STEM PROJECT STARTER
Structure of Life

Topic
Radiopharmaceuticals

PROJECT DETAILS

Course
Life Science

Grade Span
6-8

Duration
x2 45–60-minute sessions

Concept
Structure of Life

Overview

This project provides students with the opportunity to obtain, evaluate, and communicate information about present and possible future uses of radiation in medicine. They will be assigned a use of radiopharmaceuticals: diagnosis (imaging) or treatment. Then, they will research that topic to gather information. Based on their information, they will suggest expanded uses for radiopharmaceuticals and design tests to evaluate whether their expanded uses would be effective.

Essential Question

How can a pill that uses radiation help doctors diagnose and treat diseases?

Materials

- Radiopharmaceuticals Rubrics student handout
- Radiating from the Inside Out student handout
- Expanded use of Nuclear Medicine student handout

Procedure

Think Energy

1. Display the image.

2. Encourage students to look closely and try to observe as many details as possible.
   Give students five minutes to jot down answers to the following questions:
   - What do you see? Remind students to only report on things they actually see in the image.
   - What do you think about that?
   - What does it make you wonder?
   - Facilitate a group discussion about the questions.
   - Ask students to use the following stems when sharing: “I see...,” “I think...,” “I wonder....”
3. Summarize with students that the image is showing doctors preparing a patient for radiation treatment. In this lesson, students will explore how radiation treatment is used in medicine.

Create

Nuclear Medicine

1. Display the video:
   The Genius of Marie Curie (5:03)
2. Explain that Marie Curie’s research led to the development of several medical techniques for diagnosing problems and curing disease.
   Ask students to consider the question, what needs to be done to ensure that nuclear medicine and the medical community is safe?
3. Break up the word “radiopharmaceutical” into two parts, “radio” and “pharmaceutical.” Ask students if they can define what the term means by combining the two parts.
4. Invite students to read the *Radiating from the Inside Out* student handout and use an annotated reading strategy to unpack the information.

   Annotated Reading Strategy

   - ☐ Circle ideas or facts that you already knew
   - ☐ Underline ideas or facts that are new learning for you
   - ☐ ? Questions that you still have
   - ☐ Summarize what you have learned
   - ☐ Make a prediction about what you might learn next
5. Introduce the project to students. Students will research a specific example of the use of a radiopharmaceutical. They should describe at least one benefit and one disadvantage of using this radiopharmaceutical. Finally, they will describe the isotope/compound that is used and the procedure by which it is used. Distribute the *Radiopharmaceuticals Rubrics* for students to track the requirements of the project.

   Sample Answer: Radioactive iodine (specifically iodine-123) is used to treat thyroid cancer. This iodine can be taken as a pill or injected. Benefits of the treatment are that it is easy to administer. Additionally, the radioactive iodine focuses on killing the thyroid cancer cells, although it travels throughout the body. However, there is a risk in using any radioactive element internally. While radiation therapy is targeted at destroying cancer cells, it can also damage healthy cells leading to some side effects. Doctors are required to carefully monitor amount of radiation that one is exposed to.

6. Next, guide student to revisit the radiopharmaceutical they researched earlier. They should now suggest how the use of the radiopharmaceutical they researched could be expanded for other illnesses. Students should propose an investigation they could perform to determine if the expanded use could be effective using the *Expanded use of Nuclear Medicine* student handout.

   Sample Answer: Student answers will vary, but they should note a related use and a proper investigation. The thyroid uses iodine to create the hormones thyroxine (T4) and triiodothyronine (T3). The numbers 3 and 4 refer to how many iodine atoms the hormone contains. Hyperthyroidism occurs when the thyroid produces too much of one of these hormones. We could possibly use iodine as a test for hyperthyroidism. After taking a radioactive iodine compound, the patient could be examined for radioactivity in regions where the relevant hormones would tend to go. If the rate of radioactivity is high in other areas of the body, that could be an indicator of hyperthyroidism. To test this proposal, we could get two groups of people: those with hyperthyroidism and those without it. We would give half of each group a radioactive iodine compound. The other half would receive a sugar pill. Without knowing who got what or who had hyperthyroidism, researchers would then examine all patients for radioactivity in their thyroid and in the places where the relevant hormones would tend to go. Researchers would document their results, and then see if there were any statistical relationships between their observations and who had hyperthyroidism.

Connect

Future of Nuclear Medicine

1. Explain to students that nuclear medicine is constantly improving because researchers are constantly going through an iterative design process. Invite students to research the status of the nuclear medicine industry and its prospects for the future. Then, use the evidence they gather to answer the following questions:

   - What are two current applications of nuclear medicine, in addition to the application you described in Part 1?
   - How can nuclear medicine be used to treat Alzheimer’s disease?
   - What are two regulations the medical industry has to follow to make nuclear medicine safe for patients ?
   - How fast is the nuclear medicine industry growing? Why?

   Sample Answer: One major application of medicine is imaging. For example, PET scans use charged particles to create three-dimensional images of the body. Another use is finding sources of internal bleeding. Doctors can inject radioactive materials into the body and follow their path to find where the bleeding is happening.

   Doctors use the lowest effective dose of radiation on patients. Also, they must use special protective equipment for handling some types of radiopharmaceuticals.

   Nuclear medicine is increasing faster than average as a source of jobs and as an industry because of the growth of health care to underserved populations and countries that want to make use of this cutting-edge technology. Also, scientists are making many discoveries that improve nuclear medicine and apply it to more cases.

National Standards

Next Generation Science Standards

Constructing Explanations and Designing Solutions	PS3.A: Definitions of Energy	Energy and Matter
Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.	The term "heat" as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system's total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. **LS1.A: Structure and Function** Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.	Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.

Discovery Education Science Connection

Radiating from the Inside Out

New York City, 2000

Nuclear Medicine

Substances identified as "radioactive" send out invisible rays that can be dangerous to cells. Some can even cause cancer. But their properties can also work with sophisticated equipment to help doctors find out about medical problems safely, painlessly, and quickly. These procedures are used in a branch of medicine called diagnostic radiology. If you break a bone, most likely your doctor will get an x-ray taken to find out what the fracture looks like. The x-ray beams that go in the patient's body are captured on film or by another detector to produce an image, explains Dr. Alison Haimes, a diagnostic radiologist in private practice in New York City.

Nuclear technology gets into the act with an even more hi-tech (and fast-growing) diagnostic procedure known as nuclear medicine studies. In this case, patients actually take in very small amounts of radioactive materials. While x-rays show images of sizes or shapes on the body's insides and can record changes overtime, they can't show right then and there how different parts of the body are working. Nuclear medicine studies can take this extra step, says Dr. Haimes. Nuclear medicine studies are extremely sensitive, so they can reveal problems that are too small to be detected by other methods. And an early, accurate diagnosis is important for addressing the problem effectively: The sooner doctors know exactly what's wrong, the better they can treat it. This greatly improves the patient's prospects for recovery. Here's how nuclear medicine studies work: A patient swallows or is injected with a small amount of radioactive materials—also called radioisotopes or tracers. Which tracers are used depends on the part of the body being examined, because different materials are attracted to different organs, bones, and tissues. The tracers travel through the patient's bloodstream to get to their destination. Once there, they send out rays that can be picked up by special cameras and recorded in a computer, which produces an image. The radiologist's job is to analyze the images, along with the patient's medical history, to arrive at a diagnosis. "No one study can give you 100% of the information you need," says Dr. Haimes, "so I put together all the different pieces of the diagnostic equation. I love solving puzzles, which is really what it is."

Safety Zone

Although the idea of being injected with radioactive materials may sound scary, nuclear medicine procedures are actually safe because they use such small doses, she explains. Medical standards specify just how much radiation each body part is allowed to receive, and that level is tens of times higher than the amount of radiation used in diagnostic procedures. Also, the radioactive tracers don't stay in the body for long. The materials that are used have a short half-life, meaning that they decay to a harmless state within a few hours, and they are flushed out of the system through urination. In fact, patients undergoing a diagnostic procedure are in less danger than the medical specialists who work with the materials day in and day out. For their safety, they follow strict rules and take daily precautions to decrease their exposure to radioactivity: They work behind walls of lead and leaded glass when performing nuclear medicine studies and use an instrument like a Geiger counter to measure radioactive leakage.

All radioactive materials are packed in protective lead shields. At Dr. Haimes's office, employees are checked each month to make sure that they are exposed to just one-tenth of the allowable guidelines for radiation. "We kind of go overboard, but it's worth it," says Jeanine Wyka, a nuclear medicine technologist who works there. The benefits of nuclear medicine scans definitely outweigh the risks, she adds. "These tests can give the doctor so much information about the function of the body that cannot be picked up in other ways. You gain so much by using a small amount of radiation that's relatively harmless, doesn't cause any discomfort, and gives you quick results." Explaining those benefits to patients is an important part of the job—and one of the most rewarding.

Expanded use of Nuclear Medicine

STUDENT HANDOUT

Directions: Using the radiopharmaceutical you researched earlier, suggest how the use of the radiopharmaceutical could be expanded for other illnesses. You should propose an investigation that could perform to determine if the expanded use could be effective using the guiding questions below.

Guiding Questions	Ideas
What are you trying to find out? What is your prediction?	
What do you think will happen?	
What will you change, measure, and keep the same during your investigation?	
How will you carry out your experiment?	

Radiopharmaceuticals Rubrics

STUDENT HANDOUT

Evaluation Criteria:

Your answer will be evaluated based on the following criteria:

- Benefits are correct and well described for the radiopharmaceutical.
- Disadvantages are correct and well described for the radiopharmaceutical.
- The radiopharmaceutical is correctly described.

Rubric

Criteria	2	1	0
Benefit	At least one advantage is correct and well-described.	Advantage is poorly described.	Advantage is incorrect or missing.
Disadvatage	At least one disadvantage is correct and well-described.	Disadvantage is poorly described.	Disadvantage is incorrect or missing.
Description	The description is correct and well-organized.	The description is poorly organized.	The description is incorrect or missing.

Evaluation Criteria:

Your answer will be evaluated based on the following criteria:

- Expanded use of the radiopharmaceutical is feasible, clear, and concise
- Plausible investigation is clearly described

Rubric

Criteria	2	1	0
Expansion	Expansion is clear, concise, and feasible.	Expansion is unclear, poorly organized, or infeasible.	Expansion is incorrect or missing.
Investigation	Investigation is clear, concise, and plausible.	Investigation is unclear, poorly organized, or implausible.	Investigation is incorrect or missing.

Radiopharmaceuticals Rubrics

STUDENT HANDOUT

Evaluation Criteria:

Your answer will be evaluated based on the following criteria:

- Description of the nuclear medicine industry and its future prospects
- Description of two major uses of radiopharmaceuticals
- Description of the possible use of radiation for disabling mental diseases like Alzheimer's.

Rubric

Criteria	2	1	0
Future	Future is well-described and accurate.	Future is poorly described.	Future is incorrect or missing.
Major Uses	Two major uses are well-described and accurate.	One major use is well-described and accurate, or two major uses are poorly described.	Major uses are incorrect or missing.
Challenges and Regulations	Challenges and two regulations are well-described and accurate.	Challenges and one or no regulations are well-described and accurate, or challenges and two regulations are poorly described.	Challenges and regulations are incorrect or missing.