Theme

How can citizens innovate, manage, and use technology in ways that are socially responsible?

STEM Innovation Academy Unit 1

Subject: Medical Interventions Unit Title: How to Fight Infection Grade: 11	Teacher: Jonathan Lerner Duration: 9 weeks

Summary of Unit

Unit 1 introduces students to the fictional eighteen-year-old Sue Smith and her parents, Mr. and Mrs. Smith. Sue, a college freshman, is taken ill with what she mistakenly believes is a cold. Throughout the unit students will learn by acting as pathologists and eventually diagnose Sue by studying the nature of infectious diseases, antibiotics and the resistance to them, hearing impairment, and by running diagnostic tests, testing their predictions, and analyzing the results. The diagnosis of Sue Smith will involve students learning the science behind, as well as how to run tests and interpret data (where relevant) on the following: (1) antibody-based Enzyme-Linked Immunosorbant Assay (ELISA), (2) antibacterial treatment and the evolution of resistance, (3) hearing loss, (4) the physics of sound, (5) ear anatomy and physiology, (6) cochlear implants, (7) the ethics of medical intervention, (8) the mechanics of vaccine effectiveness, (9) vaccine production, (10) engineering of a paper plasmid to create a vaccine-capable viral protein, (11) epidemiology as a field, and (12) managing a potential outbreak.

Lesson 1.1
Lesson 1.1 will involve students working in small groups to analyze the physical exams and medical histories of patients. This will require the students to sequence DNA from body fluids and test the sequences using ELISA and a genetic database to identify the pathogen.

Lesson 1.2
During Lesson 1.2 students will review the structure of bacteria to understand the mechanisms by which bacteria are able to transmit their genes laterally. They will then research several types of antibiotics and the devices by which they hinder bacteria. The students will apply their knowledge by recommending a course of treatment for Sue Smith that they believe will be most effective. The lesson will conclude by exploring the phenomenon of antibiotic resistance and its increasing prevalence.

Lesson 1.3
Lesson 1.3 is centered around hearing loss. Students will begin by investigating the physics of sound, and how our ears function as sensory organs. Additionally, students will conduct hearing assessments, followed by being assigned a case study of a patient with a specific type of hearing loss. Through their case study students will gather information on how different parts of the ear can become damaged, resulting in reduced ability to hear. By interpreting audiograms students will learn how to diagnose different types of hearing loss, and suggest an appropriate intervention for their case study. Lastly, students will investigate cochlear implants from the perspective of medical science and medical ethics, the latter of which will be used as a debate topic.

Lesson 1.4
The final lesson in Unit 1 deals with vaccination. The lesson will begin with students discussing how the advent of vaccines has influenced public health. This will lead into students interpreting disease trends and how they have been shaped by vaccination. Research will be done into how the immune system functions and how vaccines interact with the immune system. Next, students will study the techniques used by scientists to synthesize vaccines, then will mimic some of the processes involved by engineering a paper plasmid for production of a vaccine. The unit will close with students acting as epidemiologists to identify and design all of the steps required for preventing and controlling a disease outbreak.

Stage 1 – Desired Results

Essential Questions:

Lesson 1.1

- What is a medical intervention?
- What are the main categories of interventions that function to maintain human health?
- How do scientists gather evidence during the potential outbreak of an infectious disease?
- What is bioinformatics?
- How can DNA sequences be used to identify disease pathogens?
- What is an antibody?
- How do antibodies identify and inactivate antigens?
- How can the ELISA assay be used to detect disease?
- Why is it important for doctors to know the concentration of disease antigen present in a patient's system?
- What steps do scientists take to diagnose, treat, and prevent future spread of a disease outbreak?

Lesson 1.2

- How do antibiotics work to fight bacterial infections?
- What methods do bacteria use to share antibiotic resistant genes?
- What actions are humans taking that are contributing to bacteria becoming resistant to commonly used antibiotics?

Lesson 1.3

- How do frequency and amplitude affect how humans interpret sound?
- What causes different types of hearing loss?
- How is hearing loss diagnosed?
- What interventions are available for patients with hearing loss?
- What are the bioethical concerns related to the use of cochlear implant technology?

Lesson 1.4

- What is vaccination?
- How does a vaccine activate the body's immune system?
- How has vaccination impacted disease trends in our country?
- What methods are used to produce vaccines in the laboratory?
- What is recombinant DNA technology?
- What are the molecular tools used to assemble recombinant DNA?
- How can recombinant DNA and bacterial cells be used to produce vaccines?
- How can engineered plasmids be inserted into bacterial cells?
- What is epidemiology?
- How can epidemiologists assist with the detection, prevention, and treatment of both chronic and infectious disease?

Objectives:

Lesson 1.1

- List medical interventions to create a classroom display.
- Group common medical interventions into categories.
- Maintain notes of an outbreak investigation.
- Create a graphic organizer displaying connections between individuals in a disease outbreak.
- Use publicly available molecular databases to search for DNA sequences and identify pathogens.
- Build a model or draw a diagram that illustrates how ELISA can be used to detect disease.
- Computer serial dilutions and calculate resultant concentrations.
- Perform ELISA testing to determine the concentration of infectious bacteria in simulated body fluids and identify infected patients.
- Write a report summarizing the multi-step process followed to investigate an outbreak of bacterial meningitis.

Lesson 1.2

- Draw and label a diagram of a bacterial cell.
- Research the method of action for different classes of antibiotics.

- Use proper laboratory techniques to “mate” a streptomycin resistant strain of E. coli with an ampicillin resistant strain of E. coli.
- Design and construct a 3D model that demonstrates one of the pathways through which bacterial cells transfer genes.
- Use a model to simulate the effects of antibiotics on the population of bacteria during an infection.

Lesson 1.3
- Create a 3D model of the structures of the ear.
- Give a short presentation to describe the type of hearing loss explained by a patient.
- Demonstrate hearing loss on the model of the ear.
- Perform several simple hearing tests.
- Trace the pathway of sound.
- Match up audiograms with their corresponding patients with hearing loss.
- Recommend the most appropriate type of intervention for a patient with hearing loss.
- Write a letter from the opposing perspectives of an adult deaf person expressing his or her reasons for choosing to get a cochlear implant versus an adult deaf person expressing his or her reasons for choosing not to get a cochlear implant.

Lesson 1.4
- Interview people from different generations about the vaccination history and organize findings in a graphic organizer.
- Design a user-friendly vaccination schedule for the parents of a newborn.
- Produce a concept map outlining the laboratory processes used to generate vaccines.
- Engineer a paper plasmid to include the genetic code necessary to produce a vaccine.
- Assume the role of an epidemiologist and complete four tasks to showcase their skills as a professional.

Standards/Outcomes:

NGSS - Performance Expectations
- HS.LS1.1 - Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells. (Lesson 1.1, 1.2)
- HS.LS1.2 - Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. (Lesson 1.1, 1.2, 1.3, 1.4)
- HS.LS4.2 - Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment. (Lesson 1.2)
- HS.LS4.4 - Construct an explanation based on evidence for how natural selection leads to adaptations of populations. (Lesson 1.2)
- HS.LS4.5 - Evaluate the evidence supporting the claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
- HS.PS4.1 - Use mathematical representations to support a claim regarding the relationship among the frequency, wavelength, and speed of waves traveling in various media. (Lesson 1.3)

NGSS - Disciplinary Core Ideas
- LS1.A
- LS3.A
- LS4.A

Stage 2 – Assessment Evidence

Performance Task(s)/Authentic Experiences:

Lesson 1.1
- Medical Intervention Inventory
- Smith Family Tree
- Investigating an Outbreak
- Using DNA To Identify Pathogens
- ELISA Lab

Lesson 1.2
- Attack of the Superbugs Lab
- When Antibiotics Fail

Lesson 1.3
- Good Vibrations
- Can You Hear Me Now?
- Cochlear Implant Debate

Lesson 1.4
- Disease Prevention through Vaccination
- Vaccine Development
- Life of an Epidemiologist

Unit Pre-Assessment:
- Last lab report from HBS
- HBS EOC score

Extensions (Tier I):
- Optional activities
  - What's the Concentration?
  - Which Antibiotic is the Best Choice

Differentiation (Tiers 2 and 3):
- Selective grouping
- Extended time
- Small groups/Individual instruction
- Options for potential research websites/videos/animations

Stage 3 – Learning Plan

https://pltw.read.inkling.com/a/b/43d63de35c894eada4e5e54487f3a0bd/p/08e78af65fd744e59a5079e0963b5bae *(Password Protected)*

Key Terms:

Lesson 1.1
- medical intervention
- outbreak
- pathogen
- bioinformatics
- genomes
- antibody
- antigens
- concentration
- solvent
- solute
- solution
- Enzyme-Linked Immunosorbant Assay (ELISA)
- enzyme
- serial dilution

Lesson 1.2
- antibiotics
- nucleoid
- plasmid
- antibiotic resistant
- conjugation

- transformation
- transduction

Lesson 1.3
- sound
- outer ear
- middle ear
- inner ear
- sensorineural hearing loss
- audiogram
- cochlear implants

Lesson 1.4
- vaccine
- vaccination
- recombinant DNA
- restriction enzyme
- epidemiology
- epidemic
- cohort study
- case-control study

Expert/Field Experience(s)

Literacy Connections/Research