CATL Scholar Program
Center for the Advancement of Teaching and Learning

Application due: February 28, 2006 (5 p.m.)
Please submit a paper copy of the signed cover sheet to Peter Felten, Holland House 109 (CB 2610)

Cover Sheet

Your name	Jeffrey S. Coker
Department	Biology
School/College	Arts and Sciences
Rank/title	Assistant Professor
Years of service at Elon **by 5/31/06**	2
Campus box	2625
Office phone	6206
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Title of proposed project:
"Reinventing Life": A New Paradigm for Biology Teaching and Learning

Short abstract of the project (<100 words):

The goal of this project is to pioneer the most engaging model for teaching and learning biology in the United States. The course title "Reinventing Life" describes the futuristic nature of both the content and the pedagogical approaches. Although the content and pedagogy will stem from fundamental biological concepts and proven teaching methods, respectively, the course will attempt to stretch 10-50 years into the future in both areas. All things considered, Elon has the potential to be a national leader in teaching biology to non-scientists in a century when biology is changing society (through genomics, cloning, stem cell research, environmental pressures, etc.). This course will be a major step in that direction, and will mark a transformational change in non-majors Biology education at Elon and in the country.

Five–year history of grants awarded to you by Elon's FR&D Committee (list date and nature of each grant):

None.

Have you been awarded, or applied for, financial or other support (reassigned time from Elon, external grant funding, etc.) during the time that you would be a CATL Scholar (2006-08 academic years)?

I am currently scheduled to have 4 hours of reassigned time in the spring of 2007.

Department chair's comments on this proposal:

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Chair's Signature

Dean's comments on this proposal:

_____

Dean's Signature

"Reinventing Life":
A New Paradigm for Biology Teaching and Learning

Jeffrey S. Coker
Department of Biology

Abstract

The goal of this project is to pioneer the most engaging model for teaching and learning biology in the United States. The course title "Reinventing Life" describes the futuristic nature of both the content and the pedagogical approaches. Although the content and pedagogy will stem from fundamental biological concepts and proven teaching methods, respectively, the course will attempt to stretch 10-50 years into the future in both areas. All things considered, Elon has the potential to be a national leader in teaching biology to non-scientists in a century when biology is changing society (through genomics, cloning, stem cell research, environmental pressures, etc.). This course will be a major step in that direction, and will mark a transformational change in non-majors Biology education at Elon and in the country.

Course Content

"Reinventing Life" will teach the basics of biology in the context of the seminal paradigm of the 21st century – rapid change of the diversity and genetics of life. The preliminary course description for "Reinventing Life" is provided below:

> An investigative approach to how the diversity and genetics of life are changing in the 21st century. We are driving many organisms to extinction at the same time that technology has allowed us to genetically engineer organisms and even create new ones. What exactly are we doing to life?

> Can we responsibly direct evolution? Topics include environmental manipulation, genetic engineering, reproductive ethics, bioinformatics, synthetic biology, and space biology. Satisfies the general studies laboratory science requirement. No credit toward biology major or minor.

Make no mistake that we are literally reinventing life on this planet. For the most part, we are doing so through the unconscious momentum of society with little thought about consequences. "Reinventing Life" will challenge students to address present and future dilemmas that have not yet been unified into an introductory course. Keeping in mind that this is likely the last Biology course these students will ever take, the content goal is to teach the basics of biology in such a way that students are prepared for the major paradigm shifts that will take place during their lifetime.

Course Pedagogy

"Reinventing Life" represents a transformational change as it integrates six components which are research-proven but uncommon in introductory Biology courses.

1. **Directed inquiry-based learning**. Designing and doing experiments is the best (and perhaps only) way to truly understand the process of science. "Directed" means that students will receive some basic instructions and will be given an overall direction, but the students themselves decide how experiments should be performed. This approach contrasts with "confirmational" inquiry approaches (i.e. cookbook labs) where students are confirming a known answer using a standard set of directions.
2. **Integrated class/lab.** The same instructor will teach class and lab, maintaining continuity between the two. The typical class/lab distinction will be blurred as much as possible in that experiments and hands-on inquiry-based learning will be used in "class" and "lab."
3. **Readings are articles.** Many major scientific societies and governmental agencies are making science education materials publicly available over the internet. Much of this material is higher in quality than any commercial textbook, undergoes a more rigorous peer-review, is more recent, provides examples of the scientific process in action, and has a

societal context. (Note: This may also morph into a futuristic textbook concept, which has already been requested by a major textbook company).

4. **Pedagogical diversity.** This course will integrate experiments, demonstrations, case studies, and other types of active learning so that each class period is a unique interactive experience. This will heighten learning experiences for all and provide models for how to teach science for our Education majors.

5. **Intensive use of technology, math, and graphing**. Elon has outstanding computer resources which are not being fully utilized in our laboratories. This course will better integrate the use of computers and other technology into data collection and analysis aspects of experiments. Related to this, more emphasis will be placed on basic skills such as math and graphing (General Studies priorities that we frequently overlook).

6. **Emphasis on information gathering/evaluation.** The assessment of the "reliability of information related to biology" is an essential lifelong learning skill. This is an area where curricula and pedagogy have not caught up with our Information Age.

All of these characteristics represent shifts in the landscape of non-majors Biology courses (although some have been implemented piecemeal).

An example of the unified content and pedagogy

Each student will prepare a sample of their own DNA using standard laboratory techniques and then submit purified DNA to Dolan DNA Learning Center at Cold Spring Harbor Laboratory to be sequenced. After students get their sequences back (2-3 weeks), they will then use publicly available bioinformatics tools on the internet to compare and analyze their own sequences. This investigative inquiry will provide several weeks of intense student engagement. Imagine it… Students will have the opportunity to analyze their own DNA and investigate their own relatedness to other peoples and organisms. Note that the author of this proposal is an expert in the area of DNA sequencing and analysis and has experience doing both with students (so this can work). Nevertheless, this will be the first time anything like this has taken place on the Elon campus. This

activity will take the mantra "Know Thyself" to the most literal level ever devised by humans, and will allow students to personally connect with and understand concepts and issues of evolution, genetic engineering, and reproductive ethics.

Student Involvement in Development, Implementation, and Assessment

Over the last year, I have hosted 4 students in hybrid Biology/Education research projects. Both students from last spring have already co-authored professional work (book review in the American Biology Teacher; poster at the American Association for the Advancement of Science conference; publication in review at the American Biology Teacher). Two of my students this semester are future high school biology teachers who are co-majoring in Biology and Education. I intend to continue involving future science teachers in my teaching and scholarly activities as it encourages them to adopt scholarly teaching practices that could serve them well for decades. I also intend to find similar students (hopefully the same ones participating in course development) to serve as Teaching Assistants for the labs. The first such student, Sarah Starkey (Education major), has already arranged to work with me on this course in the Fall.

Evaluation

Two models will be explored in order to achieve an ambitious evaluation goal: to both qualitatively and quantitatively evaluate the effectiveness of teaching and learning on an activity-specific level. This must be considered the gold-standard of scholarly teaching, as it would allow tangible, specific improvements to be made to course materials and would allow a variety of educational research projects. How could this be

achieved in a practical way? I plan to investigate two models that would digitize and automatically summarize student evaluations in real-time for daily use: Personal Response Systems (PRS) and a system where all students have laptops with a wireless connection where they can instantly connect with online evaluation instruments. I am currently surveying students to assess the feasibility of the latter approach.

Overall course evaluations and pre- and post-surveys will be compared with those of other models for teaching Introductory Biology, including previous Bio 101/102 courses taught by the author of this proposal, as well as other models used by other instructors at Elon and elsewhere. In my own Biology 101/102 sections, I have been pre- and post-testing for 2 years already to provide baseline comparisons. The fundamental questions in comparisons will include the following: How does content knowledge change? How does comfort with science change? How does understanding of the processes of science change? How does overall student satisfaction change?

Finally, several other evaluation methods will be employed, including review by an external evaluator, videotaping, and adoption of a national inquiry inventory for comparison with other inquiry-based teaching models around the country.

Dissemination

All course materials will be available to Elon faculty to teach other sections of this course as desired. Furthermore, key pedagogies will be videotaped for dissemination of teaching methods. Videos will be especially useful for the population of Adjunct Professors that frequently teach Biology courses for non-science majors on our campus. Ultimately, everyone in the world will have access through scholarly publications and a

"Reinventing Life" website which links to the articles mentioned above, and possibly a futuristic textbook/coursepack.

Currently, I am Chair of the Education Committee for the N.C. Academy of Science, a member of the Education Committee for the American Society of Plant Biologists, and on the Boards of two national journals of science education. Thus, I am uniquely positioned to disseminate these ideas in a variety of state and national settings.

Uses for time and stipend

It seems obvious enough that recreating introductory Biology with a complementary lab (in a scholarly way) is a major time commitment.

Funds would be used primarily for supplies for experiments and inquiry-based activities, including those needed to prepare samples of student DNA. Some funds will also be used to videotape some class/lab sessions for evaluation and dissemination of teaching methods. Any leftover funds will be used as student stipends/travel.

Supplement 1: Timeline

Summer 2006	First course offering (with no laboratory; already arranged). **Focus:** Develop core content and pedagogy.
Fall 2006	First course offering with laboratory. Trial use of laptops and/or PRS technology. **Focus:** Develop and integrate inquiry-based laboratory.
Winter 2007	Thorough analysis of course evaluations; course improvements.
Spring 2007	Second course offering with laboratory. **Focus:** Full integration of new class, laboratory, and PRS/laptop system.
Summer 2007	Thorough analysis of course evaluations; course improvements.
Fall 2007	Third course offering with laboratory. **Focus:** Further refinement of course.
Spring 2008	Fourth course offering with laboratory. **Focus:** Release "Reinventing Life" on state level (NCAS).
Summer 2009	Thorough analysis of course evaluations; course improvements. **Focus:** Release "Reinventing Life" on national level (AAAS, NABT).

Supplement 2: Recent Peer-Reviewed Publications

The author is an active scholar in both pedagogy and the content area, and will be able to translate a CATL Scholar award into tangible products of national significance.

Coker, J.S. and Johnson, A. 2006. Using presidential elections to engage students in science issues. Submitted to the American Biology Teacher.

Coker, J.S. and Davies, E. 2006. Incentives for mentoring undergraduate and high school student researchers in plant biology. Submitted to the Journal of Natural Resources and Life Sciences Education.

Coker, J.S., Vian A., and Davies, E. 2006. Fire damage causes the systemic up-regulation of a set of highly conserved transcripts in tomato plants. Submitted.

Coker, J.S. 2006. Citing by example: Responsible science teaching in the information age. Journal of College Science Teaching. In press.

Coker, J.S. and Agnew, J.D. 2005. The story of dinosaur evolution. National Center for Case Study Teaching in Science Case Collection. http://www.sciencecases.org/dinosaur_evolution/dinosaur_evolution_notes.pdf.

Coker, J.S., Vian A., and Davies, E. 2005. Identification, accumulation, and functional prediction of novel tomato transcripts systemically up-regulated after fire damage. Physiologia Plantarum 124: 311-322.

Coker, J.S. and Van Dyke, C.G. 2005. Evaluation of teaching and research experiences undertaken by botany majors at N.C. State University. NACTA Journal 49: 14-19.

Coker, J.S. and Davies, E. 2004. Identifying adaptor contamination when mining DNA sequence data. Biotechniques 37: 194-198.

Coker, J.S. and Davies, E. 2003. Selection of candidate housekeeping controls in tomato plants using EST data. Biotechniques 35: 740-748.

Coker, J.S., Jones, D., and Davies, E. 2003. Identification, conservation, and relative expression of V-ATPase cDNAs in tomato plants. Plant Molecular Biology Reporter 21: 145-158.

Coker, J.S. and Davies, E. 2003. Sequencing and analyzing a cDNA library. Biology Lab Clearinghouse – Genetics section. http://blc.biolab.udel.edu/Coker-Davies/.

Coker, J.S. and Davies, E. 2002. Involvement of plant biologists in undergraduate and high school student research. Journal of Natural Resources and Life Science Education 31: 44-47.

Coker, J.S. and Davies, E. 2002. Correspondence re: A.H. Ree et al., Expression of a Novel Factor in Human Breast Cancer Cells with Metastatic Potential (Cancer Res., 59: 4675-4680, 1999). Cancer Research 62: 4164-4165.