Development of a Nonmajors Biotechnology Course at the University of Richmond

Joseph Gindhart, Ph.D.
Associate Professor, UR Biology Department

Summary

The objective of this proposal is to develop an introductory-level nonmajors biotechnology course at the University of Richmond. All undergraduates at UR must take at least one science course with laboratory; proposed curricular changes will require students to fulfill this requirement during freshman year. This proposal will provide a summer undergraduate fellowship to assist in the development of the laboratory component of the course, funds for supplies and travel, and summer support. The course, "Biotechnology and Society", will help students gain a better understanding of the scientific, commercial, and ethical issues of biotechnology, and will benefit students by making them better consumers of both products and information.

An issue of great importance in science education is the enhancement of science literacy. Undergraduate curricula are addressing this issue by requiring non-science majors to complete one or more introductory science courses with a laboratory component. When implemented successfully, these courses help students better understand the scientific method and increase science literacy. Biotechnology, the harnessing of biological processes for commercial purposes, impacts everyone, yet most people do not understand what biotechnology is, what it can and cannot do, and why the ethical use of biotechnology is important. The proposed course will provide students with hands-on experiences, case studies, and opportunities to learn what biotechnology companies do, how they work, and the implications of biotechnology in everyday life.

Project Description

A. Goals and objectives

The goal of this proposal is the development and delivery of a biotechnology course for non-science majors at the University of Richmond. Although biotechnology impacts all aspects of our lives, people have a somewhat cloudy understanding of what biotechnology is and what it is not. The general public has a vested interest in how modern agricultural practices affect the food we eat, the progress of efforts to develop new drugs, the ethics and benefits of cloning, forensic science, bioterrorism, and how we can improve the environment. While the interest level of non-science majors for a biotechnology course is potentially very high, no biotechnology course is offered for majors or nonmajors at the University of Richmond. Biotechnology is an excellent way to enhance science literacy, as measured by increase in content knowledge and improved understanding of the scientific method. An informed public can understand the importance of basic science research and critically analyze science policy issues such as stem cells and global warming. The laboratory section of the course will include topics such as recombinant DNA technology, fermentation, protein engineering and purification, biosensors, and natural products. Finally, I plan to explore building connections between the course and the Richmond pharmaceutical and biotechnology industry, the University of Richmond's Pew Initiative on Food and Biotechnology, and the UR Career Development Center (1-3).

B. Background and significance

In 2003, Boston University proposed to build a high-security Biosafety Level 4 (BL4) laboratory in a residential neighborhood in the South End section of Boston. BL4 labs are required for the study of deadly agents such as plague, Ebola and smallpox. There are only a few

BL4 labs in the country; given the current emphasis on preparation for bioterrorism, the need for another BL4 facility was emphasized by local, state, and federal officials, as well as Boston University. The facility, which will employ 1,300 construction and 660 permanent workers, will generate over $1 billion per year in research grants (4). But what are the potential risks to the neighboring community? How likely would it be for an unknowingly infected employee to ride the subway, or for living organisms to escape the lab? Would it be better to build the facility in the "middle of nowhere"? Science literacy is important if citizens wish to understand relevant issues, the relative risks and benefits of the BU research lab, and make an informed decision. The project has been approved recently by the National Institutes of Health, but not before three years of hearings, protests, and lawsuits. The discussion of the pros and cons of building a BL4 laboratory in a city is exactly the type of issue that can engage non-science majors in the quest for science literacy. Furthermore, the discussion of this topic would be enriched by participation of students having diverse interests in subjects like political science, history, and sociology, for they can bring their expertise to bear on the discussion.

C. Project plan

The funds requested in this proposal will be used to develop the lecture and laboratory curriculum, as well as course enrichment activities. The lecture part of the course will be more straightforward, as I will identify the textbook most relevant to my goals, and then use the book as a touchstone for syllabus development. The laboratory part of the course, however, will require a great deal of research and development. I will identify a student assistant who will research possible labs, test whether they work and help illustrate important concepts, and write a lab manual in collaboration with me. I plan to develop contacts with the Pew Initiative on Food and Biotechnology and the Virginia Biotechnology Research Park (1, 2) to find ways to enhance

course content, such as field trips or guest lectures with policy and industry experts. The topics listed below were developed based upon my own experiences and an excellent web site developed by Drs. Dulal Borthakur and David Christopher at University of Hawaii at Manoa (5).

Topics covered in lecture may include:

- What is biotechnology?
- Molecular biology and genetics
- Microbial biotechnology: wine, cheese, and bread
- Medical biotechnology: disease detection, medical products, gene therapy, prenatal screening
- Agricultural biotechnology: plants, animals, selective breeding vs. transgenic organisms
- Aquatic biotechnology: aquaculture of plants and animals, drug discovery
- Environmental biotechnology: biofuels, bioremediation
- Biotechnology industry: regulations, marketing and sales, legal and financial aspects, careers in biotechnology and pharmaceutical industry
- Special topics: pharmacogenomics, bioterrorism, forensics
- Ethical issues: Stem cells, sex selection of offspring, genetic discrimination, privacy of genetic information, genetically modified organisms

The lab section topics listed below are tentative, and reflect the topics proposed for lecture. My goal is to have the two-hour lab section give students a variety of experiences, such as gel electrophoresis, field work collecting environmental samples, computer-based exercises, and pedigree analysis.

Topics covered in the lab may include:

- DNA technology: DNA isolation, PCR, gel electrophoresis
- Microbial biotechnology: making cheese or yogurt
- Medical biotechnology: computer lab- finding online medical information resources
- Agricultural biotechnology: genetically modified organisms
- Aquatic biotechnology: identification of bioactive molecules
- Environmental biotechnology: fecal coliform testing
- Biotechnology industry: field trip to biotechnology company
- Ethical issues: cancer gene pedigrees

D. Prior activities or research related to proposal

I have been a professor at the University of Richmond since August 2004. Prior to my arrival at UR, I was a faculty member in the Biology Department at University of Massachusetts Boston. One of my roles at UMass Boston was Chair of the Biotechnology Committee. The committee developed the curriculum for the undergraduate biotechnology concentration within the major, as well as the Biotechnology and Biomedical Science M.S. program. As chair, I had the opportunity to interact with an industry trade group (Massachusetts Biotechnology Council) and researchers in the public and private biotechnology sector. I was also the co-director on the Boston campus of a multi-campus UMass doctoral program in Biomedical Engineering and Biotechnology (BMEBT). I was involved in developing the curriculum, creating admissions guidelines, and dealing with practical issues such as course delivery by distance learning and sharing of library resources. I have taught cell biology at the undergraduate level for nine years and for six years at the graduate level, contributed to a team-taught majors biotechnology course at UMass, and in fall 2005 developed and taught an upper-level bioinformatics course. My research program is the cell and molecular biology of the microtubule motor kinesin, and is funded by an NSF award. I believe that the perspective gained from my administrative experience at UMass Boston, in combination with my teaching and research, provides me with the perspective and tools to develop a biotechnology course of broad interest.

E. Project timetable

- May-August 2006: Undergraduate research assistant develops lab content
- May-December 2006: Develop course content and syllabus, advise research assistant
- Fall 2008: Deliver course to nonmajors

Note: I would consider developing the course in the summer and fall of 2007, if funds were available for activity during that time period.

F. Requested budget (with justification)

- Undergraduate research assistant: Student will help develop laboratory content by finding appropriate laboratory exercises and testing them in the lab. Requested funds include stipend, fringe benefits, and housing allowance. $4000
- Summer support: Requested funds include two weeks of summer salary for course development. Course will be developed during summer and fall 2006. $3700
- Supplies: Requested funds will procure supplies for testing experiments, research costs at library, i.e. copying costs. $1000
- Travel: Requested funds are for short trips to meet with Pew Initiative in Washington, DC and biotechnology companies. $250
- Total funds requested: $8950

G. Context of course in curriculum

Students at the University of Richmond, as part of our general education curriculum, must take Fields of Study courses in six areas: Historical Studies, Literary Studies, Natural Science, Social Analysis, Symbolic Reasoning, and Visual and Performing Arts. The Biology Department is expected to offer a number of courses each year to allow students to fulfill their Natural Science requirement; it is a challenge, from a staffing and pedagogical viewpoint, to offer courses that appeal to students with a wide variety of interests. Currently, no course in biotechnology exists at the University of Richmond, so this course will increase the diversity of

nonmajors course offerings, and will provide me with the opportunity to contribute to an important part of our curriculum.

The University of Richmond's Task Force on Undergraduate Education (TFUGE) is developing new curriculum requirements that will be voted upon by the faculty this spring. The biotechnology course described in this proposal fits well with the proposed curriculum changes. The new curriculum, if adopted, requires that all first year students take a science course with lab. This "First Year Science Experience" will provide a transition from high school science to science Inquiry Seminars, in which small (~15 student) classes share in-depth exploration of science topics. The Inquiry Seminars have not yet been designed, but it is likely that freshman biotechnology would serve as a launching point for many different types of Inquiry Seminars offered by the Biology Department. Thus, the proposed biotechnology course can fulfill the science general education requirements at the University of Richmond, regardless of whether the new curriculum is adopted.

H. Impact on the institution, including number of students per year

There is no biotechnology course offered at the University of Richmond for majors or nonmajors, so the impact on the curriculum is potentially great. Expected enrollment for this course is 40 students (one lecture and two laboratory sections/semester). I expect that I will teach this course once every 2-3 years, but I welcome the possibility of other faculty teaching the course, which should be straightforward after the course is developed.

I. Evidence of institutional support

Please see the attached letter of support from Dr. Roni Kingsley, Chair of the University of Richmond Biology Department.

Evaluation, Dissemination, and Continued Support

A. Description of evaluation and assessment plan

Student performance will be assessed through exams, short lab reports, and a short presentation about a biotechnology or pharmaceutical company. Students will be able to examine a company from a business point of view, the relationship of the company with local government and the community, or product research and development; emphasis will be placed on companies from central Virginia. I think asking students to find more information about biotechnology companies will help bridge the gap between their expertise in the social sciences, humanities, or business and the science literacy objectives of the course. Instead of students preparing their presentation in Powerpoint, I will build a course web log (blog) where students can create presentations and make them available to their classmates and other interested parties in the "blogosphere". I have used blogs successfully in other courses for posting announcements, student presentations, and extra credit (6).

Measurement of course success will be done through formative and summative assessment. A week or two before spring break, I typically ask students to anonymously answer the following questions: 1) Do you like the class? 2) Is the class too fast, too slow, or just right? 3) Do you have any suggestions? I have received a lot of useful feedback that improves the second half of the course. I also look carefully at summative assessment to get information about how to improve the class the next time it is taught. I will also measure the success of the course in the context of whether I was able to arrange any field trips to biotechnology or pharmaceutical companies, including aquaculture and agricultural applications, and whether I was able to recruit a guest speaker or two who is directly involved in the business, research, or policy aspects of biotechnology. My goal is not to have someone give a lecture about their job,

but to facilitate a discussion about the opportunities that are available to students, even if they do not wish to be a scientist. I recall my surprise, when attending a biotech conference, at hearing a plenary speaker's assertion that many, if not most jobs at a biotechnology company are not in research and development, but are in accounting, law, sales, and other fields. Perhaps I can use this observation to help non-science majors understand the importance and relevance of science literacy.

B. Plan for dissemination of results

The outcomes of course development and delivery will be disseminated in two ways. First, the course blog will provide others with a front-row view of the ebb and flow of the course, both in real time and retrospectively. I can use the blog as an online journal about the course, describing to readers what we will do next and reflect on what we have accomplished during the semester. In addition to helping me document what worked (and didn't work), this exercise will be very useful to students, who want to know where the course is going, and to others, who could potentially use the blog as a resource for designing their own nonmajors biotechnology course. Outcomes of the course will also be showcased at a teaching conference, such as an ACS Science Reform Workshop. Finally, if feedback about the course by students and colleagues is very positive, I will consider writing a manuscript about the course for submission to a science education journal.

Literature cited

1. Virginia Biotechnology Research Park, http://www.vabiotech.com/.

2. Pew Initiative on Food and Biotechnology, http://pewagbiotech.org/.

3. University of Richmond Career Development Center, *Biotechnology Career Minute*, http://cdc.richmond.edu/careerminute/biotechnology.html.

4. Smith, S. *Biosafety lab in South End gets final approval*. Boston Globe, February 2, 2006.

5. University of Hawaii at Manoa, *Biotechnology: Science and ethical issues*, http://www.ctahr.hawaii.edu/mbbe/courses/mbbe304.html

6. Gindhart, J. *BFG@University of Richmond*, http://bfgur.blogspot.com; *Cell Biology in the News*, http://legiblyloco.blogspot.com.

CURRICULUM VITAE

Joseph G. Gindhart, Jr.

EDUCATION

1993-1997	Postdoctoral Research Fellow, Laboratory of Lawrence S. B. Goldstein, Howard Hughes Medical Institute, Division of Cellular and Molecular Medicine, UCSD School of Medicine, La Jolla, California.
1988-1993	Doctor of Philosophy, Program in Genetics, Indiana University, Bloomington, Indiana. Dissertation: Developmental Regulation of the *Drosophila* Homeotic Gene *Sex combs reduced*. Advisor: Thomas C. Kaufman, Ph. D.
1984-1988	Bachelor of Arts, Biology, University of Pennsylvania, Philadelphia, Pennsylvania, May 1988.

TEACHING EXPERIENCE

2004-present	Associate Professor, Department of Biology, University of Richmond, Virginia.
1997-2004	Assistant Professor, Department of Biology, University of Massachusetts Boston, Massachusetts.
Fall 1991	Associate Instructor, Department of Biology, Indiana University, Bloomington, Indiana.

Courses taught

2005-2006	Cell and Molecular Biology w/ Laboratory (Biol 205, 4 credits)
Fall 2005	Introduction to Bioinformatics and Functional Genomics (Biol 351, 4 credits)
Fall 2004	Advanced Cell and Molecular Biology (Biol 307, 3 credits)
Fall 2004	Genetics Laboratory (Biol 201, 1 credit)
1999-2003	Current Topics in Cell Biology (Biol 653, 1 credit)
1998-2004	Cell Biology (Biology 210, 4 credits)
1998-2003	Advanced Cell Biology (Biology 612, 3 credits)
1997-2000	Directed Readings (Biol 672, 1 credit)
1991	Genetics (lead teaching assistant)

PUBLICATIONS (since 2000) *undergraduate students; **graduate students

Gindhart, J. G. (2006) Towards an understanding of kinesin-1 dependent transport pathways through the study of protein-protein interactions. Briefings in Functional Genomics and Proteomics, doi:10.1093/bfgp/ell002.

Welte, M. A., Cermelli, S., Griner, J., Viera, A., Guo, Y., Kim, D.-H., Gindhart, J. G., and Gross, S. P. (2005). Regulation of lipid-droplet transport by the Perilipin homologue LSD2. Current Biology **15**, 1266-1275.

Gindhart, J. G., Chen, J.**, Faulkner, M., Gandhi, R., Doerner, K.*, Wisniewski, T. P.**, and A. Nandelstadt** (2003). The kinesin associated protein UNC-76 is required for axonal transport in the *Drosophila* nervous system. Molecular Biology of the Cell **14**, 3356-3365.

Wisniewski, T. P.**, Tanzi, C. L.**, and J. G. Gindhart (2003). The *Drosophila* kinesin-I associated protein YETI binds both kinesin subunits. Biology of the Cell **95**, 595-602.

Bowman, A. B., Philip, A. V., Ritchings, B. W., Kamal, A., Laymon, R., McGrail, M., Gindhart, J. G., and L. S. B. Goldstein. (2000). Kinesin dependent axonal transport is mediated by the Sunday driver protein. Cell **103**, 583-594.

External Grant Support

2006-2009	Beckman Research Foundation, *The Initiative for Scientific Discovery and the Beckman Scholars Program*, J Gindhart, PI, $96,500.
2004-2007	National Science Foundation Award, *Function of Kinesin Associated Proteins in the Drosophila Nervous System*, MCB-0342761, J. Gindhart, PI, $360,000.
2001-2004	National Science Foundation Award, *Research Experiences for Undergraduates in Biology*, DBI-0097685, J. Gindhart, PI, R. Skvirsky, Co-PI, $198,000.
1999-2003	National Science Foundation Award, *Mechanisms of Kinesin-Cargo Interactions in Drosophila melanogaster*, MCB-9974835, J. Gindhart, PI, $331,185.
1994-1997	National Institutes of Health Individual NRSA Postdoctoral Fellowship, *The In Vivo Function of Drosophila Kinesin*, 1 F32 GM16068-01A1, $66,250.
1988-1991	National Institutes of Health Predoctoral Genetics Training Grant, Indiana University, GM07757-13.

UNDERGRADUATE RESEARCHERS (*Honors; ^McNair Fellow; #Research Experiences for Undergraduates)

University of Richmond

2005-2006	Mark McCommons, Beccy Josowitz, Michelle Kosovec, Katie Weber, Kevin Miller
2004-2005	Mark McCommons, Beccy Josowitz, Michelle Kosovec, Ashley Randolph (HHMI Pre-Freshman Program)

University of Massachusetts Boston

2002-2003	Caroline Tschibelu*, Collins Kwarteng*^, Ivana Djuretic*
2001-2002	Caroline Tschibelu, Anne Von Phillipsborn (University of Freiburg exchange student) Jens Dietrich (University of Freiburg exchange student), Kate Lowenthal, Collins Kwarteng#
2000-2001	Karl Doerner*, Gwen Lambert, Adam Goetzel, Caroline Tschibelu, Kate Lowenthal#
1999-2000	Gisele de Oliveira*, Rani Sadek, Voula Christopolos, Leykza Velez, Karl Doerner#, Katrina Sergeev#, Alex Rivest#
1998-1999	Rene Maehr (University of Freiburg exchange student), Kathrin Linkemann (University of Freiburg exchange student), Allison Williams^, Iyore Otabor^, Rani Sadek, Dave Prodanas, Karl Doerner, Oleg Broytman#
1997-1998	Hans Auguste*, Thi Nguyen, Ralph Eugene, Tuba Syeda, Allison Williams, Mieu Vo#, Audeline Eugene (Hyde Park High School)

Disclosure statement

Current support

2006-2009 Beckman Research Foundation, *The Initiative for Scientific Discovery and the Beckman Scholars Program*, J Gindhart, PI, $96,500.

2004-2007 National Science Foundation Award, *Function of Kinesin Associated Proteins in the Drosophila Nervous System*, MCB-0342761, J. Gindhart, PI, $360,000.

Pending support

Summer 2006 Beccy Josowitz, NSF REU Supplement (pending)

Summer 2006 Kevin Miller, NSF REU Supplement (pending)