PreMiEr
Precision Microbiome Engineering
NSF Engineering Research Center

This lesson plan was created by a teacher participating in the Research Experiences for Teachers (RET) program from the Precision Microbiome Engineering Research Center. Are you interested in spending part of your summer in a lab getting paid to do microbiome research and create lesson plans?

Learn more here: https://premier-microbiome.org/for-teachers-ret/

Lesson Plan created by Raymond Fournier

Waves at Work: Exploring EM Tech Through Research and Lab

Overview

In this engaging three-part lesson, students explore how electromagnetic (EM) waves are used in real-world technologies. Through group research presentations, a UV sterilization lab, and an article-based analysis of Far-UVC light, students investigate how waves are transmitted and detected by various technologies that enhance our everyday lives. This lesson emphasizes student-led inquiry, scientific communication, collaborative data analysis, and application of real-world science. It is ideal for classrooms focused on active learning, scientific literacy, and cross-disciplinary skills.

Key Search Words

Physical Science, Electromagnetic Spectrum (EMS), Waves, EM Wave-Based Technology, UV Light, Far-UVC, Middle School Science, High School Science, Project-Based Learning, Hands-On Lab, Science Literacy

Learning Objectives

By the end of this lesson, students will be able to:

1. **Identify and describe** the seven regions of the electromagnetic spectrum, including key properties like wavelength and frequency.

2. **Research and explain** how real-world technologies use different regions of the EM spectrum to transmit or detect information or energy.

3. **Create and deliver** a group presentation that communicates scientific information about one part of the EM spectrum and a related technology.

4. **Conduct a lab investigation** using ultraviolet light to analyze its effectiveness in killing bacteria and collect measurable data.

5. **Construct a graph** to show the relationship between UV exposure time and bacterial growth, and use it to draw a scientific conclusion.

6. **Read and interpret** a scientific article about Far-UVC light and summarize how it works and how it differs from traditional UVC sterilization.

7. **Answer comprehension and analysis questions** to demonstrate understanding of how Far-UVC light may be used as a safe alternative in microbial control.

Curriculum Alignment

North Carolina Essential Standards:
PS.PSc.8.4: Obtain, evaluate, and communicate information to explain how instruments that transmit and detect waves are used in everyday life.

Classroom time required

Total Time: **150–210 minutes (4 Class Periods)**

Part 1 – EM Spectrum Research & Presentations
Time: 60–90 minutes

- Group research and Google Slides creation
- Group presentations and class discussion
- The teacher prepares *E.coli* (K-12 strain) Overnight Culture

Part 2 – UV Sterilization Lab
Time: 60–90 minutes (divided over two consecutive days)

- Lab setup, plating *E. coli*, UV exposure, and incubation
- CFU count, data collection, graphing, and analysis

Part 3 – Far-UVC Reading & Quiz
Time: 30 minutes

- Reading assignment, guided questions, and quiz

Sample Block Schedule (90-minute periods)

Day 1

- Part 1 – EM Spectrum Research & Presentations
    - Group research and Google Slides creation (90 min)
    - The teacher prepares *E.coli* (K-12 strain) Overnight Culture

Day 2

- Part 1 (continued) – Group presentations and peer notes (45 min)
- Begin Part 2 – UV Sterilization Lab
    - Lab setup, plating, UV exposure, and incubation (45 min)

Day 3

- Part 2 (continued) – CFU count, data collection, graphing, and analysis (45 min)
- Class discussion about the lab results and analysis questions (20 min)
- Begin Part 3 – Far-UVC Reading Assignment and Guided Questions (25 min)

Day 4

- Part 3 (continued) – Class discussion and Quiz (30 min)

Materials & Technology

Part 1 – EM Spectrum Research & Presentations

- 7 Computers (1 per group), an Internet connection, and Google Slides
- Class set of the "EM Spectrum Presentation Instructions and Peer Notes Handout"

Part 2 – UV Sterilization Lab

- Class set of the "UV Sterilization Lab Handout."
- Class set of Lab Safety Goggles
- Nitrile Disposable Gloves
- *E.coli* Culture (K-12 strain) (freeze-dried)
- Rehydration Medium (ex., Luria Broth Agar)
- 1 Inoculating Loop (10µL)
- 1 Glass Flask (50ml) with lid
- Incubator (able to maintain 37°C)
- 1 Adjustable Single Channel Pipette (100~1000µL)
- Filtering Pipette Tips (1000uL)
- 7 Pre-poured Petri Dishes/Plates with Luria Broth Agar
- 7 L-Type Disposable Sterile Cell Spreaders
- UV Light Sanitizer Box (254 nm)
- 7 Stopwatches
- 7 Magnifying Glasses
- 7 Sharpie Permanent Markers (Ultra Fine Tip)
- Sanitizing solution (for teacher)
- Biohazard bags

Part 3 – Far-UVC Reading & Quiz

- Class set of the "Far-UVC reading document"
- Class set of the "Far-UVC Reading Comprehension Questions"
- Class set of the "Far-UVC Reading Quiz"

Safety

This lesson includes a lab investigation using *E. coli* K-12 and UV-C (254nm) light. Follow standard lab safety protocols and review expectations with students beforehand.

- Use only **non-pathogenic *E. coli* (K-12 strain**) (Biosafety Level 1).
- Students must **wear gloves and lab safety goggles** at all times during the lab.
- Do not allow students to **open Petri dishes after they have been incubated**.
- Dispose of all materials (used Petri dishes, cell spreaders, gloves, etc.) in a **biohazard bag**; follow your school district's procedure for either biohazard waste pickup or sanitation.
- **UV exposure must occur in a closed UV cabinet**; students should never view or handle UV light directly.
- The **teacher controls UV equipment** and exposure time.
- Ensure students **wash their hands** and clean work areas before and after the lab.
- The teacher should sanitize work areas after the lab using a preferred sanitizing solution (e.g., 3% Hydrogen peroxide, 10% Clorox solution, 70% Ethanol).

Teacher Preparation for Activity

Day Before Day 1:

1. Copy a class set of the “EM Spectrum Presentation Instructions and Peer Notes Handout.”
2. Have seven computers available, one for each group.
3. Prepare the E.coli Culture according to the supplier's instructions. Freeze-dried bacterial samples require around 24 hours to reactivate when incubated at 37 °C. Begin the process the day before Day 1 so that it is ready by Day 2.

Sample Procedure for Preparing Freeze-Dried E.coli Culture
Materials Needed:

- Lab Safety Goggles
- Nitrile Disposable Gloves
- Sanitizing Solution
- E.coli Culture (K-12 strain) (freeze-dried)
- Rehydration Medium (ex., Luria Broth Agar)
- 1 Inoculating Loop (10µL)
- 1 Glass Flask (50ml) with lid
- Incubator (able to maintain 37°C)

Procedure:
Before starting this protocol, prepare your lab area. Spray sanitizing solution liberally, then wipe down after 5 minutes of contact time.

1. Sterilize a 50 ml glass flask and lid in the UV Sanitizer Box.
2. To the sterile flask, add 10 mL of BHI Broth.
3. Thaw the frozen secondary stock of the bacteria.
4. Combine a loopful of the secondary stock with the 10 mL of BHI broth.
5. Secure a sterile lid on the flask.
6. Incubate the culture in an incubator at 37°C for 18 - 24 hours.

Before Day 2:

1. Set up materials for the UV Sterilization Lab
2. Copy a class set of the “UV Sterilization Lab Handout.”

Before Day 3: Copy a class set of the “Far-UVC reading document” and the “Far-UVC Reading Comprehension Questions”

Before Day 4: Copy a class set of the “Far-UVC Reading Quiz.”

Procedure

Part 1 – EM Spectrum Research & Presentations

Day 1 – Research & Preparation

1. As students enter the classroom, have them **pick up the “EM Spectrum Presentation Instructions and Peer Notes Handout.”**

2. **Organize** students into **seven project groups**, ensuring that each group has access to at least **one internet-enabled device** for research.

3. **Assign each group a different region** of the **Electromagnetic (EM) Spectrum** to research.
4. **Review the project directions and grading rubric** with the class to clarify expectations for both content and presentation quality.
5. Allow students the **remainder of the class period** to research and create their **Google Slides presentation**.

Day 2 – Presentations

1. Each group will **present their Google Slides project** to the class.
   ➢ **Every group member must contribute** to the oral presentation.
2. While groups are presenting, instruct the rest of the class to:
   - **Take detailed notes** using their **"EM Spectrum Presentation Instructions and Peer Notes Handout."**
   - **Engage actively** by listening for key takeaways from each region within the spectrum.
3. **Tip**: Inform students that content from all group presentations **will be included on the next unit test.**
   ➢ This will encourage them to take high-quality notes and remain attentive.

Part 2 – UV Sterilization Lab Instructions

Day 1 – Lab Setup and UV Exposure

1. As students enter the classroom, have them **pick up the "UV Sterilization Lab Handout."**
2. **Organize** students into their **seven lab groups**.
3. **Review lab safety rules** and procedures from the handout with the entire class.
4. Instruct students to wash their hands with soap and water, and then **put on lab safety goggles and gloves** before handling any materials.
5. Have each group collect the following lab materials:
   - Pre-poured Petri Dish
   - L-type disposable sterile cell spreader
   - Ultra-fine-tipped Sharpie permanent marker
   - Stopwatch
   - Magnifying Glass

6. Students **label the lid of their Petri dish** using the Sharpie with:
    - Group number
    - The UV exposure time assigned to their group found in the **"UV Sterilization Lab Handout."**
7. The teacher retrieves the **prepared E. coli culture** solution from the incubator and sets up a **dispensing station**.
8. **One student per group** brings their labeled Petri dish to the dispensing station:
    - The students will remove the petri dish lid.
    - The teacher then dispenses **100µL of E. coli** solution using a 100–1000µL adjustable pipette with a filter tip.
    - The students then recover the petri dish with the lid and return to their lab area.
9. The teacher **demonstrates how to spread-plate** by evenly spreading the dispensed E. coli culture solution using the sterile L-Type cell spreader to create a thin layer of the **bacterial solution over the entire surface of the agar inside the petri dish.**
10. Students evenly spread-plate the culture across the entire agar surface using the sterile L-Type cell spreader.
11. **The L-type cell spreaders and pipette filter tips must be disposed of in a Biohazard bag**.
12. Groups then take their **covered, labeled dishes** and a **stopwatch** to the **UV Light Sanitizer Box (254 nm)** station.
13. **One group at a time**,

- The teacher uncovers the dish and places both the dish and the lid inside the UV box
- The teacher then turns on the UV Light Sanitizer box while the students use their stopwatches to **time the assigned UV exposure.**
- The teacher removes the dish and replaces the lid and places the **covered dishes upside down** (to control condensation) in a **37°C incubator for 18–24 hours**.

13. After the lab, **the teacher will sanitize all work surfaces** using their preferred sanitizing solution (eg. 3% hydrogen peroxide, 10% bleach, or 70% ethanol.) while **the students…**
    - **Return their lab safety goggle,**
    - **Throw away their gloves in a biohazard bag**
    - **Thoroughly wash their hands with soap and water**.

Day 2 – Observations and Data Analysis

1. Organize the students back into their **original lab groups**.

2. **Review safety guidelines and Day 2 instructions** from the lab handout.

3. Have the Students **wash their hands** and put on **goggles and gloves** again.

4. The Teacher removes the Petri dishes from the incubator and **distributes them** to each group. The Teacher will also distribute a magnifying glass to each group.

5. **The Teacher will demonstrate how to count Colony Forming Units (CFUs):**
   Procedure**:**
   - Turn the dish upside down.
   - Use a magnifying glass to count each bacterial colony-forming unit (dot).
   - Draw a dot over each one on the back of the petri dish with an ultra-fine-tipped Sharpie to avoid double-counting.

6. The Students will then count their CFUs and **record their results** in their data table.

7. The Teacher facilitates a **whole-class data share**, filling out the **Class Data Table** found in the **"UV Sterilization Lab Handout."**

8. Students then:
   - **Graph the class data**
   - **Complete analysis questions** in the lab handout

9. After the lab, **the teacher will…**
   - **Sanitize all work surfaces** using their preferred sanitizing solution (eg. 3% hydrogen peroxide, 10% bleach, or 70% ethanol.)
   - Collect all covered petri dishes and use Parafilm to seal each of them.
   - Throw away the sealed petri dishes in a biohazard bag.

10. While **the students…**
    - **Return their lab safety goggle,**
    - **Throw away their gloves in a biohazard bag**
    - **Thoroughly wash their hands with soap and water**.

11. Class discussion about the lab results and analysis questions

Part 3 – Far-UVC Reading & Quiz

1. Hand out the **"Far-UVC reading document"** and the "**Far-UVC Reading Comprehension Questions"** to each student.

2. Students will **read the article with the help of the attached comments pages** and **answer the reading comprehension questions**.

3. When everyone has finished, go over the answers to the questions with the class.

4. Students will take a **quiz** based on the reading comprehension questions that were covered in the lesson.

Differentiation

To make the "Far-UVC reading document" more accessible for students with lower reading levels, I utilized Adobe Acrobat's Comment function to add helpful comments throughout the reading, defining key terms, explaining complex concepts, and posing reading comprehension questions.

Assessment/Check for Understanding

1. Google Sides Oral Presentation will be assessed using the project rubric included in the "EM Spectrum Presentation Instructions and Peer Notes Handout."
2. The UV Sterilization Lab will be assessed by verifying that students have completed the lab handout with a well-constructed graph.
3. The Far-UVC Reading will be assessed by a reading comprehension quiz.