NAVIGATING™ NUCLEAR
Energizing Our World

Lessons

Topic

Planting the "Seeds" for a Better Future for Cancer Patients

OBJECTIVES

Students will:

- Explore and summarize the characteristics of alpha radiation.
- Research a technique of internal radiation therapy and defend potential treatment options.
- Investigate ways that scientists are making breakthroughs in targeted alpha particle therapy.

Overview

You have probably heard of radiation therapy for cancer patients, but did you know that there is a kind of radiation therapy that can be planted inside the body?

Radiation destroys cancer cells, either by using seeds to bring a source into close proximity to a tumor, or a targeted alpha therapy, which uses a molecular approach to deliver a radionuclide to cancerous tissue.

In this activity, students will summarize the unique characteristics of radiation and how it is used to treat cancer through a Think-Pair-Share activity. Using resources from the National Cancer Institute and American Cancer Society, groups of students will research an assigned technique of internal radiation therapy (brachytherapy), which uses a radiation source that is sealed in different types of implants, or "seeds," and placed in the body very close to or inside the tumor. They will describe the pros and cons of their assigned technique—either interstitial, intracavity, or episcleral—on poster paper or using a digital platform. Student groups will then receive a case study of a cancer type and participate in a Gallery Walk to determine which technique they would recommend for their imaginary patient and at which dosage. Subsequently, they will defend their recommended approach in a short class discussion. As an alternative during periods of online instruction, students can participate in the creation of a virtual gallery and conduct an online Gallery Walk using your school's online learning platform.

As an extension, students will uncover promises and potential shortcomings of targeted alpha-particle therapy and investigate ways that scientists are currently working to overcome them. Students will complete a flowchart summarizing one of these cutting-edge methods to increase the supply of rare, but effective, cancer-fighting radioisotopes.

Grade Band

9–12

Timing

Prep

Up to one hour to gather materials, prepare suggested videos

Activity

1 or 2 class periods, depending on class length and activities included.

Performance Expectation(s)

Students that understand the concept can:

- Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the process of fission, fusion, and radioactive decay. (HS-PS1-8)
- Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)

NGSS Standards

Science & Engineering Practices:	Disciplinary Core Ideas:	Crosscutting Concepts:
Developing and Using Models • Developing and Using Models • Obtaining, Evaluating, and Communicating Information	**PS1.A Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. **PS1.C: Nuclear Processes** • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. • The total number of neutrons plus protons does not change in any nuclear process.	**Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

Essential questions

- What are the unique characteristics of alpha radiation and how is it used to treat various forms of cancer?
- What are the pros and cons of different techniques of internal radiation therapy?
- How is targeted therapy (precision medicine) used to treat cancer?

Materials & Equipment

- Copies of the *Think Pair Share* capture sheet, one per student
- Computers or devices connected to the internet, one per group
- Copies of *Pro/Con* chart, one per group
- Poster paper, one per group
- Markers and tape for each group
- Copy of *Imaginary Cancer Patient Scenarios,* cut into strips
- Copies of *Extension: Cancer Fighting Alpha Emitters* flow chart

Prior Student Knowledge

Prior to beginning the lesson, students should be familiar with the following key vocabulary terms:

Alpha decay—a radioactive process in which an alpha particle is emitted from the nucleus of an atom, decreasing its atomic number by two and mass by four.

Isotopes—atoms of an element with the same atomic number (number of protons) and identical chemical behavior but with differing atomic mass due to a different number of neutrons.

Radioactive waste—the radioactive by-products from the operation of a nuclear reactor and other applications involving radioactive materials.

Half-life—the time required for the radioactivity of an isotope to decrease by half.

Targeted alpha-particle therapy (TAT)—a method of targeted radionuclide therapy for various cancers. It employs radioactive substances which undergo alpha decay to treat diseased tissue at close proximity. It has the potential to provide highly targeted treatment, delivering a radiation dose directly to microscopic tumor cells.

Brachytherapy—the treatment of cancer, by the insertion of radioactive implants directly into the tissue, and often used to treat prostate, breast, cervical, and eye cancers.

Interstitial—situated within but not restricted to or characteristic of a particular organ or tissue—used especially of fibrous tissue.

Intracavity—situated or occurring within a body cavity, such as treatment of cervical cancer, characterized by the insertion of especially radioactive substances in a cavity.

Episcleral—pertaining to the space between the fascial sheath of the eyeball and the sclera; the episclera is a fibroelastic structure covering the sclera and is formed of two layers loosely joined together by connecting fibers.

Proton bombardment—striking a target with high energy proton beams at about forty percent the speed of light for the purpose of transforming atoms into different isotopes.

Procedure

1. After providing background information and reviewing the lesson objectives, start the lesson by passing out the Think-Pair-Share (TPS) capture sheet. Additional background information is available using the U. S. Department of Energy (DOE) infographic: https://www.energy.gov/ne/articles/fission-and-fusion-what-difference
2. As an activator, show the:
    - Alpha decay Discovery Education Video: https://google.discoveryeducation.com/learn/videos/941578a9-c8e1-4bb4-bcce-4ef8d2853b6b/ (2 minutes, 40 seconds). Note: You must create a free account to access this video.

      and
    - The Atomic Heritage Foundation Targeted Alpha Therapy Video: https://youtu.be/p7Czcdco_b4 (1 minute, 19 seconds)
3. Have students Think-Pair-Share to list the unique characteristics of alpha radiation and how alpha particles differ from beta and gamma radioation. First, students will think individually, then pair up with a classmate (discuss with partner), and lastly share their thoughts with the rest of the class. As they work, they should complete the Think-Pair-Share capture sheet.
4. Next, break students into six groups of 4–5 students, and assign each group one of the brachytherapy techniques listed below (Note: two groups can research each of the 3 techniques). Hand out copies of the Pro/Con chart—one per group—poster paper, markers and tape. Explain to students that they will be researching an assigned technique of internal radiation therapy (brachytherapy), which uses a radiation source that is sealed in different types of implants, or "seeds," and placed in the body very close to or inside the tumor.
5. Using resources from the American Cancer Society (tinyurl.com/acsresource1) and National Cancer Institute (tinyurl.com/nciresource2), each group will research and then describe the pros and cons of their assigned technique—either interstitial, intracavity, or episcleral—on the Pro/Con chart. Make sure students understand that they should include information in their charts specific to certain types of cancers. Search the National Cancer Society website for cancer type by body location/system for more information to help students connect the types of techniques to specific tissue. For example, a "pro" of episcleral is that it is used to treat melanoma of the eye. In addition, they should include pros and cons for different dosages (Low and High) and durations of treatment (Temporary and Permanent). Once they have completed their chart handout, they will re-write it neatly on poster paper using the markers. Hang the six completed Pro/Con posters around the room with tape, with the duplicate techniques hanging next to one another. (As an alternative during periods of online instruction, students can participate in the creation of a virtual gallery and conduct an online Gallery Walk using your school's online learning platform.)
6. Then, pass out the imaginary cancer patient scenarios (one to each group). Have groups read their patient scenario out loud and then complete a Gallery Walk around the room to view each Pro/Con poster. Instruct students to jot down individually a few notes about which techniques, dosages, and durations might be beneficial for their cancer patient as they walk around. After viewing the posters and taking notes individually for 7–10 minutes, have group members confer with one another to recommend a particular brachytherapy technique and defend their recommendation based on their notes from the Gallery Walk. In their recommendation, students should also include a discussion of the pros and cons of different dosages (Low or High) and durations of treatment (Temporary or Permanent) their patients should consider.

Extend the learning

As an extension, students will uncover promises and potential shortcomings of targeted alpha-particle therapy and investigate ways that scientists are currently working to overcome them. Students will read one of the articles below and complete a flowchart summarizing one of these cutting-edge methods to increase the supply of rare but effective cancer fighting radioisotopes.

1. https://ornl.gov/news/ornl-ramps-production-key-radioisotope-cancer-fighting-drug
2. https://www.energy.gov/science/articles/journey-actinium-225-how-scientists-discovered-new-way-produce

Name: ____________________________________

STUDENT HANDOUT

Think-Pair-Share (TPS) What are the unique characteristics of alpha radiation?
THINK—My thoughts and ideas:
PAIR—What my partner and I think:
SHARE—What my classmates shared:

Name: ______________________________

STUDENT HANDOUT

PRO/CON CHART

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Imaginary Cancer Patient Scenarios

TEACHER ANSWER KEY

(Cut out along the dotted lines and give each group one scenario. Keep the bottom section for your reference during the report out of recommendations.)

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1. Your patient is a 70-year old man with melanoma of the eye.

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2. Your patient is a 30-year old woman with cervical cancer.

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3. Your patient is a 48-year old woman with breast cancer.

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4. Your patient is a 52-year old man with prostate cancer.

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5. Your patient is a 22-year old woman with endometrial cancer.

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6. Your patient is a 63-year old man with lung cancer.

Possible recommendation, Patient 1: Episcleral

Possible recommendation, Patient 2: Intracavity

Possible recommendation, Patient 3: Interstitial

Possible recommendation, Patient 4: Interstitial

Possible recommendation, Patient 5: Intracavity

Possible recommendation, Patient 6: Interstitial

EXTENSION: CANCER-FIGHTING ALPHA EMITTERS FLOW CHART

STUDENT HANDOUT

Directions: Read one of the articles below and complete a flowchart summarizing one of these cutting-edge methods to increase the supply of rare but effective cancer-fighting radioisotopes used in targeted alpha therapy. Name the targeted substance described in the article you choose. Then summarize the steps involved in the newest method for producing the targeted substance described in each.

1. Oak Ridge National Laboratory, “ORNL ramps up production of key radioisotope for cancer-fighting drug”: tinyurl.com/ornlarticle1
2. Energy.gov, “The Journey of Actinium-225: How Scientists Discovered a New Way to Produce a Rare Medical Radioisotope”: tinyurl.com/energyarticle2

Targeted Alpha Therapy Substance: ___________________________________

STEP 1:

STEP 2:

STEP 3:

STEP 4:

STEP 5:

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