Title: Emerging Pathogens: Global Menace to Society?

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Abstract:
Emerging pathogens are a global issue of increasing concern that should be addressed in the high school science classroom. Current biotechnology techniques and skills are an integral part of the science of emerging pathogens. This proposal describes a module that will be incorporated into a unit on Molecular Genetics in an Advanced Placement Biology class. This module will include discussions of disease transmission (including vectors), emerging pathogens, The Hot Zone, global issues concerning disease and medical care, and bioterrorism. Biotechnology techniques will also be emphasized during this module with students completing an Enzyme-Linked Immunosorbent Assay (ELISA) simulation and hands-on laboratory activity. In addition to these activities, the students will work in small groups to select an emerging pathogen, research the pathogen, and present pertinent information to the class. Finally, the potential role of emerging pathogens in bioterrorism will be addressed as an important global issue of concern.

Mission Statement:
The purpose of this module is to incorporate viral structure and replication and nucleic acid technology and applications into a unit on Molecular Genetics in an Advanced Placement Biology class. This module will introduce students to current biotechnology skills as well as the science of emerging pathogens and encourage students to consider global issues associated with these technologies and pathogens.

Description of Teaching Unit:
At the end of this module, students will be able to: (1) describe viral structure and replication, (2) describe and utilize nucleic acid technology and applications, (3) describe and discuss global issues related to emerging pathogens, biotechnology, and bioterrorism.

This module will be taught as a part of a Molecular Genetics unit in an Advanced Placement Biology class. Prior to the Molecular Genetics unit, the students will have completed units on the Chemistry of Life, Cells, Cellular Energetics, and Heredity. Within the Molecular Genetics unit, the students will study RNA and DNA structure and function, gene regulation, mutation, viral structure and replication, and nucleic acid technology and applications. Units on Evolutionary Biology, Diversity of Organisms, Structure and Function of Plants and Animals, and Ecology will follow the unit on Molecular Genetics.

During the first part of the unit on Molecular Genetics, the students will be required to independently read The Hot Zone, by Richard Preston. They will be assigned written questions to check their comprehension of the reading. During this time, the students will also be studying RNA and DNA structure and function, gene regulation, and mutation.

The emerging pathogens and biotechnology module will be taught during ten class periods. The following is a proposed schedule for completion of this module:

Day 1
- Disease transmission activity
- Whole-class discussion of methods of disease transmission

Day 2
- Lecture and discussion of emerging pathogens and other pathogens

Day 3
- Discussion of The Hot Zone
- Student selection of emerging pathogens for projects

Day 4
- Enzyme-Linked Immunosorbent Assay (ELISA) simulation (testing exposure to several viruses) – 8 groups of students

Day 5
- ELISA lab activity (Bio-Rad Kit 166-2400EDU) – 8 groups of students

Days 6 – 7
- NOVA video – Ebola: The Plague Fighters
- Whole-class discussion about video (medical care access, ethical issues, etc.)

Day 8
- Lecture and discussion of bioterrorism
    - Human pathogens
    - Agricultural pathogens

Days 9 – 10
- NOVA video – Bioterror
- Small group presentations on emerging pathogens

During this unit on Molecular Genetics, students will perform hands-on simulations and laboratory activities using bacterial transformation, polymerase chain reaction (PCR), gel electrophoresis, and ELISA. These activities will introduce the students to current biotechnology techniques used in both research and industry. In addition, the performance of these activities will assist the students in developing a more thorough understanding of molecular genetics.

The science of emerging pathogens will be integrated throughout this module. For example, the principal instruction will engage the class in discussions about disease transmission (including vectors), specific examples of emerging pathogens, global issues related to disease identification and treatment, and bioterrorism. In addition to participating in lectures and classroom discussions, the students will also complete a small-group project and presentation on an emerging pathogen.

Expertise and Contributions of the Principal Instructor:

The principal instructor was the sole developer of this action proposal. All activities presented in this action proposal will be performed by the principal instructor with an Advanced Placement Biology class at Keystone Heights Junior/Senior High School.

The principal instructor is uniquely qualified to perform the activities presented in this action proposal. The principal instructor holds a B. S. in Zoology, M. S. in Wildlife Ecology and Conservation, and M. Ed. In Science Education; she will complete a Ed. S. in Special Education in Spring 2009. All degrees have been earned at the University of Florida. In addition to her undergraduate and graduate studies, the principal instructor has completed two weeks of training in the science of emerging pathogens as part of the ICORE program in June 2008.

The principal instructor has completed more than seven years in the high school classroom teaching science; she has taught in Alachua County and Clay County. She currently holds National Board for Professional Standards teaching certification in Science / Adolescence and Young Adulthood and Florida teaching certification in Middle Grades General Science 5-9, Biology 6-12, Chemistry 6-12, Earth-Space Science 6-12, Physics 6-12, English to Speakers of Other Languages (ESOL) Endorsement, and Gifted Endorsement. Her teaching schedule for the upcoming school year will include Advanced Placement Biology, Advanced Placement Chemistry, Chemistry I Honors, Chemistry I, and Gifted Earth / Space Science. She also serves as the Science Department Chair and School Science Fair Coordinator.

Literature Cited:

Bio-Rad Laboratories, Inc. (2008). Bio-Rad Laboratories. Retrieved June 27, 2008 from http://222.bio-rad.com/.

Budget and Budget Justification:

Bio-Rad ELISA Immuno Explorer Kit	(Catalog # 166-2400EDU)	$127.50
Bio-Rad 50 µl Fixed-Volume Micropipet, blue	(Catalog # 166-0515EDU)	$31.00 × 8
Bio-Rad BR-35 Pipet Tips	(Catalog # 223-9035EDU)	$31.00
TOTAL		$406.50

The Bio-Rad ELISA Immuno Explorer Kit is an integral part of the unit on Molecular Genetics. This laboratory activity will provide the students with a vital hands-on experience using this technique. The micropipets and micropipet tips are required to complete the Immuno Explorer activity as presented in the kit.

EMERGING PATHOGENS LESSON PLAN

TITLE: Around the World in Just a Few Days (Part of Emerging Pathogens: Global Menace to Society?)

KEY QUESTIONS: How prevalent is disease globally? Why do many people have difficulty getting adequate medical attention and basic medicines? What impacts can diseases in developing countries have on people in developed countries? What is the relationship between a parasite and host? How does the rate at which bacteria reproduce affect their ability to infect organisms?

GRADE LEVEL: 10-12

GLOBAL STUDIES TOPICS: Disease and medical care, population growth

SUBJECTS: Biology, Algebra I

TIME ESTIMATE: 100 minutes

VOCABULARY: Definitions obtained from Campbell & Reece (2005).
Host – the larger participant in a symbiotic relationship, serving as home and feeding ground to the symbiont
Parasite – an organism that benefits by living in or on another organism at the expense of the host
Virus – a non-living package of genes in a protein coat
Bacteria – a type of prokaryotic cell
Pathogen – a disease-causing agent

LESSON SUMMARY: The lesson will cover methods of disease transmission, medicine and heath care in developing countries, and disease as an agent of population control. The content will be covered using a simulation activity, oral reading by teacher, class discussion, and small group activity.

STUDENT LEARNING OBJECTIVES:
SCIENCE

The student will be able to...

1. define the vocabulary terms and use them appropriately in a sentence.
2. describe the relationship between a host and parasite.
3. name two major diseases and the type of organism that causes each disease.
4. list three reasons why people have difficulty receiving adequate medical attention.
5. identify two reasons why diseases in developing countries can affect developed countries.
6. describe the role played by disease in human population growth.

MATH

The student will be able to...

7. calculate the size of a bacterial population given its doubling time and initial population size.

MATERIALS: Basic instructional items like paper, pencil, chalkboard, laptop, and overhead projector are assumed to be present. Class size of 25 students is assumed.

ESSENTIAL: The Hot Zone (1 per class) [Preston, R. (1995). *The hot zone*. New York: Anchor Books], 50-mL beakers (one per student), dilute NaOH solution (20 mL per class; 2 students will receive 10 mL each), distilled water (230 mL per class; 23 students will receive 10 mL each), phenolphthalein (12.5 mL; 0.5 mL per student), worksheet for math activity (one per student)

SUPPLEMENTAL: The Hot Zone (1 per pair of students), wall-sized world map, calculator (one per pair of students)

BACKGROUND INFORMATION:

Communicable diseases are common around the Earth, particularly in developing countries. Diseases can be caused by many vectors. These **pathogens**, or disease-causing agents, are often bacterial or viral in origin. **Viruses** are typically considered to be non-living and are composed of genetic material and a protein coat. **Bacteria** are prokaryotic cells that are considered to be the among the first forms of life on Earth. Diseases are often caused by humans being the **hosts** in a parasitic relationship. Usually the **parasite** is a virus, bacterium, fungus, or protist. Examples of viral diseases include Ebola,

influenza, and human immunodeficiency virus. Bacterial diseases include tuberculosis, cholera, and salmonella. An example of a fungal disease is ringworm. Examples of diseases caused by protists include sleeping sickness and malaria.

Medical care in many countries is substandard compared to the United States and other developed countries. In addition, many people in developing countries do not have adequate access to clean water and waste removal. Medicines are often lacking in sufficient quantities, so people do not have ready access to the most basic supplies. Populations are also frequently dense in these countries, contributing to the rapid spread of communicable disease. As a result of these circumstances, disease is perpetually a problem in many developing countries.

Although large outbreaks of disease seem to occur more frequently in developing countries, these diseases can be quickly spread around the world due to the globalization of air travel. A never-before-seen disease can emerged from the rainforest, get on a plane with its host, and be anywhere in the world within a few days. This ability for rapid dispersal places all humans at risk of infection from nearly any disease.

In addition to potentially fast travel, pathogens can spread quickly due to their extremely rapid population growth rate. Bacterial pathogens typically reproduce through binary fission, with a short generational time (doubling time). If the initial population size and the doubling time are known, then the population size can be calculated at different points in time.

In all species, disease performs an important function in population control. As populations grow, they typically become denser and place a greater strain on the environment. As a population's density increases, it becomes easier for disease to spread rapidly. Throughout history, disease has played a role in curbing population growth in natural systems.

The novel, The Hot Zone, portrays actual events that occurred between 1967 and 1993. The Ebola virus is the focus of this book. The video, Ebola - The Plague Fighters, is a documentary about this virus and describes some of the people and events from The Hot Zone.

ADVANCE PREPARATION: Read The Hot Zone, watch Ebola – The Plague Fighters [NOVA. (2007). *NOVA: Ebola – the plague fighters*. Boston: WGBH. 54 minutes.], prepare and photocopy the worksheet, prepare the solutions, and distribute 10 mL of either the NaOH solution or the distilled water to each of the beakers.

PROCEDURE AND DISCUSSION QUESTIONS WITH TIME ESTIMATES:

Simulation activity (10 minutes)

1. Stand at door of the classroom and give each student a beaker with NaOH or water as they come in the door. Do not inform students about the contents of their beakers. Warn students not to drink the contents! (Only two beakers should have NaOH; the rest should contain water. The students with NaOH are 'infected'.)
2. Tell students that today they will be exchanging 'body fluids' (i.e., the contents of the beakers) with one another. This simulates the spread of body fluids that may contain pathogens.
3. Students walk around classroom pouring their beaker's contents together and then separating them so that each student continues to have approximately 10 mL of liquid in his/her beaker. Students may choose to share as many times as they want or not share at all. Students should record who they exchanged liquids with and the order in which they exchanged.
4. When the 'body fluid' exchange is complete, add a small amount of phenolphthalein to each beaker. The presence of a pink color indicates that NaOH is present. If NaOH is present, then that student is 'infected'.
5. Briefly discuss the results by asking the following questions with the whole class:
    a. How many of you are infected?
    b. How many people do you think were initially infected?
    c. How many times did you swap 'body fluids'? Do you think this led to your being infected or not being infected?
    d. How are body fluids swapped between individuals?
    e. Are all diseases equally able to be transmitted by this method?
    f. Who do you think was initially infected? Lead the students through a web linking each of the infected students so that the class can determine who the initial carriers were.

Reading by teacher (25 minutes)

6. Introduce the novel, The Hot Zone, by describing the background of the book and reading aloud the introductory pages (i.e., the pages between the dedication and the contents).

7. Read pp. 3-24 from The Hot Zone aloud to the class; the students will be seated at their desks listening. Throughout the reading, pause periodically to ask the following questions:
    a. What were some of the hypotheses presented in the reading concerning how the man became infected?
    b. What were the symptoms of disease displayed by Monet?
    c. How did the infected man pose a great risk to people around the world?
    d. What is the relationship between a parasite and a host? What was the 'host' in this portion of the story? Why was this organism the host? What was the parasite?
    e. What was the 'hot agent' that was "trying" to find a new host? Do you think viruses "try" to find hosts?

Class discussion (40 minutes)

8. Lead a class discussion addressing the contents of the reading. The following questions (along with others) will be posed:
    a. Did the character in the book receive adequate medical attention?
    b. Why did the infected man have difficulty being treated?
    c. How did the hospital described in the book differ from those in the United States?
    d. Is adequate medical care available in all parts of the world? Why or why not?
    e. What are some common diseases in this part of Africa? Around the world?
    f. What is a pathogen? What types of organisms cause disease?
    g. Should Americans be concerned with diseases occurring in developing countries? Why or why not?
    h. What role does disease play in human population growth? Is this true for other organisms as well?

Small group activity (25 minutes)

9. Assign the students in pairs to complete the math worksheet and then distribute the worksheet on bacterial growth rate. The worksheet will include a blank data table with the headings of Time and Population Size. The students will be provided with the initial size of the bacterial population and the doubling time.
10. Explain how to complete the data table on the worksheet using the data provided. The bacterial population size will be calculated for ten generations. Demonstrate how to draw the resulting line graph of population size vs. time.
11. Have students work in pairs or threes to complete the worksheet and draw the graph.
12. Collect all student work.

ASSESSMENT SUGGESTIONS: These assessments will occur on the day of the class discussion or on subsequent days.
For objective 1, the student will draw a concept map correctly utilizing all of the vocabulary words; the concept map should include and properly relate all of the terms.
For objective 2, the student will research an example of a parasitic relationship and make a brochure describing the host, parasite, and their relationship.
For objective 3, the student will complete a writing activity comparing two different diseases.
For objective 4, the student will participate in a class discussion describing reasons for inadequate health care.
For objective 5, the student will participate in a class discussion describing potential concerns of diseases passing from developing countries to developed countries.
For objective 6, the student will research the effects of the plague on human population growth and participate in a class discussion.
For objective 7, the student will complete a worksheet with a partner that addresses initial population size and doubling time; the students will calculate population size at various points in time and will graph the results.

EXTENSIONS:

ACTIVITIES: NOVA video (Ebola – The Plague Fighters) with questions, selections from Outbreak video with questions or class discussion

LITERATURE: The Hot Zone, Demon in the Freezer

RESOURCES/REFERENCES:

Campbell, N. A. & Reece, J. B. (2005). *Biology* (7th ed.). San Francisco: Benjamin Cummings.

NOVA. (2007). *NOVA: Ebola – the plague fighters*. Boston: WGBH.

Preston, R. (1995). *The hot zone*. New York: Anchor Books.