility by:

- Setting standards that protect people and the environment.
- Managing federal radiation protection programs.
- Providing radiation protection guidance and emergency response training to other federal agencies.
- Working closely with other national and international radiation protection organizations to further our scientific understanding of radiation risk.

# History of Radiation Protection Worksheet

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Research and answer the following questions.

1. How many years ago was radioactivity discovered? \_\_\_\_\_
2. Approximately how many years elapsed between the discovery of radioactivity and the first efforts to implement radiation protection rules?  
In Britain: \_\_\_\_\_ In the United States: \_\_\_\_\_

3. How were radiation protection guidelines established in the early 1900s?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

4. In what ways do you benefit from the discovery of ionizing radiation and radioactivity?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

5. Do you think the benefits of radiation outweigh the exposure risks with the existence of radiation protection standards?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

6. Name at least three types of jobs (or industries) that use radiation or radioactive materials and practice radiation protection.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

7. When might you, or the general public, need to be aware of and practice radiation protection?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_



# History of Radiation Protection Teacher Answer Key

1. How many years ago was radioactivity discovered? **Current year - 1896 = XXX years.**
2. Approximately how many years elapsed between the discovery of radioactivity and the first efforts to implement radiation protection rules?  
**In Britain: 1915 - 1896 = 19 years**  
**In the United States: 1922 - 1896 = 26 years**
3. How were radiation protection guidelines established in the early 1900s?  
**While scientists and medical professionals saw the benefits of radiation, they were becoming more aware of the illnesses and deaths caused by radiation if it was not handled properly.**
4. In what ways do you benefit from the discovery of ionizing radiation and radioactivity?  
**We benefit from many uses of radiation, including medical and dental treatments and diagnostic tools, nuclear power generation, smoke and security detectors, and safe roads that are built and tested with moisture and density nuclear gauges.**
5. Do you think the benefits of radiation outweigh the exposure risks with the existence of radiation protection standards?  
**Answers will vary.**
6. Name at least three types of jobs (or industries) that use radiation or radioactive materials and practice radiation protection.  
**Answers will vary and may include nuclear power, medical, research, construction, transportation and industrial industries in addition to the military.**
7. When might you, or the general public, need to be aware of and practice radiation protection?  
**Potential answers may include: when receiving medical treatments (e.g., x-rays), when radon levels become too high in a home, in certain work settings, or when an accident occurs and radioactive materials are released into the environment.**

# History of Radiation

## Protection Timeline Cards



# Mendeleev introduces the periodic system of elements

|    |    |        |    |    |    |    |    |    |    |    |    |     |    |     |    |     |     |  |
|----|----|--------|----|----|----|----|----|----|----|----|----|-----|----|-----|----|-----|-----|--|
| H  |    |        |    |    |    |    |    |    |    |    |    |     |    |     |    |     | He  |  |
| Li | Be |        |    |    |    |    |    |    |    |    |    | B   | C  | N   | O  | F   | Ne  |  |
| Na | Mg |        |    |    |    |    |    |    |    |    |    | Al  | Si | P   | S  | Cl  | Ar  |  |
| K  | Ca | Sc     | Ti | V  | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga  | Ge | As  | Se | Br  | Kr  |  |
| Rb | Sr | Y      | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In  | Sn | Sb  | Te | I   | Xe  |  |
| Cs | Ba | 57-71  | Hf | Ta | W  | Re | Os | Ir | Pt | Au | Hg | Tl  | Pb | Bi  | Po | At  | Rn  |  |
| Fr | Ra | 89-103 | Rf | Db | Sg | Bh | Hs | Mt | Ds | Rg | Cn | Uut | Fl | Uup | Lv | Uus | Uuo |  |
|    |    | La     | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho  | Er | Tm  | Yb | Lu  |     |  |
|    |    | Ac     | Th | Pa | U  | Np | Pu | Am | Cm | Bk | Cf | Es  | Fm | Md  | No | Lr  |     |  |

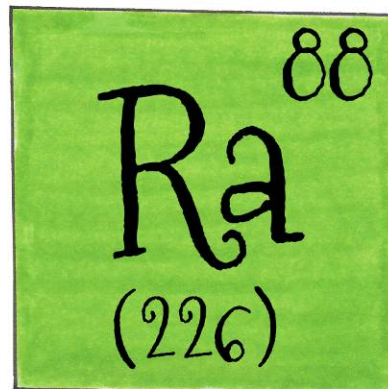
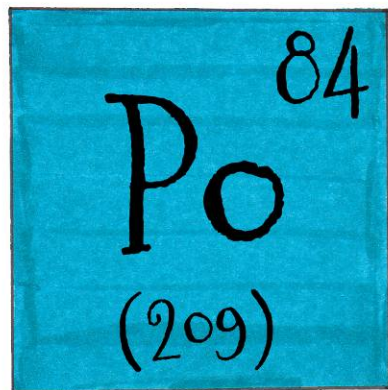
# Roentgen discovers basic properties of X-rays



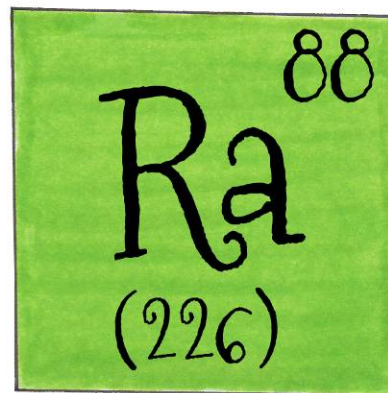
# Becquerel announces discovery of radioactivity



Curie discovers  
polonium and radium  
and coins the term  
radioactivity

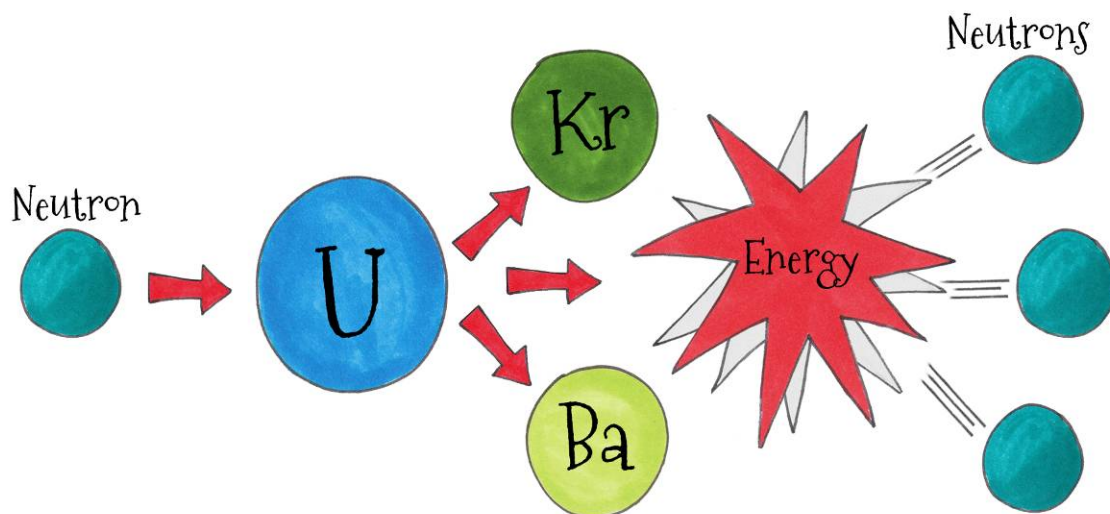


X-rays and radium are  
widely used

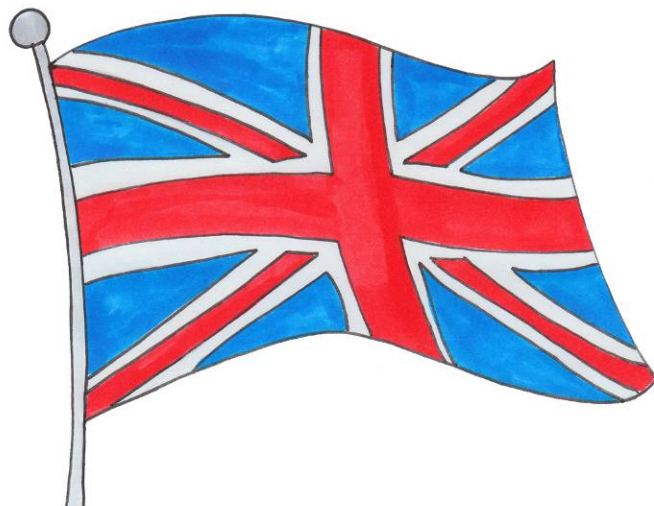




# Scientists begin to understand fission and the decay of radioactive substances

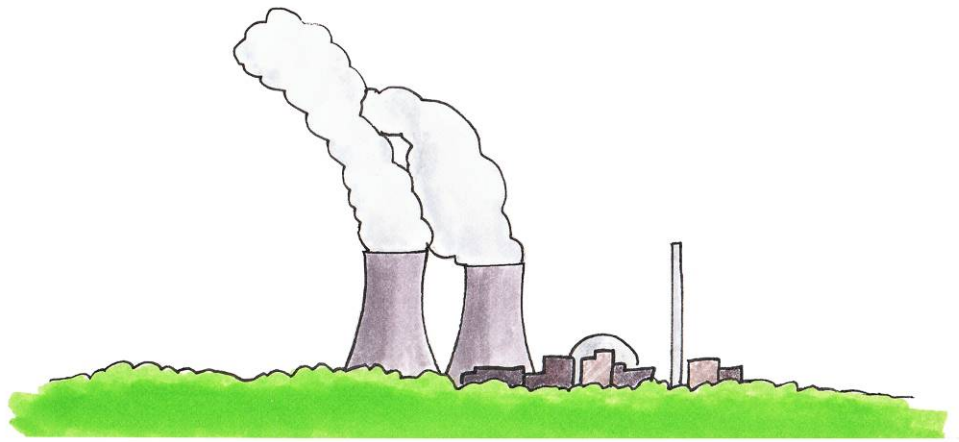


# American organizations adopt British protection rules





The first nuclear  
reactors and atomic  
weapons are developed



The British Roentgen  
Society resolves to  
protect people from  
overexposure to X-rays



Organizations form to  
address radiation  
protection in the  
United States and  
overseas

The Federal Radiation  
Council is established

# Congress creates the Environmental Protection Agency

