

Biology in Popular Culture

A Science Course for Non-Science Majors

Submitted by:

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Category: Design and Implementation of a new course

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Proposed period of grant: January 2007 – December 2008

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Biology in Popular Culture: Summary

Controversial issues in biology will serve as the foundation for the development of a new course “Biology in Popular Culture” to be offered to University of Richmond (UR) non-science majors. Students will gain exposure and experience with tools and techniques common to genetic engineering. Laboratory investigations using stem cells and antibiotic resistance in bacteria (illustrating natural selection) will serve as the basis for hypothesis-driven experimental modules.

In order to illustrate evolution, and discuss the impact of antibiotic resistance microbes, bacterial strains will be induced to exhibit a change in phenotype. Using Porifera as a model system, the students will examine the phenomenon of pluripotent cells to understand the use of stem cells in health-care related issues.

Stem cell research and bacterial antibiotic resistance are critical areas in the scientific community and health care. These two modules will be an effective means of communication used to educate students at UR about basic scientific principles while not eliminating the social and political ramifications.

This course will be designed to enable the students to develop the skills needed to differentiate media representation of science from facts. We recognize the need for science literate citizens who will be instrumental in developing policies in business and government. Though one course cannot adequately address a majority of the controversial issues, the intent of this course is to sufficiently pique students’ interest such that they will strive to be conscientious and discriminating consumers of information. They will be challenged to think about, discuss, and form opinions about controversial issues, such as DNA fingerprinting, genetically modified organisms, cloning, the use of stem cells, and evolution, which are publicized in the popular culture through newspapers, TV, and movies.

Project Description

Goals and Objectives: Non-science majors need to be informed about basic scientific principles because now and throughout adulthood they will be exposed to the scientific advances and knowledge that can become controversial by the attention of the popular press and involvement of religious groups and politicians. In this course, we will develop and improve the skills that are important in critical evaluation of the information presented in media. These students will ultimately be able to distinguish scientific from pseudo-scientific information thereby enabling them to make informed decisions. During this course, the students will confront cutting edge biological developments and knowledge in three content areas: recombinant DNA, natural selection, and stem cells.

Background and Significance: Controversial biological topics will be explored using biology in the public arena. This module-based new course will address “Genetic Engineering,” “Evolution” and “Stem Cells.” Through these modules, “hot” issues will be examined, such as the notion that eugenics only takes place in movies or in the past, embryos are the only source of stem cells, intelligent design is a plausible theory for evolution, and people become resistant to antibiotics,. By implementing the modules proposed, students will enhance their skills in: a) understanding of biological conceptual material relevant to being an informed citizen, b) implementation of laboratory experiments, and c) integration and synthesis of foundational biological information.

Biological education needs to focus on the development of students who can critically analyze information and separate half-truths and misrepresentations from valid scientific achievements. Duit and Treagust (2003) observed that students were more competent in applying information when the way science works, and how discoveries were made were emphasized

rather than a rote presentation. In this course, we will encourage students to ask questions, challenging them to think about the relevance and applications of the proposed theories, not just the theory itself (D'Avanzo, 2003). We will help our students to learn how to ask good questions.

Recognizing that this approach to higher order thinking relies upon an active process that engages one in learning, a metacognitive strategy will be employed. Metacognitive learning is divided into three target areas: strategic knowledge (general approaches for thinking), learning and problem solving (accumulation of information relating to a set cognitive task), and self-knowledge (the ability to identify and assess your own strengths and weaknesses) (Beeth, 1998). This pedagogy provides students with tools to be able to approach and attack new tasks with confidence.

We realize that all of our students will not become proficient at incorporating theory or data analysis in one semester. However, we do expect all of our students to become bioliterate, that is, to have the ability and confidence to draw reasonable conclusions about new information based on a solid foundation of biological concepts as well as grounding in critical analysis (Klymkowsky et al., 2003).

Project Details: We will focus on three major themes regularly reported in the news and popular culture. We will deviate from pedagogy where students have familiarity with a great number of concepts but their depth of understanding and ability to apply this information are very limited (National Center for Education Statistics, 2004).

Pedagogy - Lecture: Background foundational material will be presented in a traditional format for all modules. However, some topics will involve active student engagement. The students will pose a hypothesis, predict the outcome, and compare their prediction with the actual result.

The question-driven approach will introduce the students to basic tools necessary for understanding genetic engineering. Pivotal to DNA recombinant technology is the use of restriction enzymes. Using a computer simulation, students will be given a piece of DNA with the β -lactamase gene and a list of restriction enzymes. They will locate and cut out the gene using restriction enzymes. Hypotheses posed could include: Do all the enzymes cut this piece of DNA? Can enzymes cut more than once? Does it matter if an enzyme cuts within the gene?

At the end of each module students will discuss an ethical, social or policy application that is part of the controversy inherent in many of these discoveries (who should get BRCA testing? Can police take DNA samples?). Students will be challenged to form and support their opinions.

Pedagogy – Laboratory: For preliminary experiments, students will be provided with “big picture” questions and will use molecular biology tools to collect specific data. For subsequent investigations, students will be given tools and information and will have to first discuss the problem, form hypotheses, and assist in the design of their own protocols using a well defined set of experimental goals. The two multi-week experiments are “Induction of β -lactamase and “Working with Primmorphs.”

Theme Modules Presented in Lecture: I. Cloning: To prepare students to understand controversial biological issues, including DNA structure and function, we will present the central dogma of molecular biology and common themes in genetic engineering. Students will confront eugenics in history as well as current applications, genetically modified organisms, genetic counseling (BRCA 1 testing), ethics and applications of organ cloning, and forensic science.

Laboratory: Tools of Molecular Biology. Experiments performed will include restriction digestion, agarose gel electrophoresis, identification of genetically modified organisms, PCR of β -lactamase (for the last experiment), and a gel scenario concerning paternity or BRCA.

II. Evolution. Clearly, anyone watching TV or reading the newspapers is aware of the debate concerning intelligent design vs. evolution. We do not intend to cover all of evolution in this course, but to present selected topics and model systems to illustrate how organisms evolve. Students will study the evolution of antibiotic resistance in bacteria using β -lactamase in selected strains. Popular web sites (such as Flying Spaghetti Monster <http://www.venganza.org/>, Godsend <http://www.godsendinstitute.org/home.html>) will be discussed.

Laboratory - Induction of β -lactamase resistance in selected bacterial strains. Students will determine the Minimal Inhibitory Concentration (MIC) of selected bacterial isolates in a panel of β -lactam antibiotics. After the initial experiment the students will decide how many and which bacterial strains they want to examine and what antibiotic concentration(s) they will use. Then they will induce their strain with a sub-MIC level of a selected β -lactam antibiotic. Following induction, the MIC's will be repeated to evaluate induction of resistance. Students will also perform PCR of pre and post-induction samples.

Students will design the experiment they want to perform by identifying how many microbes they want to investigate, selecting which ones to continue with (based on preliminary MIC testing) and what antibiotic(s) they want to use for induction. Some questions they can ask are: Are all microbes capable of induction? Does exposure to one antibiotic result in resistance to a different antibiotic or class of antibiotics? Can very minute amounts of antibiotics cause induction?

III. Stem Cells: The use of stem cells has sparked controversy in popular media, religious organizations, in Congress, and in a number of state houses. This module will educate our students about the characteristics (pluripotent, plasticity), types of stem cells (embryo, adult) and applications (diabetes, nerve regeneration, Parkinson's) of this powerful technology.

Use of Porifera as a Model System. Sponge tissue is a useful model system to introduce students to stem cell technology. This model, used to produce select sponges in great quantities, can illustrate how stem cells can be made and an application of why the technology is warranted. In addition, sponge cells produce high levels of telomerase thus examining the relationship (of telomerase) to cancer cells can also be explored using this model.

Laboratory: Working with Primmorphs: Sponge cells will be used to demonstrate some basic concepts inherent in stem cell work. Primmorphs, the model for stem cells, have the ability to proliferate and differentiate into any cell in the adult sponge. Students will be able to monitor this process in the lab. Sponge tissue from *Microciona* (red) and *Haliclona* (tan) species will be placed in Ca – Mg free sea water resulting in disruption of cell communication, causing dissociation of the cells; this will be monitored microscopically. Combinations of the two species will be resuspended in sea water and aliquoted into tissue culture plates where students can observe the aggregation of the cells. After five days, the primmorph stage is reached. These cells have the potential to differentiate into any adult sponge cell thus has a role similar to a stem cell. The final experiment will involve isolation of RNA (to perform RT-PCR) from different developmental stages of the sponges to demonstrate gene expression of selected genes.

Students will research the role of the genes, hypothesize during what developmental stage it is expected to be transcribed, and perform RT-PCR to test their hypothesis. Some examples

are of genes to be studied include actin, and *src* tyrosine kinase which are always being transcribed and *Fox*, *Six*, *Pax*, and *Bar*(transcription factors).

Prior activities or research related to the proposal: The two principal investigators have taught non-major science courses at UR. Currently, they are team teaching a course on emerging infectious diseases (course development was funded by ACS) for non-science majors, stimulating these students by relating biology to their everyday lives. The student interest and participation has been gratifying, resulting in our motivation to create and deliver another biology based course to expose our students to controversial issues in biology.

Projected timetable: This course will be offered during the 2007-08 academic year and will be offered on a rotating basis in subsequent years.

Requested budget:

Edvotek's Photo Gel Documentation System	\$4250
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We want the students to be active participants throughout their experiments preparing their gels, loading the samples and collect the data. This gel documentation center will afford them the opportunity to complete their experiments by photographing their own gels and saving them electronically.

Context of the course in the curriculum: This course will be offered to non-science majors.

Impact on the Institution: This course will enroll approximately 64 students each semester. After the first year, it will be rotated into the course schedule offerings for non-science students.

Evidence of Institutional Support: The University has recently purchased a thermocycler that is dedicated to teaching and will be available for this course. In addition, funds will be allocated by the Biology Department to allow presentation of this course at the Association of Biology Laboratory Educators 2008 meeting, or another appropriate meeting.

Evaluation, Dissemination and Continued Support

The new course will be evaluated each time it is offered using the standard University of Richmond course evaluation system. In addition, an evaluative survey following the model designed by Kardash and Wallace (2001) will address general attitudes and perceptions students have about science classes in general. This survey will be adapted with the assistance of Mathew Levy, Coordinator of Grants and Assessment, University of Richmond, to determine the degree to which the course and also the additional lab experience effectively change the attitudes of college non-majors.

We also plan on addressing the following questions:

- a) What do students know about the uses of genetic engineering?
- b) Can student opinions be changed by providing correct information?
- c) Does participation in open-ended inquiry equate to a better ability to observe and pose relevant questions?
- d) How competent are our students when discussing the use of genetically modified organisms, stem cells and antibiotics?

In order to address these issues, we plan to design an assessment tool modeled after the Medical College Admission Test. Students will be given passages to read with a combination of multiple choice questions and open ended responses. The multiple choice questions will target the depth of their knowledge and understanding of the science, while the open ended questions will probe their feelings and opinions on these topics. Both of these tools will be used for all students enrolled in the course. By reviewing the course evaluation and survey results each time the course is offered, we will be able to identify and improve any elements of the modules or the laboratory experience which are not working as we planned.

At the culmination of the lab, the students will have a choice for their final project. One option will be to prepare a presentation on a use of the DNA technology not addressed in class. Since these are non-science majors, the topics will be multi-disciplinary, illustrating how science can be integrated into their focus area. The second option will be for a group of students to prepare an activity and presentation for life science students at selected middle schools on a topic appropriate to Virginia Standards of Learning. UR students would have the opportunity to disseminate material they have mastered to the City of Richmond public middle school students, primarily an inner city, minority population. James Wright in UR's Education Department will be providing the contacts for the middle schools. The experiments chosen will be student driven. They will be required to write a scenario (drawing on their strengths) that is topical for their experiment. Samples of potential topics include DNA fingerprinting (forensics), genetically modified organisms, gel electrophoresis to differentiate smallpox from monkeypox (all these topics are available in kits). Materials for the presentations (and necessary kits) will be made available with funds provided by the Biology Department.

This course will be presented at the Association of Biology Laboratory Educators as a mini-course. This format will allow us to illustrate the use of sponge cells as a model to discuss stem cell research. Presentations at this meeting results in a publication in the "Proceedings of the Association of Biology Laboratory Educators." Funds for this meeting will be provided by the University of Richmond of Richmond, Department of Biology.

The outline for this course will be presented for approval to the Biology Department at the beginning of the spring semester (2007). The chair of the department, Dr. Roni Kingsley, has included a letter of support with this application. There have been two texts selected (tentatively) for this course. To address the genetic engineering material, we plan to use

“Genetic Engineering: Science and Ethics on the New Frontier” by Michael Boylan and Kevin E. Brown (2001). To provide background on stem cells, we plan to use “Stem Cell Now” by Christopher Thomas Scott (2006).

It is anticipated that this course will be approved by the department and the University of Richmond General Education Committee and will fulfill the university’s Natural Science requirement. It is anticipated that it will receive approval by Academic Council. This course, after it has been offered during the 2006 – 2007 academic year, will be offered during May term (on a rotating schedule) 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.

Disclosure Statement: Currently (May 2006), we were recipients of a Keck Science Reform Grant. Funding was to cover equipment, summer salary (2006) and travel. That course, Emerging Infectious Diseases, is currently being offered, is fully enrolled for the spring 2007 semester and will be offered May term 2007. It will then be rotated on a regular basis with non-science courses offered by the Biology Department. This new course would be offered during the 2007-08 academic year.

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Position: Director of Biological Laboratories, University of Richmond
Courses:

- ◆ Laboratories in Genetics,
- ◆ Cell and Molecular Biology,
- ◆ Unseen Life: a microbiology course for non-science students

Research Interests: Antibiotic resistant mechanisms in bacteria, the presence of antibiotic resistant bacteria in the environment, induction of antibiotic resistance

Professional Preparation:

The Pennsylvania State University	Medical Technology	B.S., 1975
Rutgers University (University of Medicine and Dentistry of New Jersey)	Biochemistry/ Microbiology	M.S., 1991 Ph.D., 1994

Appointments:

Director of Biological Laboratories University of Richmond	Current (1996)
Director of Biological Sciences Greater Richmond Area Higher Education Consortium (GRAHEC)	2001 - 2004
Adjunct Instructor J. Sargeant Reynolds Community College Virginia Commonwealth University	1995-1996
Instructor Rutgers University – Microbiology Laboratories	1993-1995

Synergistic Activities

Presentation at the ACS Keck Science Reform & Education Workshop	October 2006
Research Seminar “The Development of Antibiotic Resistance” Virginia State University	March 2006
Metro Richmond Science Fair Judge	March 2006

Metro Richmond Science Fair Reader	February 2006
Panelist, “An Assessment of Education in the Biological Sciences” hosted by Centra Technology for federal government agencies, Arlington, VA	October 2005
Instructor (and curriculum developer) in University of Richmond Summer Scholars Program	2205-2006
ACS Teaching Learning Workshop at Rolins College	June 2001
Mentor – High School students VJAS and Richmond Metro	Current (1999)
Developed Biology courses for GRAHEC	1997-2002
Participated as a Workshop leader (Biotechnology) for secondary school teachers at Virginia State University	1997-1998

Research Grants /Awards

Associated Colleges of the South – Science Reform Mini-Grant	2006
Campus Community Partnership of Metro Richmond Grant	2002 -2003
NSF-CCLI Laboratory Adaptation Grant (NSF-DUE Proposal - 0126955).	2002 - 2004
The Greater Richmond Area Higher Education Consortium Grant	2001-2003

Publications

Lessem, P. B & D, Wohl. (2005) Unseen Life: Engaging Non-Science Students Through Microbiology, Proceedings of the Association of Biology Laboratory Educators

Poster Presentation

Emerging Infectious Diseases: Biology, Historical Significance and Public Policy Associated Colleges of the South	October, 2006
Engaging Non-Science Students Through Microbiology, Association of Biology Laboratory Educators	June , 2005
Tuckahoe Creek Project –Virginia Academy of Science	May, 2002

Graduate/Thesis Advisor

Stanley Katz, Ph.D. – Professor, Cook College,
Rutgers University

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Courses:

- Exploring Human Biology---Lecture and Laboratory
- Environmental Biology---Lecture and Laboratory
- Emerging Infectious Diseases—Laboratory and Lecture
- Undergraduate Research (Fall 2005)

Professional Preparation:

Mary Washington College	Biology	B.S., 1983
New York University	Biology	M.S., 1986

Appointments:

Director of Biological Laboratories University of Richmond	Current (1988)
Instructor of Biological Sciences Greater Richmond Area Higher Education Consortium (GRAHEC)	2001-2002
Laboratory Technician Medical College of Virginia- Department of Microbiology And Immunology	1986-1988

Synergistic Activities:

Development and implementation of Emerging Infectious Diseases	Current (2006)
Integration of technology in Exploring Human Biology and Environmental Biology	Current (1995)

Developed Cell Biology course
for GRAHEC 2000

Awards:

ACS Grant: "Emerging Infectious
Diseases: Historical Significance
And Public Policy (\$ 7800) 2006

PETE Grant 2004
Travel support to NABTmeeting

PETE Grant 2000
Course development

Meetings:

NABT—Reno, Nevada 1998

NABT---Fort Worth, Texas 1999

NABT—Orlando, Florida 2000

NABT—Cincinnati, Ohio 2002

ACS conference—"The Reform
of Introductory Science Courses
for Non-Majors" at Millsaps
College, Jackson, MS. 2004

Presentations:

"Endangered Species: The
Impact of Silent Spring". 2005
University of Richmond:
Lora Robins Gallery