Biology in Popular Culture
Natural Science Field-of-Study Proposal

1. *Course number* (assigned according to Arts & Sciences guidelines and after consultation with the Registrar's Office) 103

2. *Full course title* Biology in Popular Culture

3. *Catalog description*. Current topics in contemporary biology will be used to introduce students to genetic engineering, stem cells, and the evolution of antibiotic resistance in bacteria. These issues and the impact of this technology will be explored examining their various roles in the medical community and popular culture. Laboratory investigations will emphasize the scientific method allowing for student driven experimentation. Will not serve as basis for further work in science nor meet entrance requirements for any health profession. Three lecture and two laboratory hours per week.

4. *Prerequisites* (if any): none

5. *Number of Unites:*1

6. Estimate of *student enrollment*: 72 students in 3 lecture sections and 4 laboratories

7. *By whom and when the course will be offered* (e.g., whether every year, alternate years, summer session): Paula Lessem and Maren Reiner. This course will be offered as part of the biology courses available for non-science students and will be offered on a rotating basis.

8. *Staffing implications* (regarding any need for additional staff, overloads, reassignments, and changes in the staffing of general education and other courses): Paula Lessem and Maren Reiner will administer this course as part of their regular teaching assignment.

9. *Adequacy of library, technology, and other resources* (to be previewed and certified by the appropriate staff members from the library, computer services, etc.) :adequate

10.*Contact person:* Paula Lessem (plessem@richmond.edu) X6691

B. Biology in Popular Culture: Summary

Controversial biological topics 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 undergraduates. Students will gain exposure (and experience) with tools and techniques common to genetic engineering. Two major issues, stem cells and antibiotic resistance in bacteria (evolution) will serve as the basis for hypothesis-driven laboratory 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 fact from pseudo-science recognizing the need for science literate citizens as they will be instrumental in developing policies (business, government). Though one course cannot adequately address a majority of the controversial issues, it is the intent of this course is sufficiently pique their interest such that they will be strive to be conscientious consumers of disseminated information. They will be challenged to think about, discuss and form opinions about controversial issues (DNA fingerprinting, gene testing, gene therapy, genetic counseling, cloning, use of stem cells and evolution) publicized in the popular culture (newspapers, TV, movies).

This course will fulfill the philosophy of field of study requirement in both the "lecture" and laboratory component. The "lecture" component will be designed to challenge students to address controversial biologically relevane topics providing students various opportunities to question their perceptions and to research course related topics. Resources will include secondary literature, newspaper sources and web sites. Examples of topics to be discussed include bioethics and eugenics, β-lactam resistance (pencillin) using the methicillin resistant *Staphylococcus aureus* currently in the news, tools of genetic engineering (genetically modified organisms), forensics, and stem cells and cancer.

The laboratory component will be hands-on and will include multi-week modules. After preliminary experiments designed to introduce the students to techniques essential for the studies to follow (micropipettors, dilutions) the students will begin the investigative modules. Once the introductory techniques have been presented, the scientific method will be utilized in varied experiments. The first module will involve student-driven hypotheses where they will be able to design their own experiment (significant background and guidance will be supplied) involving the induction of β-lactamase resistance. Further studies, using tools of genetic engineering, will also be hypothesis driven as students will use virtual data to design their experiments investigating molecular biological techniques like the polymerase chain reaction, restriction digestion and agarose gel electrophoresis. The third module will look at gene expression using *Porifera* (sponges) as a model to investigate the utility of stem cells. In this module, students will be able to form hypotheses concerning when genes are being expressed.

In both the discussion and laboratory components, the topics covered will be supplemented with virtual experiments, bioinformatics as well as selected readings. A more detailed outline of the course is provided below.

*This course has been funded by the Associated Colleges of the South. Funds provided will purchase an Edvotek Gel Documentation Center. The Department of Biology will support presentation of this course at a National Meeting (2008).

Biology 103: Course Overview

Introductory topics:

Issues to ponder (suggested): There will be more controversial papers that we will discuss the first two class periods. The intent of these readings is to pique and stimulate student interest

- Is your baby gay?: http://www.radaronline.com/from-the-magazine/2007/03/is_your_baby_gay_1.php
- Eugenics and the Misuse of Genetic Information to Restrict Reproductive Freedom : Board of Directors of the American Society of Human Genetics
- Genes, Embryos, and Future People.

Module I: Lecture: Begin DNA thinking about the impact on students lives: DNA (chromosomal and plasmid) transcription, translation, mutations, meiosis, mitosis

Laboratory Exercises: Laboratory policies, requirements for the group project, laboratory tools: micropipettors, serial dilutions

Module II: Evolution of antibiotic resistance in bacteria: natural selection, sources of genetic variation, mutations, inversions, transposons.
Bacteriologic background: Peptidoglycan: function, synthesis, and role in β-lactamase production, exchange of bacterial DNA: transformation, conjugation
β-lactam antibiotics: efficacy, use, development of multiple generations of antibiotics, origin of antibiotic resistance, specifically β-lactamase , evolution of β-lactamase, relevance of methicillin resistant *Staphylococcus aureus*

Laboratory Exercises: Students will be given the opportunity to plan and design their investigation (for this multi-week investigation) concerning the generation of β-lactam resistance. Preliminary data will include evaluating the antibiotic resistance spectra of different bacterial strains (they will be able to choose from selected bacterial strains) using the minimal inhibitory concentration protocol to a selected panel of β-lactam drugs. After they collect this data, they will decide what question(s) they want to investigate. Some of the questions they can ask include: (We will provide some guidelines to assist them in designing their study)

(1) Which bacteria do they want to use? There will be multiple species available.
(2) What antibiotic will they use as the inducing agent?
(3) What concentration of the antibiotic will they use?
(4) Will they decide to use more than one antibiotic?
(5) Overall, they will construct a hypothesis concerning the evolution of β-lactam resistance.

Issues to ponder:
- Controversy: Kansas School Board, Flying Spaghetti Monster
- Over usage of antibiotics, creation of "superbugs", Methicillin Resistant *Staphylococcus aureus*

Module III: Genetics: impact on students lives: Tools of genetic engineering: agarose gel electrophoresis, restriction digestion, PCR, RT-PCR, genetic testing and screening, gene therapy, cloning- gene, cell, organ (ethical concerns), forensics (paternity, crime scene analysis), genetic counseling (BRCA positive women), and eugenics.

Laboratory exercises: All the exercises that illustrate tools of genetic engineering involve investigating the β-lactamase gene (the gene product is the focus of the previous laboratory module). This will also be a multi-week investigation. The students will isolate a plasmid,

pUR3, from *E. coli.* This plasmid is sequenced illustrating the location of the relevant gene (β-lactamase) as well as restriction sites. Once the plasmid is isolated, the students will select enzymes using the map and a list of enzymes available to them. Preliminary work will investigate restriction digestion using a web based program (see Bioinformatics section). For one "wet lab" experiment, they will use restriction enzymes and will digest the plasmid DNA previously isolated. Another technique, PCR, will be illustrated using the β-lactamase gene. Students will be given the challenge to design the primers (with explicit directions) needed for successful amplification of the DNA. Both the PCR and the restriction digestion will be evaluated using agarose gel electrophoresis.

Issues to Ponder (suggested):

- Can DNA demand a verdict?
- Project Innocence
- Ethical implications of genetic technology
- Role of insurance companies
- BRCA, Parkinson's, and others
- http://www.godsendinstitute.org/home.html

Module IV: Stem Cells – Diversity of Cell Lines and Uses: Background information: definition of stem cells, different cell lines, characteristics of stem cells, uses of stem cells(medical research, tissue repair)
Porifera – why use sponges, characteristics of sponges, basic body plan development, telomerase. If time allows there will be a brief discussion of cancer.

Laboratory exercises: *Microciona* and *Haliclona*, will be used. Students will observe disssacociation of sponges (dissecting microscope), monitor reassociation, and will use PCR (followed the next week with agarose gel electrophoresis) to examine gene expression. Using sponges, samples will be provided representing different stages of sponge development: samples will be processed at day 0, 3 and 5 days. Using these samples, students can construct a hypothesis concerning gene expression in sponges. The genes to be studied will include actin, Six-3, and BarBsh. Students will be able to ask some of the following questions:

(1) Are all genes expressed all the time?
(2) Why might some genes be expressed early in development and others later on?
(3) Can gene expression be demonstrated?

This exercise will illustrate that certain time points in cellular development are critical for specific
genes to be expressed closely relating to the classroom discussion of stem cells.

Issues to ponder (suggested):

- A NEW LOOK INTO CANCER'S ROOTS; SCIENTISTS REVIVE STUDY OF STEM CELLS' LINK TO DISEASE
- Stem Cell Hope, Hype; Save these precious cells and ensure your future health, coax a flurry of new, private tissue banks. They're getting ahead of the science.

- The Nation; LOOSENING OF STEM CELL LIMITS BACKED; The NIH director calls for lifting Bush's federal funding restrictions
- Britain to allow women to donate eggs for stem cell, cloning research with compensation
- Stem cells a priority for new Congress
- Where faith and stem cells meet; Jesus might have us use embryos - otherwise destined to be discarded - to aid the sick and dying

Incorporation of Bioinformatics: Throughout this course, bioinformatics and computer simulations will be used to reinforce concepts discussed in class, perform experiments that are not scheduled in the lab, and to expose the students to the wealth of information available. While they will not have the tools to comprehend the majority of the information attainable, hopefully, they will appreciate the wealth of knowledge accessible if queries are posed. All bioinformatics exercises will be accompanied by detailed guides assisting them closely as they navigate the sites. Prompts will be included to direct their thinking.

1. Phylogenetic analysis: Use of bioinformatics and the http://workbench.sdsc.edu/ site to illustrate the relationship between penicillin binding proteins (PBP) (innate role in construction of the peptidoglycan pivotal to the integrity of bacteria and the site of action of β-lactam antibiotics) with β-lactamases, enzymes whose role is to destroy β-lactam antibiotics. This study will accompany the first laboratory module. To illustrate evolution, students will use the accession numbers of many proteins, either pbp (innate) or β-lactamase. By following the prompts in the "workbench" site, they will be able to visualize the relationship between pbp and β-lactamase.

2. Simulation of restriction digestion of pUR 3 to "cut" the β-lactamase gene out of the plasmid. The sequence and map of this plasmid will be made available to the student. It will be their goal to choose enzymes(s) that will restrict the plasmid and remove the β-lactamase gene with as little as possible extra base pairs. The web based NEB cutter will be used for this simulation and will (http://tools.neb.com/NEBcutter2/index.php) generate DNA fragments. This program enables them to see a virtual gel of the products from restriction digestion. After they have done this they will repeat the process using the enzymes available in our lab. This will provide them with virtual agarsoe gel electrophoresis illustrating the number of DNA bands and their respective sizes that they should obtain in the "wet lab." They will to critically analyze their results to determine which band contains their gene of interest.

3. Primer design for β-lacatamase. The sequence of the plasmid and the β-lactamase gene will be provided for the students. We will show them Primer 3 (http://frodo.wi.mit.edu/) and illustrate the ease (and some of the challenges inherent in primer design.

4. Paternity determination using a web based program: (http://www.sumanasinc.com/webcontent/anisamples/dynamicillustrations/paternitytesting.html This program provides three children, one mother and two potential fathers. The students must use multiple PCR analyses to match up the child with the parent. It includes selections of different markers (illustrating that more than one gene is necessary for a match), virtual gels, and a "family tree" with cartoon pictures of the family.

5. Bioinformatic searching to determine the roles of the three genes amplified from sponge tissue: The students will investigate basically what the potential role of each of these genes. Based on what they find they will predict when, over the three time points explored, this gene will be expressed.

Laboratory Project: For the final laboratory project the students will have to design an interactive exercise to educate others (especially a non-science population) about one of the major topics covered in this course. It is intended that many of these groups will disseminate this information to Richmond Public School (RPS) students, primarily in the middle or high schools. These students need to design an activity, an interactive exercise, or a presentation for use in RPS. It is intended that a select number of student groups (4students/group) will be willing to go to the schools and interact with the students. We will be able to accommodate many groups if there is sufficient interest. This will help to foster a relationship between RPS and UR students. Other groups will develop materials that can be used to enhance biology education in the RPS classrooms covering topics that the teachers do not have time for. In addition, our students can provide resources (activities, references) for enhancement of the experience of the students. James Wright and I have collaborated and we have contacts established at local schools.

Potential Reading Material:
"Stem Cell Now" by Christopher Thomas Scott.
"Next" by Michael Crichton
Other articles and web sites