Action Proposal

Emerging Pathogens Unit with Culminating Qualitative Analysis of MRSA using MRSA Select Plates

Brett Stubbs

MYP and DP IB Science Educator

Suncoast High School

1717 Avenue S

Riviera Beach, FL 33404

Abstract

As technology has advanced new and interesting techniques have been developed within the sciences in order to record and analyze data. This has allowed us to answer questions and develop solutions to problems that we had no way of addressing before. Biotechnology has allowed everything from the creation of hunger reducing GMO crops, insulin generating bacteria, qualitative analysis of evolutionary relationships form gene sequencing, and detection/vaccination against many emerging pathogens. In the classroom, this information is often delivered only as lecture or readings without the injection of energy from actually working with biotechnology. Students are known to become more engaged and retain more information when they are participating in effectively designed hands-on labs. Over this proposed unit we will emphasize these lab techniques and discoveries through kinesthetic participation rather than teacher directed lessons. Surprisingly, these techniques are basic and can teach student universal lab skills which can be carried on to college and professional careers.

Rationale

This unit is targeted at 9th grade Honors Biology and will incorporate State Standards and education extensions to give relevance and scope to the content. The rationale behind this action proposal is to incorporate the use of biotechnology techniques within the context of threatening emerging pathogens like MRSA. This unit will tie together multiple units of instruction from evolution of the MRSA, to biotechnology and its applications, prokaryotic cell structure, and human impacts upon their environment. This will not only cover critical science content for EOC assessment but provides students the invaluable time with real biotechnology equipment. In addition, students gain knowledge about prevention and research about many important pathogens that impact them directly and other areas of the world to a great extent. The idea behind this is to ignite the students mind about this topic so that they will move forward in their education prepared to answer their questions.

Description

This action proposal will outlay a unit that focuses on the immune system and emerging pathogens that have large impacts upon society. Students will begin by investigating the human immune system, the three layers of the immune system, antibodies versus antigens, and how the cell-specific immune system functions. With this basis students will make small group projects to learn about different types of pathogens that exist. They will research their pathogen and then through a speed dating jigsaw format, they will present their information to their peers with enthusiasm. This will ensure that each student is educated about each disease without having to the research individually each pathogen.

Standards and Learning Objectives

The student will be able to…

1. Illustrate what SA is and its impact upon health and society SC.912.L.14.6: Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.

2. Draw and label a prokaryotic cell and identify SC.912.L.14.3: Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells.

3. Evaluate the use of antibiotics and the increase of bacterial resistance SC.912.L.14.52: Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics.

4. Apply evolutionary mechanisms to the emergence of new diseases SC.912.L.15.13: Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success.

5 . Explain transduction and its influence upon the development of MRSA SC.912.L.16.7: Describe how viruses and bacteria transfer genetic material between cells and the role of this process in biotechnology.

6. Assess the tools and techniques used within class in evaluating the presence or absence of MRSA in patients SC.912.L.16.10: Evaluate the impact of biotechnology on the individual, society and the environment, including medical and ethical issues.

Day 1-Immune System and You

- Bellwork: Ask your neighbor what disease they have had? How did they get them? Did you spread them? Why did you get better? Any cool examples? (After initial bellwork, each bellwork will be used for *Hotzone* discussion.)
- Immune System- Your Body's Castle Lecture 3 Levels of Defense
- Antibody versus Antigen-Uniforms and Swords
- Mode of Transmission Lab- Use Glogerm to demonstrate the effectiveness of disease spread and identify modes of transmission using class discussion
- B-Cell Versus T-Cell Graphic Organizer
- The Hot Zone- Reading Hook at the end of class

Day 2- Exploring Microbes- What's Growing on You?

- Bell Work- Hotzone Discussion 1

- Comparing Bacteria, Protozoa, and Viral Structure Coloring/Drawing Exercise
- Stop Picking Your Nose- Pouring Agar Plates
- Giant Microbes Research and Poster Project- Allow to students to select and detail project
- Individual Research Time

Day 3- MRSA- Impacts of Modern Medicine on the Evolution of Superbugs

- Bell Work- Hotzone Discussion 2
- MRSA- Introduction and Evolution Lecture
- Stop Picking Your Nose Lab- Sterile technique Demo and Microbe Swapping MRSA Inquiry Lab
- MRSA Evolutionary Tag Game

Day 4- Giant Microbes Dating Game

- Bell Work- Hot Zone Discussion 3
- Contagion Movie Segment 1- Movie Question Sheet
- Stop Picking Your Nose - Results and Discussion of Article
- Giant Microbes Speed Dating Presentations

Day 5- Designer Plates and Social and Technological Side of Pathogens

- Bell Work- Hot Zone Discussion 4
- Designer Plates- Micro Pipetting Lab
- Contagion Movie Segment 2- Movie Question Sheet
- Impacts of Society, Trade, and Industrial Revolution on Emerging Pathogens Activity

Day 6-Zoonoeses and Wrap- Up

- Bell Work- Hot Zone Discussion 5 Wrap-Up
- Zoonoses- Animals and Pathogens Working Together Lecture
- Group Jeopardy Review

Day 7

- Summative Formal Assessment of Immune System and Pathogens Unit

Data Collection

Data collection for this unit will consist of several forms of summative and formative assessment both formal and informal. The students "speed dating" posters will serve as a formative assessment to ensure the students understand the concepts of viruses versus cells, the methods of transmission, range of the disease, impacts of the pathogen, and possible treatments/ preventative methods. The students' lab results will count as a significant technical and application grade. They must demonstrate proper lab technique throughout the data collection and analysis process. In addition they must do a small write up with the lab which will ask them to analyze the MRSA testing results and effectiveness. A final assessment will be a formal summative test for the unit on the immune system, pathogens, and laboratory technique. This test will consist of both multiple choice and free response questions that allow the students to demonstrate their knowledge. I will analyze the results and ensure that students have met the learning goals identified above

Budget

The budget for this project will be supplied by the grant from CPET at the University of Florida in combination with additional classroom funds from the school. The principle and instructor will also petition if additional funds or resources are necessary to ensure complete coverage of all the students. Attached is an itemized list of the materials that will be required by the teacher to administer the unit.

Item	Quantity	Total	Source
Glo-Germ Powder	2	43.70	Amazon
McCoy Innoculating Loop	10	25.00	Amazon
UV Flashlight Blacklight	4	31.80	Amazon
23g Dehydrated Nutrient Agar	5	64.75	Amazon
American Educational Plastic Culture Petri Dish, 70mm Diameter (Bundle of 100)	2	52.52	Amazon
PYREX 500mL Narrow Mouth Erlenmeyer Flasks with Heavy Duty Rim, 6/pk	1	31.47	Amazon
Giant Microbes Stuffed Toys	30	Rented for No Cost	CPET at UF
Staphylococcus aureus (coagulase positive), MicroKwik Culture®, Pathogen, Vial	2	31.00	Carolina Biological
MRSASelect 20 x 90 mm chromogenic culture plates	3	320.00	BioRad

for direct identification of methicillin-resistant Staphylococcus aureus (20 plates)			
Total Amount of Funds Necessary	N/A	599.24	N/A

Literature Cited

Using Quick MRSA Testing- http://general-medicine.jwatch.org/cgi/content/full/2008/513/1

MRSA Plates - http://www.biorad.com/prd/en/US/adirect/biorad?cmd=BRCatgProductDetail&isFromSearch=true&entryPoint=adirect&catID=M4T0AB4VY&vertical=CDG&messageType=BRCatgProductDetail&parentCategoryGUID=M4SZHV15

Evaluation of MRSA Plates- http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2884491/

Preston, Richard (1995-07-20) [1994]. The Hot Zone, A Terrifying True Story. Anchor Books (Random House), Sagebrush Education Resources, Tandem Library Books. ISBN 0-385-47956-5.

Contagion- September 9, 2011 (USA)

Applications of Real-Time PCR Testing-http://cmr.asm.org/content/19/1/165.full

Gel Electrophoresis Virtual Lab- http://learn.genetics.utah.edu/content/labs/gel/

Emerging Pathogens Talk- Dr. J. Glenn Morris Director of the UF EPI

Red Rover, Red Rover, Send MRSA Over!!!!

Content Topic(s) Bacteria and Antibiotic Resistance
Target Grade Level(s) (9-12)
Specific Subject Honors Biology

OBJECTIVES

Within this lesson, students will learn about the new emerging pathogen threats that are much closer to home then they realize. As our world has developed new technologies, the mechanisms behind the evolution, emergence, and spread of diseases like Methicillin Resistant Staphylococcus aureus or MRSA. SA is a common prokaryotic Eubacteria that lives on the surface of our skin. If a wound is exposed to this pathogen, it can cause severe infections which can spread via the body's circulatory systems. In order to treat this disease, doctors prescribe antibiotics which will kill off most of the infection if taken correctly. The remaining pathogens are resistant to the antibiotics if not eliminated from the immune system can cause a secondary infection.

As humans develop and used antibiotics, the bacteria have evolved resistance to its effects. This is because you are essentially artificially selecting for resistance within the bacteria. Bacteria are also very genetically dynamic because they have modes of horizontal gene transfer. MRSA has become a big issue because we have limited ways to treat it. If students can understand the mechanism behind the transmission and creation of antibiotic resistant, they will be better prepared to treat against it in the future.

The student will be able to…

1. Illustrate what SA is and its impact upon health and society SC.912.L.14.6: Explain the significance of genetic factors, environmental factors, and pathogenic agents to health from the perspectives of both individual and public health.
2. Draw and label a prokaryotic cell and identify SC.912.L.14.3: Compare and contrast the general structures of plant and animal cells. Compare and contrast the general structures of prokaryotic and eukaryotic cells.
3. Evaluate the use of antibiotics and the spread of antibiotic resistance SC.912.L.14.52: Explain the basic functions of the human immune system, including specific and nonspecific immune response, vaccines, and antibiotics.
4. Apply Darwin's theory of evolution to the rise of MRSA SC.912.L.15.13: Describe the conditions required for natural selection, including: overproduction of offspring, inherited variation, and the struggle to survive, which result in differential reproductive success.
5 . State how antibiotic resistance can be spread by horizontal gene transfer SC.912.L.16.7: Describe how viruses and bacteria transfer genetic material between cells and the role of this process in biotechnology.

MATERIALS

Teacher Materials:
Hotzone Discussion Questions
MRSA Lecture PowerPoint (Adapted from Dr. Morris)
6 Traffic Cones
Red and Green M&M Candies
Two Bowls
Red and Green Stickers
26 index cards with Bacteria picture (Half Semicircle Convex and Half Triangle Convex)
26 index cards with Eukaryote picture (Half Semicircle Concave and Half Triangle Concave)
Incubator

Student Materials:
Student Materials (Per Lab Group of 4 Students):
3 Petri Dishes with Nutrient Agar (Prepared Previously)
1 MRSA Select Plate with Selective Agar
Inoculating Loop
4 Cotton Swaps (Sterile)
Stop Picking Your Nose Lab Data Sheet
Small cup of sterile water

PROCEDURE AND DISCUSSION QUESTIONS

1. Bellwork- (10 minutes)
    - ❖ Students will form small groups of 2 or 3 students. They will follow and answer the discussion questions provided by teacher on the board for the second segment of their reading of the Hotzone.
2. Introduction Lecture- (15 minutes)
    - ❖ Review Bacteria Structure.
    - ❖ Introduce Staphyloccus aureaus and its health risks, show gross pictures.
    - ❖ Do you think it's on your right now? (Poll Students)
    - ❖ Explain its prevalence upon the body and symbiosis of bacteria.
    - ❖ How do we treat bacterial infections? (Wait for Antibiotic Response, Probe if necessary)
3. MRSA Evolutionary Tag Game (30 minutes)
    - ❖ Explain to students that you are going to simulate your own body's defense against Staph
    - ❖ Distribute role cards to each student and emphasize that they should keep them hidden.

- ❖ Each Student will receive either a bacteria cell or eukaryotic cell. There are four basic cards, the two convex cards of triangle and semi-circle will be the Staph aureus. These represent their antigens and will match concave cards for the eukaryotic cells representing their antibodies.
- ❖ This assigns them to a team either the Staph Team or the Body Team. They most correctly identify the cell structure to play.
- ❖ In addition, mark with stickers 2 bacteria, one round and one triangle, with a red sticker (This stands for Penicillin Resistance) and 1 bacteria, one round and one triangle, with a green sticker (This stands for Methicillin Resistance).
- ❖ Mark Off 20 yards x 20 yards split in half using 6 cones at each corner and a central line. Split students onto opposite sides of the battlefield. Stand in the middle with your supplies of antibiotics (M&M's) and resistance plasmid stickers.
- ❖ Explain Rules.

Explanation of the Rules

- **The game is Jail Break. The object of the bacteria is to get across to the other side without being caught.**
- **Only a body cell with the correct matching antibody (shape on card) can stop the appropriate matching antigen on the Staph pathogens unless they employ their antibiotic.**
- **A bacteria cell can counter antibiotic attack with resistance if it has the appropriate colored sticker on its card.**
- **Body cells can eat candy antibiotic if they don't use it each round, bacteria can eat the candy if they thwart it with resistance.**
- **At the end of each round, body cells can get another antibiotic of either type.**
- **At the end of each round, bacteria cells can "transduce or mate" with only one another bacteria to gain a resistance plasmid for the next round.**
- **Repeat until all bacteria are resistant**
- **Honors Extension: Teacher can have students data of number of bacteria that make it and number of resistant/type of resistant bacteria. This information can be graphed later on Excel or with pen and paper.**

4. MRSA Resistance Lecture and Discussion (15 minutes)
    - ❖ Ask students how the immune system was able to fight the infection the first round. Did they need to use antibiotics? What happened as they used more antibiotics?
    - ❖ Show the evolution of MRSA graph and be sure to note the speed and development of drug resistance.
    - ❖ Introduce the process of transduction, how does this promote the emergence of MRSA?
    - ❖ Discuss the movement of MRSA from hospitals to communities
    - ❖ Discuss sterile technique for swapping and inoculating plates
5. Stop Picking Your Nose Lab Inoculation- (30 minutes)
    - ❖ Put students into groups of 4. Each group will receive cotton swaps, inoculating loop, 3 petri plates with nutrient agar, and one MRSASelect plate in addition to the data sheet for the lab.
    - ❖ Explain to students that they are going to be sampling and culturing microbes from anywhere within the room on their 3 nutrient agar plates. They can sample anything they want, as long as they use the correct sterile technique.
    - ❖ The teacher will setup a sterilization station with a flame burner. Remind students that they must sterilize their loop and allow it to cool before each sample is taken.
    - ❖ The students will record their sample areas and hypothesize which will have the most microbial growth.
    - ❖ After the students have sample three areas, they will sample each group member for MRSA using the MRSASelect plate.
    - ❖ Have the students divide the plate into four regions using a marker.
    - ❖ Then have one student dip a cotton swap in the sterile water and then swapping the inside nasal area of another student. The student will then streak ¼ of the MRSA select plate.
    - ❖ Repeat for each student.
    - ❖ Have students place samples in the incubator for 24 hours.
    - ❖ Results will be recorded next class.

ASSESSMENT SUGGESTIONS List specific assessments for EACH objective:
For objective 1- How has MRSA effected hospitals and the community differently? (Stop Picking You Nose Lab Sheet)
For objective 2- Compare and contrast prokaryotic cells like MRSA and eukaryotic cells found within your body. Give 3 differences. (Summative Assessment Unit Test)
For objective 3- How did resistance spread? Did the use of antibiotics increase its spread? (MRSA Evolutionary Game Discussion)
For objective 4- Using MRSA as your example, identify and apply each of Darwin's principles for natural selection. (Summative Assessment Unit Test)
For objective 5- What is transduction and how does it allow antibiotic resistant to spread? (Summative Assessment Unit Test)

RESOURCES/REFERENCES :

Emerging Pathogens Talk- Dr. J. Glenn Morris Director of the UF EPI

Using Quick MRSA Testing- http://general-medicine.jwatch.org/cgi/content/full/2008/513/1

MRSA Plates - http://www.biorad.com/prd/en/US/adirect/biorad?cmd=BRCatgProductDetail&isFromSearch=true&entryPoint=adirect&catID=M4T0AB4VY&vertical=CDG&messageType=BRCatgProductDetail&parentCategoryGUID=M4SZHV15

Evaluation of MRSA Plates- http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2884491/