Superbugs, Science, and Society: Integrating Biology with Social Sciences Increases Understanding of Infectious Diseases

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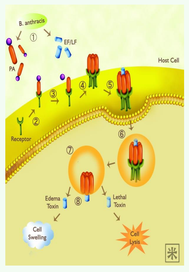
BACKGROUND

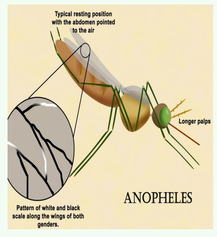
Studies show that students learn and retain knowledge for longer periods when the subjects taught draw upon topics of interest to the students and upon previous knowledge. With this in mind, Duke students working with the RISE office and an advisory team of six health sciences high school teachers developed an elective biology course for high school students called "Infectious Disease: Superbugs, Science, and Society". Six disease-focused modules and several activities teach the biology of infectious diseases in conjunction with the social, political, and historical factors that contribute to their prevalence. The course was taught by a first-year teacher during the Fall 2007 semester to twenty-three 11th and 12th graders at the South Granville Health Sciences High School. Two of the students have never taken a biology class and most had not taken chemistry. The following is an assessment of the Infectious Diseases course as a teaching tool.

Schwartz-Bloom & Halpin, (2003) **J. Res. Sci. Teach**. 40:922-938
Kwiek et al., (2007) **Science** 317:1871-1872.

COURSE MODULES

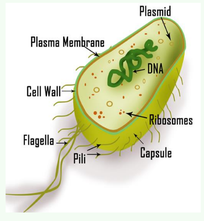
MALARIA Discovery of malarial parasite, transmission by mosquitoes, characterization of geographical hotspots, sickle cell protection, prevention and controversy



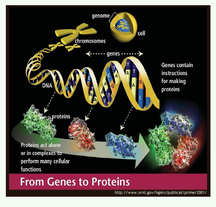


HIV History of HIV/AIDS, evolving policy in response to the growing Africa epidemic, modes of transmission, how a virus infects a cell, progression of HIV to AIDS, mechanism of action of drugs, and resistance

SMALLPOX-ANTHRAX Definitions of biological warfare and biodefense research, anthrax pathology, symptoms of anthrax, origins of smallpox, smallpox eradication, smallpox research controversy



AVIAN FLU History of 1918 flu pandemic, evaluation of avian flu threat, structure of flu virus, evolution of flu virus and species crossing, vaccines and antiviral treatments, Tamiflu controversy and compulsory licensing



TUBERCULOSIS History of TB, discovery of TB-causing bacteria and Koch's postulates, link between HIV and TB, basics of bacteriology, mechanism of action of antibiotics and resistance development

PRIONS Definition of prions and description of prion diseases, review of Central Dogma, modes of infection, debate over infectious agent of prion diseases

ASSESSMENT

Students were administered the same test before and after the course. The assessment has been reproduced below. The questions were not administered in the order shown but were scrambled by the teacher before given to the students. The questions have been grouped according to the six areas of knowledge tests, and the number corresponds to the order in which the questions appeared. The students' score in each area of knowledge was averaged and a paired t-test was performed on the averages to quantify the difference in scores before and after the course. Due to the small sample size, more sophisticated statistical analyses could not be performed on the data.

Antibiotic Resistance

1. What is the most likely cause of drug resistant TB?
   A. Patients stop taking their medicines prematurely.
   B. The *M. tuberculosis* bacteria acquire drug resistance genes from their host.
   C. Seasonal variation among bacterial strains.
   D. Bacterial strains exchange genetic material in an animal reservoir.
   E. The bacteria transmit misfolded proteins to the host.
   F. Don't know.

10. Antibiotic resistance is usually the result of changes in a pathogen's:
   A. Protein conformation.
   B. Lipid bilayer composition.
   C. Environment.
   D. Cytosolic pH.
   E. Genetic sequence.
   F. Don't know.

12. Antibiotics can be used to treat which of the following infections?
   A. Fungal
   B. Viral
   C. Trypanosome
   D. Bacterial
   E. Prions
   F. Don't know

Vaccine Development

2. A vaccine works because it causes the body's immune system to recognize an:
   A. Aptamer.
   B. Isotope.
   C. Epitope.
   D. Gene.
   E. Oligosaccharide.
   F. Don't know.

14. A major challenge to developing viral vaccines is:
   A. The vaccine is toxic to the patient.
   B. The viral genome mutates frequently.
   C. Dead viruses can't be used as vaccines.
   D. Live viruses can't be used as vaccines.
   E. The patient's genome mutates frequently.
   F. Don't know.

16. Vaccines for anthrax could be harmful because:
   A. The purified anthrax proteins halt cell division.
   B. Inoculation with the whole bacteria can cause side effects.
   C. A DNA-based vaccine can cause mutations.
   D. The vaccine disrupts cell membranes.
   E. The vaccine is only effective at near-lethal doses.
   F. Don't know.

Transmission

3. Which prion disease occurs in animals, but can not be transmitted to humans?
   A. Scrapie.
   B. BSE.
   C. Kuru
   D. CJD.
   E. Fatal familial insomnia.
   F. Don't know.

11. Which is not a transmission route for HIV?
   A. Intravenous drug use.
   B. Ingestedted sex.
   C. Aerosol.
   D. Blood transfusions.
   E. Breast milk.
   F. Don't know.

17. TB is usually transmitted to humans by:
   A. Touch.
   B. Intravenous drug use.
   C. Eating *M. tuberculosis* infected meat.
   D. Mosquitoes.
   E. Aerosol.
   F. Don't know.

Pathogenic

9. Which of these has female and male forms?
   A. Prions.
   B. Trypanosomes.
   C. HIV.
   D. Anthrax.
   E. *M. tuberculosis*.
   F. Don't know.

15. Which of these can not enter an inactive state?
   A. *M. tuberculosis*.
   B. Anthrax.
   C. Avian flu.
   D. HIV.
   E. Trypanosomes.
   F. Don't know.

18. Which of these primarily targets macrophage cells?
   A. Trypanosomes.
   B. HIV.
   C. Prions.
   D. Smallpox.
   E. *M. tuberculosis*.
   F. Don't know.

Socio-economics/ Geography of Disease

4. The worldwide distribution of malaria cases is not affected by:
   A. Temperature.
   B. Humidity.
   C. Wind patterns.
   D. Mosquito density.
   E. Access to medicines.
   F. Don't know.

7. What is not a reason that AIDS is more common Africa than elsewhere?
   A. The high price of antiretroviral therapies.
   B. Prevalence of prostitution spreads the disease in congested cities.
   C. Lack of safe-sex education programs.
   D. Those that have the disease often keep it secret.
   E. Greater chance of acquiring the virus from monkeys.
   F. Don't know.

8. What is a factor causing the spread of drug-resistant TB in Russia?
   A. The high crime rate leads to overcrowded prisons.
   B. Russian medicines emphasize natural cures rather than antibiotics.
   C. Open-air poultry markets spread the disease.
   D. The climate is favorable for bacterial spores.
   E. Russian vaccination programs are impeded by economic woes.
   F. Don't know.

Historical Aspects of Disease

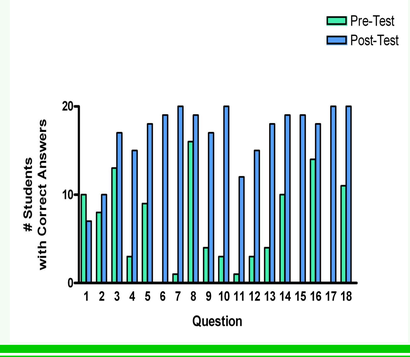
5. The latest evidence suggests that the 1918 influenza came from:
   A. Birds.
   B. Pigs.
   C. Cows.
   D. Ferrets.
   E. Monkeys.
   F. Don't know.

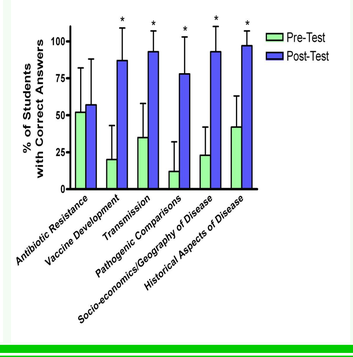
6. Whose postulates tell us whether a pathogen is the cause of a disease?
   A. Lavoxier's.
   B. Fleming's.
   C. Pasteur's.
   D. Koch's.
   E. Gedjusek's
   F. Don't know.

13. Which disease did Edward Jenning invent a vaccine for?
   A. Tuberculosis
   B. Anthrax.
   C. Smallpox.
   D. Influenza.
   E. Malaria.
   F. Don't know

RESULTS

The students demonstrated a substantial increase in knowledge as a result of the Infectious Diseases elective. Students gave more correct answers on the post-test on all questions but the first. Students showed significant improvement in all areas of knowledge, all with a p-value equal to 0.0001, except Antibiotic Resistance (p=0.12). The students completed a number of the activities at the end of each module and some created by the teacher, including a model of an avian-human hybrid flue virus, an ethical issues analysis of malaria research, and an informative HIV/AIDS brochure for students in Malawi.





DISCUSSION

Students improved on 17 of 18 questions and significantly improved in 5 of 6 areas of knowledge. Students did not significantly improve in the area of Antibiotic Resistance and performed worse on the first question (in the same area) after the course. Future studies will determine if this is a a problem with the way these concepts are taught.

The teacher reported the following on her evaluation of the course:

- the students found the HIV, Malaria, and Anthrax-Smallpox modules most interesting and the Prions and Avian Flu modules least interesting
- the Avian Flu module was most challenging to relate to because the Avian Flu has yet to reach the US and contained the most difficult vocabulary and concepts.
- frequent and voluntary participation in class and an increase in the students' knowledge of biological principles and understanding of the interaction between the hard sciences and the social sciences increased and believes many will enroll in science electives in the future
- the need for more hands-on activities

- The Infectious Diseases course aligns with components of 9 of the 13 competency goals of the North Carolina Standard Course of Study for Biology (http://www.ncpublicschools.org/curriculum/science/scos/2004/23biology). The areas in which the course was lacking involved evolution and hands-on experiments.

FUTURE DIRECTIONS

Future studies will include a larger sample size and a control group. The students' demographic information will also be collected to assess the course's ability to close certain achievement gaps. This course is currently being taught at the East Wake School of Health Science.

ACKNOWLEDGMENTS

The Infectious Disease course and manual was designed and written by Joseph C. Babcock and Dr. Nicole Kwiek. Senmaio Zhan gathered and designed many of the graphics in the manual. All graphics in the "Modules" panel are the original creation of Senmaio unless otherwise cited. Thanks to South Granville School of Health Sciences for allowing us to test this elective with their students.

Supported by a Trinity College Undergraduate Research Support Grant to SA and a NSF/ SENCER grant from the National Center for Science & Civic Engagement