GRADES
6–12

NAVIGATING™
NUCLEAR
Energizing Our World

Middle and High School Digital Lesson

# EDUCATOR GUIDE

## Realities of Radiation

ANS Center for Nuclear Science and Technology Information | U.S. Department of Energy Office of Nuclear Energy | Discovery Education

# Background Info

**What are the misconceptions about radiation?**
Many people are not aware that we are interacting with radiation in various forms every day of our lives. In fact, without radiation, we would not be able to detect fires in our homes, see injuries to our bones and bodies, use electronics such as cell phones, or even see the world around us!

Radiation can be divided into two major types—ionizing radiation and non-ionizing radiation. While it is true that ionizing radiation does have the potential to change DNA, it is also a very valuable tool that we utilize in various fields such as medicine, environmental science, and agriculture.

**What are the various types of radiation and what do they do?**
In these 4 sessions, students will investigate the various types of radiation and the role that each plays in our lives. Through a series of activities, students will discover how wave and particle radiation differ from one another, and what ionizing radiation is, including alpha, beta, gamma, X-radiation, and ultraviolet light. They will learn about radioactive decay of isotopes and then will use this information to balance nuclear decay equations. Students will calculate, graph, and determine the half-life of a fictional radioactive atom. A Challenge activity is presented for consideration as a culminating activity following completion of the initial sessions. The Reflect portion of the lesson bundle is intended to be used as a final closing activity.

**For more information**, click here to watch as Mary Lou Dunzik-Gougar, President of the American Nuclear Society and Associate Professor of Nuclear Engineering at Idaho State University, demonstrates ways to make this digital lesson bundle even more tangible and engaging for student scientists.

## Additional Questions

- How are the four types of ionizing radiation—alpha radiation, beta radiation, gamma radiation, and x-radiation different? How are they similar?
- What is a half-life? How is it determined? How is it used?
- Can radiation be used to solve problems?

## How Do the Sessions Work?

Instructional Sequence: The Educator Guide provides details to help educators facilitate a series of three to four 45-minute sessions designed to be taught in sequence and used with middle and high school students. This guide was created to give educators ideas and strategies for presenting the content in the digital lesson. It includes slide-by-slide details for educators, so they are prepared to engage with students as they explain, discuss, and effectively facilitate the content in each of the sessions.

In addition to the Educator Guide, an accompanying presentation was created with PowerPoint so that it can be used in a variety of classroom settings. If you are using a laptop with a projector, simply progress through the PowerPoint by clicking to advance. All of the interactive aspects of the presentation are set to occur on click. The corresponding videos link to the slides. Click on the images to play the videos. If you are using an interactive whiteboard, tap on each slide with your finger or stylus to activate the interactive aspects of the presentation. It doesn't matter where you tap, but you can make it appear as if you are making certain things happen by tapping them. Teacher notes are included for each slide with information on how to proceed.

## Session Structure

Each session provides the following information to guide the educator through session implementation, integrating necessary skills and content.

- Objectives: State overall goals as well as specific behavioral and cognitive objectives for students.
- Required Materials: Any materials necessary for the session are clearly outlined and included when possible to facilitate prior preparation as well as easy implementation of the session.
- Definitions: Content-specific vocabulary words will be defined for educators
- Key Points: Used to guide discussion and reinforce concepts, key points are listed next to the corresponding slides.

- Student Responses: Guidance for suggested student responses for activities and questions, located next to corresponding slides.
- Summary/Wrap-Up: Listed at the end of each session so the educator can provide reinforcement of the key concepts and objectives of each session.

## Source Information

ANS has used and recommends these sources for radioactive sources, radiation detectors, and cloud chamber kits:

- Carolina Biological
- Geiger counters
- Cloud chamber kits
- Spectrum Techniques: For purchasing radioactive sources, like the button sources, radioactive needles, etc.

Less expensive and free sources for Geigers are noted in Navigating Nuclear's Middle School Lesson Measuring Radiation in the Educator Guide, page 3.

# Session 1 | Engage

To introduce the topic of radiation, activate prior knowledge and reveal misconceptions, students will participate in a MythBustin' activity. Students will be shown statements that reflect both truths and misconceptions about radiation. Students will pair up and discuss if they think the statements should be "confirmed" or if they think the statements will be "busted." They will then view short video segments that relate to each of the statements. Student pairs will gather evidence from the videos to support their final decision to "confirm" or "bust." As each statement is presented again to the class, allow the whole class to vote if the statement should be confirmed or busted—allow student pairs to share the evidence they believe supports their stance.

Slides 1–8 contain activities to engage students in understanding the realities of radiation and dispelling misconceptions.

## Content Areas

Life and Physical Sciences, Human Health

## Grade Level

Middle/High School

## Objectives

- What are the misconceptions about radiation?
- How is radiation useful and important in our lives?

## Materials

- "MythBustin': Realities of Radiation" CER Capture Sheet (1 per student pair/small group)
- Radiation Graphic Organizer Card Cut-outs set (1 per group)
- String
- Scissors
- Student devices (laptop, tablet, phone)
- Radiation Concept Map Notes Sheet (1 per student)

## Definitions

**radiation**: the emission of energy as electromagnetic waves or as moving subatomic particles, especially high-energy particles which cause ionization

**mutation**: the changing of the structure of a gene, resulting in a variant form that may be transmitted to subsequent generations, caused by the alteration of single base units in DNA, or the deletion, insertion, or rearrangement of larger sections of genes or chromosomes

**ionizing radiation**: any type of particle or electromagnetic wave that carries enough energy to ionize or remove electrons from an atom

**electromagnetic radiation**: energy released in the form of waves in which electric and magnetic fields vary simultaneously.These energies are recognized in a spectrum from lowest to highest energy and include: radio waves, microwaves, infrared, visible light, UV, x-rays, and gamma rays

**neutron radiation**: a form of ionizing radiation that presents as free neutrons

### Pre-Lesson Instructor Preparation

If using cards for the radiation concept map card sort (rather than a digital concept map maker), teachers will want to cut the cards out allot each group a desired amount of string before beginning the activity.

## Slides 1–3

Open by asking students to pair up for an activity that will test their knowledge of the realities of radiation. Give each pair a copy of the "MythBustin': Realities of Radiation" CER Capture Sheet. Use the accompanying PowerPoint to introduce 3 statements about radiation to which students must apply critical thinking and problem-solving skills in order to "Confirm" or "Bust." Ask students to write the statement in the first column. Have students make predictions about which statements they believe they will "Confirm" or "Bust." Play the selected video clip for each statement:

1. "You are naturally radioactive."
https://www.epa.ie/radiation/radexp/exposure/
2. "Radiation is used to control mosquito populations and hinder disease."
https://www.youtube.com/watch?v=RVMAasW5dHc&t=75s
3. "You are exposed to low levels of radiation when you fly."
https://www.cdc.gov/nceh/radiation/air_travel.html

## Slide 4

As the students watch each clip, ask them to record and discuss evidence that would support their choice to "Confirm" or "Bust" each statement in the last column of their capture sheet. To conclude, review the statements as a class and allow students to vote with "Confirmed" or "Busted." Ask students to share the evidence they found to support their stance.

Discussion Points:

- What did you learn about radiation that you didn't know before?
- Do you think that radiation is something that people should have concerns about? Why or why not?

# Explore

**Overview:** In this activity, students will explore radiation. They will do research to learn how types of electromagnetic and particle radiation differ from one another. Students will study ionizing radiation, alpha, beta, gamma, ultraviolet, and X-radiation. They will sort card cutouts and connect them to create a concept map that compares and contrasts the various types of radiation.

## Slide 5

Direct students' attention to the word cloud on the screen. Explain to students that before they can further study radiation and how it relates to their lives, they need to have an understanding of how all of these terms relate to one another. As they have already learned, forms of radiation differ by their energy level and if they consist of waves or particles.

**Key Talking Points**

- Radiation is a broad term that describes many different forms of energy
- Radiation can be divided into categories according to form and energy level

## Slide 6

Ask students to get into pairs or small groups. Explain to students that they will be given string, scissors, and a set of cards that contains terms relating to radiation. They should use their student devices and the internet websites provided in the PowerPoint to research how these terms relate to each other and create a concept map. To help them get started, the red card with the term RADIATION should be the heading. Then, the two blue cards with the terms ELECTROMAGNETIC RADIATION and PARTICLE RADIATION should divide the rest of the cards into two major groups and connect the cards using the string. Give each student group a copy of the RADIATION CONCEPT MAP NOTES SHEET. Explain that they can use this to take brief notes as they research how the cards relate to one another.

Once groups have finished their own sort, ask student groups to compare their card sort with another group and discuss how and why they sorted them in the way they did.

**TEACHER NOTE**

Students may use free online concept mapping tools, such as www.creately.com to create a digital concept map in place of using cards. A tutorial to help students learn how to use Creately can be found here: https://www.youtube.com/watch?v=EfUhwl3Q91s and should be shown before students begin to create the concept map.

**Key Talking Points**

- Radiation can be described by wavelength or the type of sub-atomic particle emitted.
- Higher energy radiation has the potential to change atomic structure.

## Slide 7

Reveal the answers to the Radiation Concept Map on the overhead screen, shared document, or share the Radiation Concept Map Key with students. Ask students to discuss any errors they had as they were sorting the cards to identify misconceptions or questions about radiation. Ask students to copy down the concept map correctly on the back of their notes sheet or use their students devices to take a picture of the concept map key.

Engage in a class discussion to end the lesson and activate brainstorming for session 2 of this lesson: What types of radiation can alter atoms of living things? Why is this? What is different about ionizing radiation?

**Key Talking Points**

- How can creating a concept map help us connect terms?
- What do the various types of radiation have in common? How are they different?

## Slide 8

Summary/Wrap of Session:

- Define radiation
- Compare and contrast two major types of radiation : ionizing and non-ionizing.
- Discuss how various types of radiation could pose a potential threat to human health or could be beneficial.

# Session 2 I Explain

**Overview**: Students will review the basic structure of atoms, ions, and isotopes. They will learn the difference between stable and unstable nuclei and use an interactive website to build virtual atoms. Next, they will use their knowledge of radioactive decay to balance nuclear reaction equations. Finally, they will participate in a small group activity that will simulate radioactive decay and calculate, graph, and determine the half-life of fictional radioactive atoms.

Slides 9–15 contain activities to engage students and further their understanding of the nucleus of a radioactive atom. They will determine the half-life associated with radioactive decay and how this knowledge can apply to human health, the age of the fossils, and geological formations.

## Objectives

- Describe the structure of atoms and predict what happens when a nucleus becomes unstable
- Write and balance nuclear reaction equations
- Explain half-life and use data to determine the half-life of fictional atoms

## Materials

- Radioactive Decay Notes Capture Sheet (1 per student)
- 1 cup (per student group)
- 50 pennies (per student group)
- 50 dimes (per student group)
- Determining the Half-Life of a Radioactive Isotope Data capture sheet (1 per student group)
- Optional—student devices such as laptops or tablets
- Optional—graphing calculator

## Definitions

**isotope:** atoms of the same element, as identified by the number of protons, with different numbers of neutrons. They have identical atomic numbers but different mass numbers, and therefore a different mass. Isotopes of an element have varying mass with the same chemical properties.

**half-life:** the time elapsed for the isotope's mass to decrease to one-half its original value.

**radioactive decay:** the spontaneous disintegration of a radioactive substance by the emission of ionizing radiation.

**alpha decay:** an atom's nucleus sheds two protons and two neutrons in a packet that scientists call an alpha particle. Since an atom loses two protons during alpha decay, it changes from one element to another.

**beta decay:** a type of decay in which an atom emits a beta particle—either a positron or an electron—from its nucleus. Beta decay of a neutron transforms it into a proton and an electron. Beta decay of a proton transforms it into a neutron and a positron.

### TEACHER NOTE

Before beginning this lesson, students should have prior knowledge of the basic structure of an atom, including protons, neutrons, and electrons. They should also understand how to use a periodic table.

## Slide 9

Explain to students that in order to understand where ionizing radiation originates, they first need to review the basic structure of an atom and understand what happens to cause a nucleus to become unstable.

Ask a student to volunteer to come up to the front and identify the parts of the model atom seen on Slide 9. Ask for feedback from the whole group to ensure that the student has correctly identified the parts of the atom, including the nucleus, neutrons, protons, and electrons.

Next, ask for a second volunteer to explain the parts of the periodic table as seen in the image on Slide 9. They should be able to correctly identify the element name, atomic number, atomic symbol, and atomic weight. They should also understand that the atomic number is determined by the number of protons in the nucleus and that the atomic mass is the average mass of all isotopes of the element. Students can also calculate the number of neutrons in an isotope by subtracting the atomic number from the mass number.

**Key Talking Points**:

- Atoms are composed of protons, neutrons, and electrons
- The number of protons defines the element
- The nucleus is composed of protons and neutrons.
- The mass of the atom is determined by the mass of the nucleus—the combined mass of the protons and neutrons.

## Slide 10

Hand out a copy of the Session 2 Radioactive Decay Notes Capture Sheet to each student.

Next, play the video "Stable and Unstable Nuclei—Fuse School" (https://www.youtube.com/watch?v=UtZw9jfIxXM) Ask students to answer the questions and complete the chart as they watch the video.

**Key Talking Points**

- There is a strong nuclear force holds the protons and neutrons of the nucleus of an atom together.
- An unstable (radioactive) atom gives off excess protons or neutrons until it transforms into a stable atom.
- The type of decay (alpha or beta) that occurs can change the atom into a different element and give off high energy radiation.
- Explain how we might predict the type of decay of an element.

## Slide 11

Instruct students to take a look at the second part of their notes sheet where they will practice balancing nuclear equations.

Explain the diagram on the slide that shows that the top number in the equation represents the atomic mass and the bottom number represents the atomic number. Next, ask students to open the virtual periodic table on their devices (laptop or tablet) at https://ptable.com/ or give each student a paper copy of the periodic table.

Complete the first problem as a class, giving students the correct answer after they have had a few minutes to complete it. Then allow students time to balance the rest of the equations.

Allow students to compare their answers with the person(s) sitting next to them and discuss any differences between their answers.

**Key Talking Points:**

- After decay, the type of atom may change according to the number of protons in the nucleus.
- Atoms that change the number of protons they have, will become a different element
- Atoms that undergo alpha decay will change in their atomic mass, while atoms that undergo beta decay do not.

## Slide 12

Once students have completed balancing the nuclear equations, reveal the answers to each problem on Slide 12. Ask for feedback from the whole group—how did they do?

Explain to students that to conclude this lesson, they will participate in a small group activity where they will calculate the half-life of a fictional isotope, which is the time it takes for half of the radioactive nuclei to decay and emit an alpha particle, beta particle, or gamma rays.

Key Talking Points:

- Balancing nuclear equations can show us how atoms will change and what type of radiation will be emitted if the atoms become unstable.

## Slide 13

Instruct students to form small groups of 3. Ask each group to get the following materials: 1 cup, 50 pennies, 50 dimes, and a copy of the "Determining the Half-Life of a Radioactive Isotope Data" capture sheet.

Ask students to read through the instructions on the sheet and record their data in the data table. They should construct the graph when they are finished and follow the instructions to determine and indicate the half-life of their penny atoms on the graph.

Ask each group to share what they determined the half-life of their penny atom to be. How do the groups compare?

## Slide 14

How can we use the information we just gathered? Show students the following video clips on Slide 14.

- How Does Radiocarbon Dating Work?
  https://youtu.be/phZeE7Att_s
- How Does A PET Scan Work?
  https://www.youtube.com/watch?v=GHLBcCv4rqk

Tell students that in the next session, they will be examining other ways that radiation can be used to help improve the lives of people or solve global problems.

**Key Talking Points**

- We can help determine the relative age of fossils and geological formations by looking at the half-life of substances like Carbon-14.
- Radioactive tracers can be used in the medical field to help indicate harmful conditions such as tumors, by giving off radiation as the tracers decay.

## Slide 15

**Summary/Wrap of Session**

Ask students to reflect on the importance of understanding ionizing radiation. What information have we gained from determining the half-lives of radioactive isotopes? How could this knowledge be both helpful and harmful to living things?

**Key Talking Points**

- Ionizing radiation may cause concern at first glance, but our understanding of this high-energy radiation has led to the discovery and creation of many techniques and tools that are used in different fields.

## Slide 16

# **Sesion 3:** Challenge!

In this radiation challenge, students will research and brainstorm ways to improve how ionizing radiation and nuclear techniques are used to help solve global problems.

**Example Problem Scenario**
Student groups will be assigned an area in which ionizing radiation is used (agriculture, medicine, genetics, environmental science, etc.) to create an innovative and unique product (or a product that improves on one that already exists). They will create a prototype model of their innovation, along with a product name and presentation that explains how their innovative product will theoretically work or improve an existing product. This will be presented to the whole group to help make real-world connections to ways that the power of radiation can be used for good.

**TEACHER NOTE**
Teachers should use the EDP (Engineering Design Process) as a guide as students work to create their innovative product. Teachers who are not familiar with the EDP can go to the following resource for information and examples of how the EDP can be used in the classroom: https://www.nasa.gov/audience/foreducators/best/edp.html

## Slides 17–18

Display the following areas in which radiation is used and examples of how it is used:

- Agriculture: Food irradiation
- Agriculture: Crop pest sterilization (SIT—Sterile Insect Technique)
- Agriculture: Using nuclear science to trace nitrogen in soil and crops
- Medical: Radiation therapy for cancer
- Medical: Radiation in x-rays and scans

- Medical: Radiopharmaceuticals
- Global Health: Mosquito sterilization (SIT—Sterile Insect Technique)
- Genetics: Gamma irradiation to improve and create plant species
- Environmental Science: Using nuclear science to trace microplastic in ocean life
- Environmental Science: Using nuclear science to understand drought

Ask students to form small groups of 3–4. Allow students to choose an area in which radiation and nuclear techniques are used.

Explain to students that their job is to research how radiation is used in their field of study.

**TEACHER NOTE**
If students are unfamiliar with how to determine if a news source is credible, the following infographic may be displayed on the overhead screen or printed so that each student group has a copy: https://guides.library.cornell.edu/evaluate_news/infographic

They should then create an innovative product that will allow people to use the power of radiation more easily or give easier or more cost-effective access to these techniques. Encourage students to use the engineering design process.

They will create a prototype 2-D or 3-D model of their product and a brief Google Slides or PowerPoint presentation that will explain how their product will work.

Give each student group a copy of the "Radiation Innovations Research and Model Sketch" Capture Sheet. Allow students to have time to complete their research using their devices (laptops or tablets) and create their models and presentations. This could take 1–2 additional class periods.

**TEACHER NOTE**
Teachers may provide materials for building 3-D prototype models, such as glue, tape, scissors, cardboard tubes, plastic bottles, modeling clay, craft materials, etc. or the teacher may elect to have students use their own materials.

## Slide 19

Once students have completed their models and presentations, allow each group 3–5 minutes to present to the whole class. After each presentation, give the whole group a chance to ask questions and give feedback on the presentation and innovative product.

## Slide 20

# Reflect

Students will summarize their learning by participating in a review game that allows them to showcase their knowledge of radiation. Student teams will compete against each other to answer trivia questions about radiation to collect "radiation cards." These cards will be assembled to create a complete radiation spectrum that showcases the many types of radiation."

## Slides 21–30

Ask students to form teams of 3–4. Give each team a white board and dry erase marker. As you display the questions about various types of radiation from slides 20–29 on the overhead screen, give the teams a specific amount of time (15–20 seconds) to write down their answer to the question without using notes or devices such as laptops, tablets, or cell phones. Teams will hold up their answers when time runs out, and each team that answers the question correctly first will get a card that has the name of that type of radiation (See Reflection Capture Sheet: Radiation Trivia Cards). Alternatively, teachers can create a virtual version by using sites like Plickers or Kahoot.

**Questions/Answers**

1. These are considered to be one of human's most important discoveries as they made communication much more efficient. **A–Radio waves**
2. These have the smallest wavelengths and the most energy of any wave in the electromagnetic spectrum. **A–Gamma rays**
3. NASA and other space agencies use these for deep space communication. **A—Microwaves**
4. This form of radiation is actually a helium nucleus. **A–Alpha radiation**
5. This type of radiation lies in the invisible spectrum, which gives it the name 'black light'. **A–Ultraviolet (UV)**
6. This is the only form of radiation that can make other objects radioactive. **A–Neutron radiation**
7. We can only see color because our eyes can detect the reflection of this radiation off of objects. **A–Visible light**
8. In this type of radiation, a neutron actually turns into a proton. **A–Beta-radiation**
9. This type of radiation got its name because the man who discovered it in 1895 didn't know what it was! **A–X-rays**
10. Some snakes have special sensory pits that are used to "see" this type of radiation and detect warm-blooded prey. **A–Infrared radiation**

## Slide 31

The team that collects the most radiation cards will be declared the winner. If there is a tie, the teams will go head-to-head, and the first team to assemble their cards in order of energy level (from lowest energy to highest) will be the tie-breaker and will win!

## References and National Standards

Myths & Facts About Radiation
https://www.aerb.gov.in/english/myths-facts-about-radiation

Electromagnetic Spectrum
http://earthguide.ucsd.edu/eoc/special_topics/teach/sp_climate_change/p_emspectrum_interactive.html

Introduction to the Electromagnetic Spectrum
https://science.nasa.gov/ems/01_intro

Imagine the Universe—The Electromagnetic Spectrum
https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html

Radiation Basics
https://www.nrc.gov/about-nrc/radiation/health-effects/radiation-basics.html

## Primary Standards
## Next Generation Science Standards

**HS-PS1-8 Matter and its Interactions**

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.

**MS-PS4-2 Waves and their Applications in Technologies for Information Transfer**

Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

**HS-PS4-5 Waves and their Applications in Technologies for Information Transfer**

Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

**MS-ETS1-2 Engineering Design**

Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**HS-ETS1-3 Engineering Design**

Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.

STUDENT HANDOUT

# Realities of Radiation MYTHBUSTIN'!

Gather evidence in the tables below to confirm or bust each myth about radiation as you watch the video!

| **MYTH 1: You are naturally radioactive.** | |
|---|---|
| **CONFIRMED** | **BUSTED** |
| Evidence/Reasoning: | Evidence/Reasoning: |

| |
|---|
| Confirmed or Busted? |

| **MYTH 2: Radiation is used to control mosquito populations and hinder disease.** | |
|---|---|
| **CONFIRMED** | **BUSTED** |
| Evidence/Reasoning: | Evidence/Reasoning: |

| **MYTH 3: You are exposed to low levels of radiation when you fly.** | |
|---|---|
| **CONFIRMED** | **BUSTED** |
| Evidence/Reasoning: | Evidence/Reasoning: |

| |
|---|
| Confirmed or Busted? |

## Session 1 Capture Sheet

STUDENT HANDOUT

# Realities of Radiation MYTHBUSTIN'!

As you do research to help complete your concept map, use the following sheet to take some brief notes over the various categories, types, and uses of radiation:

| RADIATION TERM | Notes |
|---|---|
| Radiation | |
| Electromagnetic radiation | |
| Particle radiation | |
| Radio waves | |
| Microwaves | |
| Infrared waves | |
| Visible Light | |
| Ultraviolet light | |
| X-rays | |

# Session 1 Capture Sheet

STUDENT HANDOUT

| RADIATION TERM | Notes |
|---|---|
| Gamma rays | |
| Alpha radiation | |
| Beta radiation | |
| Neutron radiation | |

What makes some forms of radiation more harmful than others?

What are some ways that we use radiation to benefit us? Which types do we use?

## Session 1 Card Sort

STUDENT HANDOUT

*The instructor should cut each set into individual cards. Each pair or small group of students will need one complete set as well as string and a pair of scissors to cut the string into appropriate lengths to link the cards together in the concept map.

**HINT FOR STUDENTS:** The blue card should be the first card at the top of the concept map. Next, they should use the two red cards to begin to separate the terms into two main groups.

| | |
|---|---|
| RADIATION | ELECTROMAGNETIC RADIATION |
| PARTICLE RADIATION | CONSISTS OF WAVES OF VARYING ENERGY |
| CONSISTS OF PARTICLES OF VARYING ENERGY | LOW ENERGY WAVES |

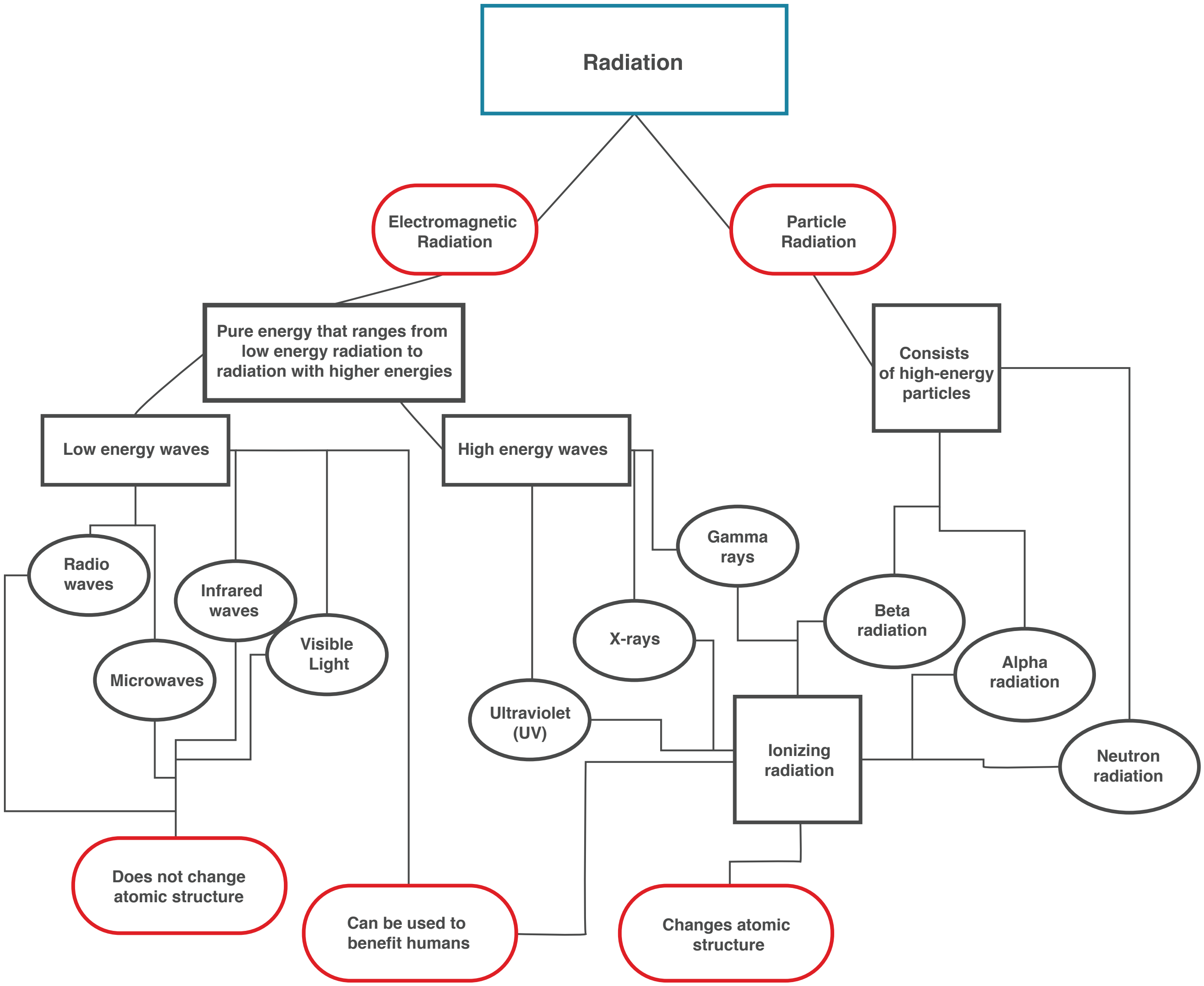
| | |
|---|---|
| HIGH ENERGY WAVES | RADIO WAVES |
| MICROWAVES | INFRARED WAVES |
| VISIBLE LIGHT | ULTRAVIOLET LIGHT |
| X-RAYS | GAMMA RAYS |

| | |
|---|---|
| BETA RADIATION | ALPHA RADIATION |
| NEUTRON RADIATION | IONIZING RADIATION |
| DOES NOT CHANGE ATOMIC STRUCTURE | CHANGES ATOMIC STRUCTURE |
| CAN BE USED TO BENEFIT HUMANS | |

# Session 1 Radiation Concept Map KEY

**STUDENT HANDOUT**

This key can be displayed on the overhead screen or shared digitally with students to allow them to determine if the concept map they created is correct.



# Realities of Radiation Radioactive Decay Notes

**PART 1: VIDEO—Stable and Unstable Nuclei**

As you watch the video, answer the questions and complete the chart about radioactive decay.

1. What holds the nucleus of an atom together?

2. What causes nuclei to become unstable?

3. When unstable nuclei give off excess protons or neutrons it is called ______

Complete the chart from the video:

| TYPE OF DECAY | MASS NUMBER (protons & neutrons) | ATOMIC NUMBER (protons) | EMITTED PARTICLE | COMMENTS |
|---|---|---|---|---|
| ALPHA | | | | |
| BETA MINUS | | | | |
| BETA PLUS | | | | |

# Session 2 Capture Sheet

STUDENT HANDOUT

**PART 2: Balancing Nuclear Equations**

Use the periodic table provided by your teacher or go to the following link: https://ptable.com/ to help you balance the following nuclear equations.

## ALPHA DECAY

$$^{4}_{2}\text{He}$$

The following isotopes will emit an alpha particle as they undergo radioactive decay.

**Remember:** In alpha decay, the nucleus is emitting 2 neutrons and 2 protons. This will change the atomic mass AND the atomic number!

1. $^{224}_{88}\text{Ra} \rightarrow$ __________ + ___________
2. $^{238}_{92}\text{U} \rightarrow$ __________ + ___________
3. $^{210}_{84}\text{Po} \rightarrow$ __________ + ___________

## BETA (β-) DECAY

$$^{0}_{-1}\text{e}$$

The following isotopes will emit a beta particle as they undergo radioactive decay.

**Remember:** In beta (β-) decay, the nucleus is emitting 1 electron. This will NOT change the atomic mass BUT WILL change the atomic number!

4. $^{14}_{6}\text{C} \rightarrow$ __________ + ___________
5. $^{238}_{92}\text{U} \rightarrow$ __________ + ___________
6. $^{210}_{82}\text{Pb} \rightarrow$ __________ + ___________

Check your answers when you are finished! How well can you balance nuclear equations?

# Session 2 Capture Sheet



**Determining the Half-Life of a Radioactive Isotope Data**

Procedure:

1. Obtain 1 cup, 50 pennies, and 50 dimes. Each penny represents a radioactive element that will decay.
2. Put all 50 pennies in the cup.
3. Shake the cup with the pennies inside for 5 seconds.
4. Dump the pennies out of the cup.
5. Any penny that lands with the tails side up represents an atom that has decayed. Count and remove any atoms that have decayed (any pennies that have fallen with the tails side up).
6. Replace the decayed pennies with dimes. The dimes represent the new type of atom the penny has become through decay.

   **Remember**—*atoms become new elements as they decay, they do not just disappear!*
7. Record the number of decayed atoms (dimes) and the number of atoms remaining (pennies) in your data table under 5 seconds.
8. Repeat this procedure for the remaining time intervals (10, 15, 20 seconds, etc.) until all atoms have decayed (become dimes) or you have reached 60 seconds.

   DATA:

| TIME (sec) | ATOMS DECAYED | ATOMS REMAINING |
|---|---|---|
| 5 | | |
| 10 | | |
| 15 | | |
| 20 | | |
| 25 | | |
| 30 | | |
| 35 | | |
| 40 | | |
| 45 | | |
| 50 | | |
| 55 | | |
| 60 | | |

# Session 2 Capture Sheet

STUDENT HANDOUT

Next, create a graph from your data. If a graphing calculator is available, this may be used in place of a graph on paper. The X axis should represent TIME (sec) and the Y axis should represent the # OF ATOMS REMAINING.

**To determine the half-life, find the point on the graph where just half the atoms were remaining from the original amount. Use a colored pencil or pen to draw a line indicating the half-life of your penny atoms.**

## Session 3 Capture Sheet

STUDENT HANDOUT

### Challenge: Radiation Innovations Research and Model Sketch

**Directions:** Use the space below to record notes from your research that you will use in your presentation. As you perform your research, do your best to find reputable news sources, and focus on quality over quantity! Your notes do *not* have to be in complete sentences.

Name of your area of study where radiation is used:

What radiation is used for in this industry? Which type of radiation?

What technique or use of radiation has your group chosen to focus on? How does it work?

What are some of the shortcomings of this technique or use of radiation?

What might be some ways that your product could improve upon existing products or techniques?

# Brainstorming

STUDENT HANDOUT

In the space below, create a sketch of what your product might look like and add notes to explain how it might work.
(You can use this to guide you as you build your 3-D model or create your final 2-D model.)

| **Name of Product:** |
| --- |
| |

## Reflect—Radiation Trivia Cards

**STUDENT HANDOUT**

Cut out 1 complete set of cards per team. Each team collects a card when they answer the question related to it.

| | |
|---|---|
| **REFLECT: Radiation Trivia**<br>radio waves | **REFLECT: Radiation Trivia**<br>microwaves |
| **REFLECT: Radiation Trivia**<br>infrared waves | **REFLECT: Radiation Trivia**<br>visible light |
| **REFLECT: Radiation Trivia**<br>ultraviolet light | **REFLECT: Radiation Trivia**<br>x-rays |

## Reflect—Radiation Trivia Cards

Cut out 1 complete set of cards per team. Each team collects a card when they answer the question related to it.

| | |
|---|---|
| **REFLECT: Radiation Trivia**<br>gamma waves | **REFLECT: Radiation Trivia**<br>alpha radiation |
| **REFLECT: Radiation Trivia**<br>beta radiation | **REFLECT: Radiation Trivia**<br>neutron radiation |