

**Teacher’s Guide**

 **Radiation. The Good. The Bad. And Its Place in Our Modern World.**

***December 2021***

**Table of Contents**

[Anticipation Guide](#_Anticipation_Guide) 2

Activate students’ prior knowledge and engage them before they read the article.

[Reading Comprehension Questions](#_Student_Reading_Comprehension_1) 3

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[Graphic Organizer 5](#_Graphic_Organizer)

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[Answers 6](#_Answers_to_Reading)

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[Additional Resources 8](#_Additional_Resources_1)

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

[Chemistry Concepts, Standards, and Teaching Strategies 9](#_Chemistry_Concepts,_Standards,)

# Anticipation Guide

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

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. In the 1910s and early 1920s, glow-in-the-dark watches were painted with a green paint containing radium.
 |
|  |  | 1. The element radium glows by itself.
 |
|  |  | 1. Radioactivity can safely be used to treat certain medical conditions.
 |
|  |  | 1. Marie Curie coined the term “radioactivity.”
 |
|  |  | 1. Radium undergoes alpha decay to produce radon and an alpha particle.
 |
|  |  | 1. Alpha particles go through skin.
 |
|  |  | 1. Radium and calcium are both alkaline earth metals, so they react similarly.
 |
|  |  | 1. Many early inventors and scientists who worked with radiation developed cancer.
 |
|  |  | 1. All radiation is radioactive.
 |
|  |  | 1. Today’s glow-in-the-dark watches use radioactive isotopes that emit beta particles which are blocked by the watch case.
 |

# Student ReadingComprehension Questions

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

**Directions**: Use the article to answer the questions below.

1. Identify the two primary ingredients in Undark.
2. Who is credited for discovering that uranium emits radiation?
3. Who coined the term radioactivity and in what context?
4. What are alpha particles made of?
5. Explain the function of the Us Occupational Safety and Health Administration.
6. How many protons and neutrons does the nucleus of an atom of radium-226 contain?
7. Explain how radium causes zinc sulfide to glow.
8. Why did Marie Curie, Pierre Curie and Henri Becquerel win the Nobel Prize in Physics in 1903?
9. What are the two scientific definitions of the term *radiation*?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Analyze two benefits and two drawbacks of radioactivity.
2. Explain aplastic anemia and how it can be caused by radiation.
3. Explain how smoke detectors utilize radiation.
4. The article mentions that gamma rays can be used to sterilize food. Conduct research to learn more about this process and explain why foods are sterilized in this way, how the process works, and the labeling requirements.
5. In the article you learned about some of the symptoms that resulted from radiation exposure. Perform research to learn about some of the treatments for radiation exposure that are available today. Select one treatment and write a paragraph about how it works.

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe radioactivity and its uses. Make a bulleted list in each column.

|  |  |
| --- | --- |
| **History of radioactivity** | **Important scientists and their discoveries:** |
| **Dangers of radioactivity** | **Different types of ionizing radiation and how they affect the body:** |
| **Modern uses of radioactivity** | **Medical and other uses and how to protect people from harmful effects:** |

**Summary:** On the back of this sheet, write a short email to a friend explaining why many of the Radium Girls developed cancer.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

**Directions**: Use the article to answer the questions below.

1. **Identify the two primary ingredients in Undark.**

*Undark’s two main ingredients are zinc sulfide and an isotope of radium.*

1. **Who is credited for discovering that uranium emits radiation?**

*Henri Becquerel discovered that uranium spontaneously emits radiation.*

1. **Who coined the term radioactivity and in what context?**

*Marie Curie coined the term radioactivity in her thesis.*

1. **What are alpha particles made of?**

*Alpha particles are made of two protons and two neutrons that are released from a nucleus.*

1. **Explain the function of the Us Occupational Safety and Health Administration.**

*OSHA is the US Occupational Safety and Health Administration tasked with defining and enforcing safe working conditions.*

1. **How many protons and neutrons does the nucleus of an atom of radium-226 contain?**

*The nucleus contains 88 protons and 138 neutrons.*

1. **Explain how radium causes zinc sulfide to glow.**

*When a particle of radiation collides with an atom or molecule, it excites an electron to a higher energy level. When the electron returns to its ground state, it emits energy in the form of light.*

1. **Why did Marie Curie, Pierre Curie and Henri Becquerel win the Nobel Prize in Physics in 1903?**

*Henri Becquerel, Marie Curie and Pierre Curie won the Nobel Prize in 1903 for their exploration of radioactivity and discovering that it was a nuclear rather than chemical characteristic.*

1. **What are the two scientific definitions of the term *radiation*?**

*Radiation can be used to refer to the energy that is part of the electromagnetic spectrum or it can be used to refer to the process of radioactive decay.*

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. **Analyze two benefits and two drawbacks of radioactivity.**

*Two benefits are that radioactivity can be used to slow or destroy cancer and can sterilize foods. Two drawbacks are that it can cause sickness and death and, in the case of nuclear accidents, be costly to contain and clean up.*

1. **Explain aplastic anemia and how it can be caused by radiation.**

*Aplastic anemia is when the body stops producing enough new blood cells. This can be caused by radiation destroying the stem cells in bone marrow which are responsible for producing new blood cells.*

1. **Explain how smoke detectors utilize radiation.**

*Smoke detectors have small amounts of 241Am that sends out a steady stream of alpha particles. When the stream is disrupted by smoke, the alarm is triggered.*

1. **The article mentions that gamma rays can be used to sterilize food. Conduct research to learn more about this process and explain why foods are sterilized in this way, how the process works, and the labeling requirements.**

*As a starting point for their research, students can use this* [*webpage*](https://www.fda.gov/food/buy-store-serve-safe-food/food-irradiation-what-you-need-know) *hosted by the Food and Drug Administration.*

1. **In the article you learned about some of the symptoms that resulted from radiation exposure. Perform research to learn about some of the treatments for radiation exposure that are available today. Select one treatment and write a paragraph about how it works.**

*As a starting point for their research, students can use this* [*CDC website*](https://www.cdc.gov/nceh/radiation/emergencies/countermeasures.htm)*.*

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

# Additional Resources

**Simulations**

**Radioactivity Simulation**: Students can use this simulation to explore four different radioactive sources and materials that can be used to block radiation.

<https://www.farlabs.edu.au/radioactivitysimulation/>

**Lessons and lesson plans**

**Detecting Radiation in our Radioactive World**: This resource developed by the American Nuclear Society includes a variety of lesson plans and activities on topics related to radiation including half-life, irradiation, fission, decay chains, radiation types, and waste.

<https://assets-global.website-files.com/5ed97259050e9609486076e1/5ed977227025a348a1925667_ANS-Teacher_Resource_Guide_web.pdf>

**Radiological Applications of Isotopes:** Using this activity will provide students with the opportunity to apply their understanding of nuclear notation to learn more about the applications of radioisotopes in the field of medicine.

<https://teachchemistry.org/classroom-resources/radiological-applications-of-isotopes>

**Projects and extension activities**

**Marie Curie Video Questions**: Students can learn more about Marie Curie and her work by viewing this video resource and accompanying questions on the American Association of Chemistry Teachers website.

<https://teachchemistry.org/classroom-resources/marie-curie-video-questions>

**Backgrounder on Smoke Detectors**: This resource explains how smoke detectors utilize radiation to detect smoke. Diagrams of the process are included.

<https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/smoke-detectors.html>

**Use of Radiation in Medicine**: Students can use this EPA resource to learn more about the types of radiation that are used in the medical field.

<https://www.epa.gov/radtown/use-radiation-medicine>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Nuclear chemistry
* Alpha/beta/gamma decay
* Radioactive isotopes
* Radiation

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-PS1-1.** Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy levels of atoms.

**HS-PS1-7.**  Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).

**Disciplinary Core Ideas:**

* PS1.A: Structure and Properties of Matter
* PS1.C: Nuclear Processes

**Crosscutting Concepts:**

* Cause and effect
* Energy and matter
* Stability and change

**Science and Engineering Practices:**

* Engaging in argument from evidence
* Constructing explanations and designing solutions

**Nature of Science:**

* Scientific knowledge is based on empirical evidence.

**Correlations to Common Core State Standards**

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students how radioactive elements were used in the past, and how they are used today. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
	+ As they read, students can find information to confirm or refute their original ideas.
	+ After they read, ask students what they learned about radioactivity and its effects on the body.
* After students have read and discussed the article, consider showing the ACS Reactions Video “Can Radiation Give You Superpowers?” (4:35) at <https://youtu.be/GbmSmgTIQ8s> to continue the discussion of radiation.