Emerging Infectious Diseases: Biology, Historical Significance and Public Policy

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Summary

At the University of Richmond we propose a new course for non-majors that will deal with emerging infectious diseases**.** Emerging infectious diseases pose threats to health care and effective Homeland Security management. These microbes can cause infections ranging from sporadic to pandemic in scope. Effective genetic manipulation of some of these microbes could result in a "super bug" able to launch a successful biological attack. As travel becomes faster and efficient, the specter of an outbreak of an emerging infectious disease becomes more plausible. It is imperative that college students become capable at comprehending both the scope of the event as well as the public policy response.

Historical pandemic infections will serve as background material. In order to understand the evolution of these microbes and the dissemination of information between microbes, basic concepts of genetics (spontaneous mutations, conjugation) as well as bacterial and viral structure/function will be examined. To complement laboratory experiments, computer simulations will be utilized to illustrate specific biological processes (development of antibiotic resistance in *Mycobacterium tuberculosis*, mutations / and epidemiological studies).

The direct impact of an outbreak on the health care infrastructure and the public policy response will be evaluated by investigating the actions taken by the Ford administration (Swine flu threat,1976) and will be compared the level of readiness achieved for dealing with an Avian flu outbreak (and other topics will be discussed).

Lecture and outside assignments will introduce this population to many resources that track emerging infectious diseases (Center for Disease Control, World Health Organization). The intention of this course is to sufficiently pique their interests that they will be informed consumers of the news of outbreaks and will be empowered to gather more information.

Project Description

Goals and Objectives: Emerging infectious diseases will be used to teach biological concepts needed to understand how microbes cause disease. The intention of this course is to expose students to the clear and present danger posed by these infectious agents, in order for them to understand the impact these microbes can have on the world community. Additionally, they will learn the difficulties inherent in constructing and implementing a comprehensive and successful public policy response. The possibility of an outbreak, whether it occurs naturally or as the result of a biowar event, is real; therefore, it is critical for undergraduates to be able to evaluate and understand the ramifications of such an event. A further goal is to pique their interest sufficiently that they will continue to read relevant stories and investigate future outbreaks.

Background and significance. Since emerging infectious diseases are reported in the news and have the potential for tremendous worldwide impact, the microbes that cause these diseases will be used to expose non-science students to basic tenets of science. Many non-science students approach the science requirement with trepidation, not focused on nor interested in the material that will be presented. In an effort to stimulate their interest, this course will be topic-based and will present pertinent biological concepts using current and historical events as a backdrop for researching and discussing public policy responses. A fundamental grounding in biological concepts is imperative to be able to understand the many policies implemented. Students will explore past and current policy, discussing the relative efficacy of these policies and begin to understand the many constraints and challenges faced when trying to construct and implement effective policy.

Non-science students typically do not have the knowledge to fully understand the ramifications of these microbes whether as agents of disease or biowar. There are undeniable

reasons why it is essential that college students become competent with both the scientific process and concepts. Dissemination of these microbes could possibly cripple some public health arenas and hurt a country's economy. Lack of science literacy can negatively impact funding opportunities for research, and increase beliefs in pseudoscience endeavors (astrology, scams) (http://www.nsf.gov/statistics/seind04/c7/c7s2.htm#c7s2l2). Furthermore, science illiteracy could negatively impact national security policies, especially if the policy makers and public are not adequately equipped to make informed decisions (Wallace, 2000).

Project description. Historical evidence provides numerous cases where infectious disease has significantly affected population survival. In the context of these historical examples, emerging infectious diseases will be used to educate non-science students in fundamental biological concepts as well as scientific methodology. Introductory topics will examine the significance and effect of some notorious diseases on world history using the Black plague, and flu epidemics (1918, 1976, and a possible Avian flu outbreak as examples. Reading material will provide examples of representative governmental responses. Students will investigate steps necessary to prepare for an Avian flu outbreak and identify where our level of preparedness lies**.**

There will be emphasis on bacterial and viral morphology particularly those structures that assist microbial survival. Attention will be focused on the ability of bacteria and viruses to invade cells and survive (flagella, capsules), and will examine the arsenal of weapons (toxins, capsules) microbes possess which allows for pathogenicity. These "weapons of mass infection" will be examined across diverse genera. Sample viral illnesses investigated will include AIDS (HIV), hemorrhagic fever (Ebola), influenza, and smallpox (*Varciella*). Some representative bacteria capable of mounting serious diseases presented will include *E. coli*, *Staphylococcus aureus*, and *Bacillus anthracis.*

Microbial and viral structure is important when discussing effective vaccination programs, water safety, and bioterrorism. Many vaccines are based on surface antigens; vaccine production must be altered on an annual basis due to mutations in these surface antigens (influenza) leading to yearly serum being produced. Other outer membrane structures (and adaptations) allow microbes to survive in seemingly hostile environments (e.g. *Legionella* in water towers) while other structures assist in dispersal and survival (e.g. anthrax spores). Bacterial toxins present a credible threat as some can survive in water supplies, potentially poisoning many individuals.

Public policy, as it pertains to emerging infectious diseases and bioterrorism centers upon evaluation of the water supply, food safety, animal surveillance, and vaccination programs. Prevention of outbreaks of emerging infectious diseases is difficult, if not impossible. Dengue fever is a mosquito borne tropical disease endemic to South America. Between July 1999 and January 2000, people in Texas contracted dengue fever. During the same time period Boy Scouts in New York state contracted malaria underscoring the idea that microbes are only seen in set environments is erroneous (http:///www.cdc.gov/globalidplan/4-introduction.htm).

Students will discuss some problems faced by the government including preventing entrance of microbes into the country (e.g.travelers, food, animals, insects), the role these microbes play in Homeland Security, what role vaccination programs play (should vaccinations be mandated), and the effect on the health care infrastructure, economics and foreign policy.

The laboratory component will be designed so students experience science. The initial experiment will investigate the efficacy of hand washing and provide students with the opportunity to design and implement their own experiment. Before data collection, the students will be required to research policies concerning where hand washing is mandatory.

Experiments investigating spontaneous mutations and conjugation will be performed to illustrate the acquisition of antibiotic resistance genes. An examination of antibiotic resistance/susceptibility will be accomplished using the Kirby-Bauer method and Minimal Inhibitory Concentration (MIC) assays. Acquisition of increased antibiotic resistance, due to exposure to sub-MIC antibiotic concentrations, will be explored providing students with insight to antibiotic resistance as a problem.

Computer simulations will supplement laboratory exercises. Students will determine the antibiotic resistance of *Mycobacterium tuberculosis* due to its re-emergence in immunocompromised patients and the isolation of multiply antibiotic resistant samples to selected drugs and then examine the site of action of these antimicrobials. Further experiments will examine the DNA sequences provided to determine whether the antimicrobial differences are genetically mediated. Potentially, they will be able to identify the gene(s) responsible for the noted response. This exercise will require utilization of material from lecture, previous labs, experimental design, data presentation, and analytical skills.

The spread of HIV through a population will be simulated followed by an ELISA (Enzyme Linked Immunosorbent Assay) for detection. Students will address various policy issues concerning those infected with HIV. Topics to be discussed include distribution of needles, condoms and whether food servers and health care providers should disclose if they are HIV positive. Students will read current material, form their own opinion and discuss these topics in an open forum (in lab).

Simulations will use smallpox as the representative agent of biowar examining a bioterrorism scenario where students will use DNA fingerprinting to detect smallpox. A subsequent experiment will evaluate the impact and possible risks of vaccination programs.

An epidemiological case study will last the entire semester. Each pair of students will be assigned an emerging infectious disease during the first week of the semester that is currently being tracked on the CDC Morbidity and Mortality web site. After viral and bacterial morphology have been presented the student must define their bacteria or virus using those constraints (e.g.Gram reaction for bacteria, structure for virus). Over the course of the semester they will use web sites provided to track the progress of the disease.

This project will utilize many of the concepts presented in lecture. The information required will include transmission/reservoir of the microbe, treatment and morbidity and mortality data looking for seasonal variations. This project will require the students to research appropriate policy available to deal with the possibility of an outbreak of this type of agent. There will be flexibility allowed for the final project as their presentation will be directed by their overall career goals. For instance, a political science major would take a policy track and present their agent from a public health prospective while a business major may be more interested in the economical impact.

Reading material for this course will include "The Power of Plagues" by Irwin W. Sherman (ASM Press 2006) which provides historical context for many infectious diseases and explores their relative impacts. Microbes presented include *Mycobacterium tuberculosis,* HIV, and *Treponema palladium*. Another book, "The Cobra Event" by Richard Preston which so frightened President Clinton that he requested that federal agencies investigate the possibility of such an event occurring. Students will be asked to critique the book for its biological content as well as the government response.

Prior activities or research related to the proposal. Maren Reiner has spent her tenure at the University of Richmond developing and instructing courses for non-science majors and has been

successful challenging and engaging non-science students. My role (Paula Lessem) has involved designing and implementing laboratories for core courses in genetics and cell biology. In addition, I have co-designed a non-majors course in microbiology (funded by NSF), and I have extensive experience with summer programs working with high school students. My research focuses on antimicrobial resistance patterns in bacteria isolated from environmental waters.

Projected timetable. This course will be taught Fall 2006 and Spring 2007.

Requested budget: **$11,000**

Micropipettors(20 students/lab): 3 different volumes X~$250/pipettor X 18 = $4500.

Gel electrophoresis apparatus = $400; Power Supply= $400

Summer salary for course development (approximately 3 weeks) = $3000 (P. Lessem)

Travel: Associated Colleges of the South (for 2 people) and Association of Biology Laboratory Educators (if approved): $2700.

Content of course in curriculum. This course will be a Field of Study course in the Natural Sciences that will fulfill a general education requirement.

Impact on the Institution. This course will be offered during the Fall semester of 2006 and Spring 2007 enrolling 80 students each semester. After the first year, it will be rotated into the course schedule offerings for non-science students

Evidence of Institutional Support. This course has received departmental approval and General Education approval. Paula Lessem has been reassigned for the 2006-07 academic year to prepare and implement curriculum along with Maren Reiner. The department has allocated resources to support 80 students each semester.

Evaluation, Dissemination and Continued Support

To assess student literacy and interest, a questionnaire will be distributed the first day of lecture. Questions posed will be aimed at evaluating three different content areas. The first content area will probe basic student perceptions about infectious disease, what it means and where they get their information (TV, movies). Students' knowledge of the field of epidemiology will also be evaluated. The second subject field will address basic science literacy. Students will be asked to differentiate between bacteria and viruses, antibiotic resistance, and the role of DNA in the spread and production of infectious diseases. The final area will explore students' knowledge of disease causing microbes and the potential impact on health care, and the effective public policy responses to a natural outbreak or a bioterror attack. This same questionnaire (used the first day of class) will also be distributed the last week of the course to determine if their impressions and basic scientific literacy had changed. Additionally, a follow up questionnaire will be designed to assess retention of the material and continued interest. The follow up survey will be distributed at one year after taking the course (to those students still on campus). Though this evaluation will be after the final grant report is due, the data would still be interesting to collect.

Sample topics probed (for the first content area) will include their level of knowledge about the anthrax attack, pandemic infections versus sporadic outbreaks, mortality versus morbidity, transmission and reservoirs of these microbes. We will include some examples from popular culture ("Outbreak" "Jurassic Park") to investigate the validity they place on the science presented (other topics will be included for not all students will be familiar with these movies). An important topic for this section will question students about influenza, vaccination strategies, why vaccines need to be altered, and the possible development of an Avian flu outbreak.

Basic science literacy will investigate student knowledge differentiating between viruses and bacteria (illustrating similarities and differences between the microbes), structure/function of DNA, mutation and exchange of genetic information. Student perceptions concerning the use and dispensing of antibiotics (even when antibiotic therapy is not indicated), and the real threat posed by antibiotic resistant microbes will be probed.

The last section will investigate student perceptions concerning policy and potential impact of an outbreak (natural or biowar). Students will be questioned about their knowledge of governmental agencies (CDC, NIH for example), the role of Homeland Security, and where to gather relevant information. Questions concerning the anthrax attack of 2001 will be posed as well as probing the challenges faced by health care during this event (not recognizing anthrax in patients). Included in this section will be basic queries examining student knowledge and perceptions of public policy (Should patients and/or doctors disclose that they are HIV positive? Should the government decide?) The last set of questions will investigate student knowledge of microbes as potential weapons.

We plan to apply to present this course at The Associated Colleges of the South (ACS) meeting and at the Association of Biology Laboratory Educators (if permission is granted since the meeting is after the final grant report due date).

The outline for this course has been approved by the University of Richmond General Education Committee and will fulfill the Natural Science requirement. It is anticipated that it will receive approval by Academic Council. This course, after it has been offered both semesters during the 2006 – 2007 academic year, will be offered during May term and will be added to the list of subjects available for non-major biology education. It is anticipated that it will be rotated

on a regular basis. The University of Richmond Department of Biology has the necessary resources to be able to continually support this course.

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