NAVIGATING™ NUCLEAR
Energizing Our World

Project Starters

Topic

Making Mosquitoes SIT!

OBJECTIVES

Students will:

- Investigate types of radiation and understand how radiation can be used to solve problems and benefit humans.
- Gather evidence such as facts and statistics concerning deadly global diseases that use mosquitoes as vectors.
- Create a health campaign to inform the public of the use of mosquito sterilization as a sustainable technique to help combat the deadly diseases that they spread.

Overview

In this lesson, students will participate in an interactive survey to determine what their misconceptions may be about the risks and sources of radiation they are exposed to in their daily lives. They will next be introduced to how radiation, such as gamma radiation, can be used to help solve problems by examining the quest to eradicate Aedes mosquitoes, which are vectors for deadly diseases around the world. They will participate in a jigsaw, where students share information with each other about the mosquito's unique role in the transmission of pathogens such as dengue, malaria, and the Zika virus. Students will review various ways that humans have tried to control and eliminate mosquitoes that carry these diseases, and why there is a current need for alternative methods. Next, students will be introduced to the Sterile Insect Technique: (SIT). In SIT, male insects are sterilized in a laboratory through the use of gamma radiation to disrupt DNA, and are then released to mate. Mating is unsuccessful, which results in a sustainable decrease in insect pest populations over time in the areas where SIT has been used. Students will form groups and be asked to create a campaign to help garner funding and support for the use of SIT to combat mosquitoes and the deadly diseases they spread in an assigned country. They will introduce the specific problem in their country that is related to disease transmission by mosquitoes using research and statistics. They will also create an interactive 3-D model, animation, or video that explains how SIT uses gamma radiation for sterilization and describes the advantages of SIT over other control methods.

Grade Band

9–12

Topic

Ionizing radiation, gamma radiation, disease transmission

Real-World Science Topics

- Ionizing radiation
- Insects as disease vectors
- Solutions to global health concerns

Next Generation Science Standards (NGSS)

HS-PS4-4

Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Asking Questions and Defining Problems
Analyze complex real-world problems by specifying criteria and constraints for successful solutions.

Disciplinary Core Ideas

HS-ETS1-1: Engineering Design
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Crosscutting Concepts

Influence of Science, Engineering, and Technology on Society and the Natural World
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Time Needed

2–3 Hrs.

Background Information

Sometimes, public perceptions of radiation, including its potential to affect living things, can be negative and fueled by events like the tragedy at the Chernobyl reactor site or stories of humans turned into monsters or mutants, as seen in popular comic books and movies. It is important that students understand that radiation exists in many forms. Radiation is around them all the time and in everyday things, such as cell phones, microwaves, smoke detectors, and even bananas! Radiation can be divided into two types: electromagnetic and nuclear. Electromagnetic radiation is pure energy and ranges from low-energy radiation, like radio waves and visible light, to radiation with higher energies, such as UV rays, X-rays, and gamma rays. These types of high-energy radiation are ionizing, meaning that they have sufficient energy to remove electrons from any atomic orbits, creating ions. Ionizing radiation has the potential to disrupt the structure of atoms in molecules, such as DNA, which can be harmful to living things. However, it is important to know that scientists have discovered how these high-energy forms of radiation, such as X-rays and gamma rays, can be harnessed to help solve real-world problems. X-rays have long been used to help diagnose medical problems, and gamma rays can be used in radiotherapy and radiation oncology to target and kill cancer cells.

Another way that the power of ionizing radiation is being used to solve a problem is in controlling diseases carried and spread by Aedes mosquitoes. According to the World Health Organization (WHO), mosquito-borne illnesses cause millions of deaths each year around the globe. Malaria—a pathogen dependent on and transmitted to humans by mosquitoes—is believed to have caused roughly 438,000 deaths in 2015 alone. While pesticides can be used to kill mosquitoes, the chemicals can damage ecosystems and have a negative effect on living things other than mosquitoes. So, instead of killing them directly, scientists have actually begun breeding mosquitoes in labs and releasing them into the wild. This may seem backwards, but these laboratory mosquitoes are not your average insect! Because ionizing radiation, such as gamma radiation, can disrupt DNA, scientists are exposing these mosquitoes to X-rays and gamma rays in a technique called Sterile Insect Technique (SIT) to create a potential solution to this global problem. In SIT, radiation is used to sterilize male mosquitoes, making them unable to produce offspring. When these infertile male mosquitoes are released from the laboratory, they look for females to mate with, but their breeding does not result in offspring. The hypothesis is that over generations, the mosquito population will shrink, reducing the number of illnesses and deaths that are spread by these insects. SIT has been successfully used to target insect pests that harm livestock and crops and is currently used in agriculture. Maintaining a healthy, balanced ecosystem with insects is of course a high priority as well!

Additional information can be found at: https://www.iaea.org/topics/sterile-insect-technique

Key Vocabulary

- **Radiation:** energy emitted in the form of waves or particles
- **Ionizing radiation:** radiation consisting of particles, X-rays, or gamma rays with sufficient energy to cause ionization in the medium through which it passes
- **Gamma rays:** have the shortest wavelengths and the most energy of any wave in the electromagnetic spectrum
- **SIT (Sterile Insect Technique):** a method of using gamma rays or X-rays to sterilize mass-reared insects so that, although they remain sexually competitive, they cannot produce offspring
- **Vector:** an insect that transmits disease

Materials & Equipment

- Copies of the Mosquito-Borne Illness Infographic (one per student)
- Computers or other devices connected to the internet
- Copies of the SIT Country Campaign Research sheet (one per student or one per group)

Procedure

Warm-Up Activity: To open the lesson and activate students' prior knowledge, ask them to complete a short survey on radiation using their devices. Depending on your class size, you can use www.polleverywhere.com or https://www.surveymonkey.com/.

*Prior to having the students answer survey questions, the instructor should create an account and a survey on students' preconceived ideas about radiation. Below is a list of sample questions (some will be YES/NO questions, and some will be open response; the instructor may add or remove questions as they choose):

a. When is radiation harmful?

b. When is radiation helpful?

c. Are you ever exposed to radiation? If so, how often?

d. What are some sources of radiation that you are familiar with?

e. What types of radiation have you heard of?

f. Which of the following types of radiation would you consider dangerous: radio waves, microwaves, infrared waves, visible light, ultraviolet light, X-rays, and gamma rays?

1. After the students have completed the survey, display their answers on the overhead screen. If student devices are not available, the instructor may read the questions to students and ask for a show of hands or allow students to share their answers with the class.

2. To discover what students correctly identified about radiation, show the video, "Is Radiation Dangerous?—Matt Anticole" (approximately 5:20 minutes) https://www.youtube.com/watch?v=zI2vRwFKnHQ&t=176s.

   As students watch the video, encourage them to identify their misconceptions about radiation. What did they already know? What new information did they learn from the video? What was the most surprising thing they learned? What further questions does this make them want to ask? Allow students to share their reactions to the information in the video with the class.

   Key points to emphasize from the video include:

   - There are two major types of radiation: electromagnetic radiation and nuclear radiation.
   - Types of electromagnetic radiation are categorized by wavelength and energy level, with radio waves having the least energy (low frequency) and gamma rays having the most energy (high frequency).
   - Both electromagnetic and nuclear radiation are naturally occurring, and we use and interact with radiation in our daily lives.
   - Radiation is not harmful to us if there is understanding of the energy level and the exposure level if we understand the energy level and exposure level and take necessary precautions.
   - Ionizing radiation has the potential to harm living things by damaging DNA, but is usually only harmful through acute (sudden and severe) exposure, which is rare.
   - We must understand more about radiation so we fear less!

   Distribute **Categorizing Radiation**. Ask students to use information obtained in the video to summarize and organize the different types of radiation. Review responses with students. This will be a helpful resource as they continue with the lesson.

3. Ask students to brainstorm ways that high-energy, ionizing radiation might be used to help people. After students have shared their ideas, show the class the following clips that show how ionizing radiation is used to fight tumors in cancer patients and create beneficial mutations in crops:

a. Using Nuclear Science to Boost Plant Diversity: https://www.youtube.com/watch?v=y4sCyuF4x2E

b. Radiotherapy in 60 Seconds: https://www.youtube.com/watch?v=5XFXKKr0zZU

4. Next, students will learn about the global epidemic of mosquito-borne illnesses. Ask students if they think they know what animal is the deadliest on Earth. Allow students to share their responses with the class, asking them to give the reasoning behind their ideas. To answer this question, play a portion of the following video on the overhead screen: "What's The Deadliest Animal In The World? https://www.youtube.com/watch?v=GRP1I7UPhng (from 0:00–3:17). Explain that the danger mosquitoes pose to humans is because of their role as a biological vector, which is an organism that transmits diseases to other species.

5. **Insect Vectors Jigsaw:** Tell students that next they will conduct research and participate in a jigsaw, where they will share information with each other about the mosquito's unique role in the transmission of pathogens such as dengue, malaria, and the Zika virus through a simple infographic they will create. Their infographic will review various ways that humans have tried to control and eliminate mosquitoes that carry these diseases, and where humans have fallen short, such as in the use of insecticides and increasing drug resistance among pathogens.

6. Break students into six groups of roughly equal size. Each group will become "experts" on one of the following diseases that are transmitted by mosquitoes:

   - Dengue fever: https://www.medicinenet.com/dengue_fever/article.htm
   - Malaria: https://www.medicinenet.com/malaria_facts/article.htm
   - Zika virus: https://www.medicinenet.com/zika_virus/article.htm#what_is_zika_virus
   - Chikungunya https://www.medicinenet.com/chikungunya_virus_infection/article.htm
   - West Nile https://www.medicinenet.com/west_nile_encephalitis/article.htm
   - Yellow fever https://www.medicinenet.com/yellow_fever/article.htm#yellow_fever_facts

   **If they are using devices that have access to the internet, students can find additional information about their mosquito-borne illness by going to* https://www.cdc.gov/az/a.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Faz%2Findex.html *and typing the name of their disease in the search bar.*

   Instruct students to use the link provided (or article, if printed) to them to get started on their research and their infographic. Give each student a copy of the **Mosquito Borne-Illness Infographic** to use when creating their infographic. The teacher may provide colored pencils or markers to add color. Allow students to collaborate with others in their group to ask questions and clarify information about their disease.

   If students have 1-to-1 devices such as laptops or iPads, they may use free infographic maker websites such as Canva (www.canva.com) or Piktochart (www.piktochart.com) to create a digital version of their infographic.

Students' infographics should include the following key aspects:

- In what part of the world is your disease prevalent?

- What species of mosquito carries your disease and how is the mosquito involved in the transmission of your disease?
- Facts and statistics about your disease.
- How have humans tried to control this disease, and how/why have they fallen short?
- Pictures, images, maps, etc. to accompany their information.

7. When students have completed their infographics, ask (or assign) them to form jigsaw groups of six that include one member from each disease group. They should present their infographic to their jigsaw group, explaining the role that mosquitoes play in disease transmission and why they are such a danger to humans.

8. **SIT Mosquitoes!:** Now that students have an understanding of what a huge problem mosquito-borne illnesses are for people, explain that they will be introduced to a technique that scientists have developed that does not involve killing mosquitoes, but instead breeding millions more mosquitoes and releasing them into wild populations! How could this possibly help? Tell students that it involves the power of ionizing radiation that they learned about previously—so SIT and listen!

   Show students the following video, which introduces them to SIT, the Sterile Insect Technique, and how it has been used to control crop pests and other insect populations: How Sterile Insect Technique Helps Fighting The Spread of Mosquitoes and Diseases (https://www.youtube.com/watch?v=RVMAasW5dHc&t=75s).

9. Explain that in the final part of this lesson, students will form small groups that represent countries that face mosquito-borne diseases. They have been asked by the scientists working on SIT to create a campaign that will help garner funding and support for the use of SIT to combat mosquitoes in their country.

   Each group will introduce the specific problem in their country that is related to disease transmission by mosquitoes using research and statistics, and create an interactive 3-D model, animation, or video that explains how the SIT technique uses radiation for sterilization and describes the advantages of SIT over other mosquito control methods.

10. Assign each student group one of the following countries:

    a. Nigeria (Malaria)
    b. Brazil (Dengue)
    c. Thailand (Zika)
    d. Ethiopia (Chikungunya)
    e. Greece (West Nile)
    f. Democratic Republic of the Congo (Yellow Fever)

11. Give each group a copy of the SIT Country Campaign Research Sheet. They should use this sheet to compile important information and arguments for using SIT. While students should use the internet or available articles to research the problem in their country or the history of outbreaks, remind them that there are experts in their class available to discuss specifics about various mosquito-borne illnesses. (Infographics created earlier in the lesson can be a source of information as well as information for campaigns as well. They can be shared digitally, as hard copies, or hung around the classroom.)

12. When their research is complete, students should choose how they would like to present information in their campaign to garner support for SIT from the public in their country. Options could include making a 3-D interactive model that can be used to demonstrate how ionizing radiation is used in a laboratory to sterilize male mosquitoes, creating an animation (using free online sites such as www.animoto.com), or filming a brief informational video that explains the SIT procedure and its benefits over other methods of controlling or eradicating mosquitoes.

13. These visual representations and explanations of SIT and its benefits for a community and environment can be paired with other information on the group research sheet to create a country campaign presentation that will give citizens information

about why they should support the sterilization of mosquitoes to eradicate mosquito-borne illnesses in their country. Groups can present their campaigns to the whole class for feedback if time allows.

Extension Activity

As an extension of this lesson, students can further explore the importance of using SIT closer to home by looking at the number of mosquito-borne illness cases reported in the United States. They can use this data, along with population data, to calculate the rate of infection for various diseases discussed in the lesson in the United States or individual states.

Students can go to the Centers for Disease Control (CDC) Disease Case Counts Widget (https://www.cdc.gov/widgets/diseaseandconditions/data-maps.html) and use the drop-down menu to search for specific mosquito-borne illness incidences in the United States. They can then find current US populations or current state populations on the World Population Review website (http://worldpopulationreview.com/states/).

The formula for calculating the rate of infection is:

$$\text{Rate of infection} = K\left(\frac{\text{(Number of infections)}}{\text{(Number of those in a population that are at risk of infection)}}\right)$$

The constant, K, is an assigned value. Using a constant of 100 gives the infection rate as a percentage.

Through this extension activity, students may be surprised at the number of incidences of diseases that have cropped up in the US. They can then compare the rate of transmission in the US to those of other countries, discussing reasons for differences in the rates.

Name: _____

STUDENT HANDOUT

Categorizing Radiation

We know that radiation is all around us. It might come from natural sources, like the sun, or it might come from human-made sources, like the EMF radiation from your cell phone. All radiation is broken up into two kinds ionizing and non-ionizing. Use the descriptions in the chart below, and information obtained in the video shown by your teacher to sort the types of radiation.

Radio

High Ultraviolet

Microwave

X-ray

Gamma ray

Nuclear Radiation

Low Ultraviolet

Visible

Infrared

Non-Ionizing Radiation	**Ionizing Radiation**
Non-ionizing radiation is longer wavelength/lower frequency/ lower energy. This type of radiation does not carry enough energy to break molecular bonds and ionize atoms.	Ionizing radiation is short wavelength/high frequency/higher energy. This type of radiation carries enough energy to break bonds between molecules and ionize atoms.

Name: _____

STUDENT HANDOUT

Mosquito-Borne Illness Infographic

Name of Disease, and Type of disease (virus, parasite, etc.)

Area(s) of World Affected

Symptoms

Species of and Method of Transmission by Mosquito

Facts and Statistics

Attempts to Control or Eradicate Disease

Name: _____

STUDENT HANDOUT

SIT Country Campaign Research Sheet

History

Describe your country's history with mosquito-borne diseases.

- What are some of the major outbreaks the country has faced?
- What are some of the statistics linked to mosquito-borne diseases in your country? (i.e., number of people affected, number of deaths, etc.)

Fighting Disease

How did the country try to eradicate mosquito-borne illnesses?

- What strategies or actions did the country take to help combat the continued spread of diseases?
- In what ways were these strategies or actions successful?
- In what ways did these strategies or actions fail or need improvement?

Name: _____

STUDENT HANDOUT

SIT Country Campaign Research Sheet

Sterile Insect Technique (SIT)

In your own words, how does SIT work?

- Describe the methods used in this technique.

Why use SIT over other methods?

- What benefits does SIT have over other methods of insect or disease eradication?
- Include any evidence to support this from studies or collected data..