Huckabay Teaching Fellowship Proposal
Applicant: Jevin West
Mentors: Dr. Benjamin Kerr and Dr. Carl Bergstrom

The Evolution of Teaching Evolution

''Research has taught us a great deal about effective teaching and learning in recent years, and scientists should be no more willing to fly blind in their teaching than they are in scientific research.''—Bruce Alberts, former President, National Academy of Sciences[1]

The Problem

"Is America flunking science?" This was the cover story of a recent edition of Time. Data has shown that "the quality of education in math and science in elementary and high schools has plummeted" and that the Federal Government "has steadily been cutting back on investment in research and development" [2]. In response a remarkable consensus has recently formed among business leaders, elected officials and scholars that science and engineering education must be improved to maintain our innovative edge in an increasingly competitive world economy [3]. Yet, in the midst of this revamping of our educational system, one of the most important, unifying concepts in science—evolution—is being attacked by those promulgating "intelligent design" (ID).

Because ID proposes a complete attack on naturalistic approaches, this movement not only affects evolutionary biology, but science as a whole. University presidents around the country believe that "this matter has become so urgent" that they have made it a central subject in their addresses[4]. Despite the nearly unanimous acceptance within the scientific community, evolution is one of the most widely misunderstood concepts among the general public. For example, a November 2004 Gallup poll revealed that only 37% of Americans (and only 52% of college graduates) consider evolution to be "a scientific theory supported by the evidence" [5]. Consequently, this misunderstanding has turned into "opposition so vocal in the U.S. that it has threatened federal funding of evolutionary research" [6]. This comes at a time when evolutionary biologists have been called to aid farmers in combating insecticide resistance; to help doctors in preventing the proliferation of antibiotic resistance; and to assist epidemiologists in battling infectious disease like the SARS coronavirus, H5N1 avian influenza, HIV, tuberculosis, malaria and a host of others[7]. When asked where we would be in our fight against deadly viruses without the tools of evolutionary theory, director for the Centers for Disease Control, once flatly remarked, "potentially dead!" [8].

This (primarily American) controversy over evolution may be due to literal readings of religious texts, dubious political motivations, or the mistaken assumption that, in science, any conflicting view deserves equal emphasis; however, there may be an alternative explanation that too often gets overlooked—ill-founded pedagogical techniques[9]. Postsecondary science educators commonly underestimate the value of investment in teaching. This may contribute to the fact that most college graduates lack critical thinking skills for comparing conflicting ideas and deciding which arguments, scientific or otherwise, are well-founded. Some of these college graduates become influential leaders in society, not the least of which are high school teachers.

Indeed, there is no profession that will have a greater effect on the state of science education and how its associated debates play out in society than high school biology teachers. Unfortunately, "college science classes have prepared so few of the teachers to do it" [9] and, thus, have left a heavy burden on high school teachers. In a recent study, it was found that teachers felt that "they could be more effective in teaching evolution if they possessed the most up-to-date information about evolution and genomics…and access to richer lesson plans" [10]. If scientists are going to communicate the importance of evolution to the general public, success will come through high school biology teachers.

The Project

The Huckabay fellowship would be used to design a course that would prepare prospective teachers for dealing with this socially controversial issue. The class would be different from what has been offered so far. First, the class will be much smaller than previous courses in evolutionary biology. This will allow for student-student discussions and more student-instructor interactions. Second, the course will center on evolution as an *applied science*. We think that this will better demonstrate the usefulness and importance of evolution in science and technology. And, third, each week will consist of a either a field trip (e.g., trips to the Burke Museum, visits to labs applying evolutionary theory) or lab exercise (e.g., antibiotic resistance, viral evolution). The field trip or lab exercise will be followed up that same week with an online discussion via the Catalyst discussion board and an in-class instructor-led, student-student discussion related to the trip or exercise.

The follow-up discussion will center on two things: (1) foundational knowledge in evolution and (2) pedagogical techniques for teaching evolution. Foundation knowledge discussions will revolve around issues like the following: what evolution is, why it is important and how it is conducted; the use of vernacular terms in society like "theory," "adaptation" and "fitness"; and the supposition of the mutual exclusivity of religion and science (a supposition undermined by the very existence of religious scientists and religious leaders endorsing evolution education; indeed, many within both communities believe that it is a disservice to religion and science to pit them against each other).

Pedagogical discussions will revolve around questions like the following: are teleological and anthropomorphic explanations appropriate for the classroom; is constructivism and engagement of a student's preconceptions an effective way to teach evolution; and how valuable is the lab experience in evolutionary biology? There will also be a few guest-led discussions by world-renowned scientists in this field. In addition, each student will put together a project about some hands-on approach they would use to teach evolution in their own high school class. We hope to implement one, if not more, of the projects in a real high school biology classroom.

Jevin will work closely with Dr. Ben Kerr and Dr. Carl Bergstrom in developing the details of the curriculum. Jevin has met with Dr. Helen Buttemer, Director of Biology Programs for Teachers at UW. He also has received an endorsement from Dr. Tom Daniel, the department head, to teach this course, if he were to receive the Huckabay fellowship. We feel that this class will be a unique opportunity for these students to see first-hand how this socially debated topic is used on this campus and around the world in hopes of better preparing them for questions from students like "what is evolution good for anyway?"

Assessment

This class is unique in that the students themselves will be future teachers, so this puts a twist in the traditional assessment of the course. Not only do we have to (1) assess the students' comprehension of the course and Jevin's teaching strategies, but we must also (2) assess the students' own pedagogical development to gauge their effectiveness as high school teachers of this subject matter. With regards to the first part of the assessment, Jevin will meet with his mentors on a weekly basis during the preparation quarter and during the quarter of the class. A journal will be kept for self-assessment and reflection. We will arrange in-class visitations by staff from the Center for Instructional Development and Research. We will evaluate prior and post knowledge of evolutionary biology using Catalyst tools. In addition, we will use the standard Office of Educational Assessment to evaluate this class performance compared to other evolutionary biology classes. Jevin will also design a class website using Catalyst web tools that will include a class discussion board and anonymous questionnaires of student feedback. With regards to the second part of the assessment, we will follow up on one or more of the students as they employ their own teaching strategies (the fruits of their final project) in a real high school biology class environment. We will employ the same assessment strategies described above to the high school students to gauge the effectiveness of our students' (i.e., the future high school teachers) pedagogical development. We hope that all of this assessment can be used not only by Jevin, the mentors and our students, but also by others outside this class. For example, we hope to publish our assessment in an education journal or post it to AAAS, NCSE or SSE[11].

References

1 Committee on Undergraduate Science Education. 1997. *Science teaching reconsidered: A handbook.* (p. v) National Academy Press, Washington, DC.

2 Lemonick, M. (Feb. 13, 2006) Are we losing our edge? *Time*. Vol. 167, No. 7

3 Alan I. Leshner, chief executive officer, *American Association for the Advancement of Science*. March 19, 2006 http://newsok.com/article/1790749/

4 State of University Address, Dr. Hunter Rawlings III, President, Cornell University. Oct 21, 2005 http://www.cornell.edu/president/announcement_2005_1021.cfm

5 Bergstrom, C. Teaching Evolution as an applied science: the value of examples from infectious diseases. *American Geological Society newsletter*. 2006 (in press)

6 Futuyma, D. J. (1999) *Evolution, science and society: Evolutionary biology and the national research agenda.* Office of University Publications, Rutgers, The State University of New Jersey, New Brunswick, NJ. (p. 43)

7 Feldman, M, et al. 1997. *The White Paper.* Endorsed by American Institute of Biological Sciences, National Science Foundation

8 Scharmann, L. (Jan. 2005) A Proactive Strategy to Teaching Evolution. *The American Biology Teacher*. Vol. 67, No. 1

9 Nelson, C. (Nov. 2005). How can we help students really understand evolution? *Bioscience.* Vol 55, No. 11, p. 923

10 Griffith, J. (Feb. 2004) Teaching Evolutionary Biology: Pressures, Stress, and Coping. *Journal of Research in Science Teaching*. Vol.41, No. 8, p. 791-809

11 American Association for the Advancement of Science (AAAS), National Center Science Education (NCSE), Society for the Study of Evolution (SSE)

Huckabay Teaching Fellowship Application: Student Statement
Jevin West

Reasons for interest

A large part of why I came to grad school was to teach. One of the goals I have while at UW is to design and teach my own course. The Huckabay Fellowship would be an excellent opportunity for that. In addition, the project that my mentors and I have proposed is something I feel very strongly about. I am a PhD student in the biological sciences but am very much interested in what happens outside the walls of academia. One issue outside the walls—the evolution debate—has reached every corner of our society, even the White House. The debate, however, suggests to me that there may be a failure in an aspect of basic science education.

The overriding goal of this project is to improve science education. As a grad student studying evolutionary biology, I come to this subject matter with great personal interest. I believe that this controversial issue has engaged the public and therefore provides an opportunity for demonstrating what science is and is not and how it is conducted. The most meaningful impact I can have on the current state of public understanding of evolution is to support and interact with those on the front lines of this issue—high school science teachers. No group will be better for communicating this socially controversial issue to the public than high school science teachers.

Qualifications

Teaching: I feel very lucky as a grad student. I have had the opportunity to TA for the equivalent of 7 quarters already. During my Masters and now PhD, I have been a TA for classes ranging from Human Anatomy to Plant and Animal Physiology. I have given lectures and developed new lab exercises. I have received the highest marks as a TA, including student evaluation comments like "the best TA I have ever had"[1]. I have had the chance to teach extensively outside of science, as well. For example, I was a tennis-pro and instructor for two years. Interestingly, some of my best in-class pedagogical ideas have come from this experience. I have also had the chance to tutor students from elementary school to undergrads. I am currently tutoring a high school biology student. I even had the chance to mentor a 9 year-old prodigy enrolled in college courses.

Knowledge: My mentors and I propose a course that involves a socially controversial issue. I am sensitive to the reactions some people have to this topic. Recently, I have taken steps to increase my knowledge in this area. I am a part of UW's FOSEP committee (Forum on Science and Ethics and Policy), which deals directly with this issue. Spring quarter I will be taking Biol484 (a course on the intelligent design controversy). Last quarter I rotated in an evolutionary biology lab, gaining the necessary skills to teach this course. I have received an RA to work with a theoretical biologist who uses evolutionary tools to predict the potential spread of an avian flu pandemic. I have read extensively on the societal controversy surrounding evolution and have spoken in public forums about evolution. Most recently, I spoke to a Seattle book club about what evolution is from a scientist's point of view. This summer I will be working with several faculty in Biology, developing a lab course for biology majors that deals directly with evolutionary concepts. These experiences and others, I feel, have and will prepare me for this project.

Place, time and people: UW is an ideal place for teaching a course like the one we propose (with access to some of the world's finest biological laboratory facilities, the Burke Museum, modern genome technologies, Friday Harbor Laboratories and faculty working on many aspects of evolutionary biology). Because of the recent media attention devoted to the evolution debate, this is an ideal time to teach this course. Controversial issues are effective tools in engaging students and teachers, and this issue in particular is an excellent opportunity to illustrate epistemological issues that arise in evolutionary biology. This quarter I will get the opportunity to meet with Eugenie Scott, the Executive Director for the National Center for Science Education, and Bruce Alberts, the former President of the National Academy of Sciences—both who are passionate about science education. I hope to get their input on this course. The mentors I have chosen to collaborate with for this course are ideal for the following reasons: they are both experts in the field of conducting and teaching evolution and feel as passionate as I do about this subject; Dr. Bergstrom is a nationally recognized leader in evolution education, speaks at national meetings on the subject and published a number of popular and semi-popular chapter, op-eds and articles on evolution education. Dr. Kerr has conducted and taught various aspects of evolution, including designing labs for teaching evolution. He has also given talks on the debate, exploring the social and foundation side of evolution and will be teaching a course on the intelligent design controversy this quarter.

Tasks to perform

The Huckabay fellowship will be used to develop the proposed course during the fall quarter. I will then teach the course the following winter quarter. The tasks that I will perform to prepare for teaching of this class will include, but are not limited to, the following: (1) reading relevant literature and developing a reading list (2) arranging visitations for in-class critiques by staff from the Center for Instructional Development and Research (3) development of a class website and discussion board using the Catalyst web tools, (4) designing lab exercises with the help of faculty within the Department of Biology, (5) arranging field trips to the Burke Museum, Friday Harbor and Genome Sciences building, (6) meeting with nationally recognized advocates for science teaching, like Eugenie Scott and Bruce Alberts, (7) developing computer simulations for demonstrating difficult-to-understand concepts, (8) coordinating speakers' schedules, (9) maintaining a personal journal on the assessment of the class and my teaching, (10) formulating questions for the student discussions, (11) developing the details of teaching and assessment strategies, (12) preparing video for each in-class discussion and presentation to be recorded, (13) attending relevant CIDR workshops and classes and (14) and meeting weekly with my mentors. Following the teaching of the class, I would like to reflect on my teaching experience by writing a paper for publication in a pedagogical journal in order to share the results widely with interested teachers.

[1]Reviews available on request

Huckabay Mentors' Statement
Applicant: Jevin West
Mentors: Carl Bergstrom and Ben Kerr

Our interest in the project:

We are both thrilled to have this opportunity to write on behalf of Jevin West and to express our fullest support for his Huckabay proposal. There are two reasons we are so enthusiastic about this proposal. First, Jevin is proposing a project that we feel passionate about ourselves. As evolutionary biologists, we have been actively following the judicial, political and cultural events surrounding the teaching of evolution in our public schools. In the public sphere, we feel there is substantial misunderstanding about the nature of science generally and evolutionary science specifically. We feel that at least part of this misunderstanding is due to faulty instruction about how scientists explore the natural world. We are both dedicated to exploring more effective ways to communicate scientific methodology (see below) and we feel a course tailored to future high school teachers is one of the most meaningful ways to develop effective scientific pedagogy. The second reason for our enthusiasm is that Jevin has all of the characteristics that will make this project successful. Jevin is superbly creative and innovative in his teaching. He uses a variety of forms of active learning and his style is tremendously engaging. Whenever he gives seminars or guest lectures, the feedback from the audience and students is uniformly positive. Not only is he a fine instructor, but he is deeply passionate about the subject of science education (reading voraciously on the subject, talking to the public about it, and exploring the most effective ways to share information). Jevin is the ideal person for a course that is ideal to offer at this moment in time.

Our qualifications for the project:

Carl Bergstrom has repeatedly taught the evolution section to the introductory biology course (BIOL 180). In this course, he co-designed a laboratory exploration on antibiotic resistance (using bacteria from the skin surfaces of students). Carl will be teaching a "Foundations in Evolution" course (BIOL 354) this coming year that will explicitly explore evolutionary issues in epidemiology. Carl is featured on UC Berkeley's popular website "Understanding Evolution" discussing evolutionary modeling and microbial evolution (http://evolution.berkeley.edu/evolibrary/article/0_0_0/bergstrom_01). Carl is a nationally recognized leader in evolution education, speaking regularly at meetings on the subject. He has published a number of popular chapters, op-ed pieces and articles on effective education of evolutionary science.

Ben Kerr's research focuses on experimental evolution using microbial populations (bacteria, viruses and yeast). Ben has designed laboratory exercises (using bacteria and viruses) to illustrate evolutionary change in real-time (e.g., most recently for BIOL 562 this previous autumn). This quarter, Ben will be teaching an upper-level undergraduate seminar (BIOL 484) that explores the nature of science in the era of the intelligent design controversy. In collaboration with two other Biology faculty members, Ben will be developing and teaching a course entitled "Experimental Evolutionary Ecology" this coming autumn, which will be a hands-on approach to understanding evolutionary phenomena using experiments (in the laboratory, greenhouse and field). Ben has also given lectures on several different occasions on the nature of science and the intelligent design debate.

Our proposed involvement in the project:

We plan to be involved in all stages of this project—its planning, the course itself, and the assessment afterwards. We expect this to be a rich learning experience for Jevin (in taking a leading role in the development of a course on a controversial, but important, subject). Here we outline our specific roles.

Planning of the course:
We will work with Jevin to develop his syllabus by picking reading material that best strengthens understanding of basic evolutionary content and provides effective pedagogical strategies in the instruction of evolutionary biology. Together with Jevin, we will design, test, and write up effective laboratories to illustrate key evolutionary concepts. We will draw on our own experience to build hands-on real-time experiments with microbes (e.g., bacteria and viruses). We will also help design computer simulations, where students can explore evolution of artificial life and where students can use real genetic data to infer relationships between genetically sampled organisms (using modern phylogenetic tools). We will help arrange for trips to the Burke museum (where students can explore fossils and talk with paleontologists about the role of evolutionary biology in their work) and we will plan to involve several other UW faculty members that use evolutionary biology in a number of different ways (both inside and outside the Biology department).

Running the course:
We will both sit in on the course and its labs. Also, we will both lead one student-student discussion. We will regularly meet with Jevin during the quarter to assess how the course is running and what adjustments might be implemented. We will solicit the advice of CIDR staff and arrange for in-class visitations to provide Jevin with input and feedback on his teaching strategies. We will both happily participate in supervising the implementation of a student project in a real high school classroom.

Assessing the course:
We will keep track of the Catalyst assessments. For successful teaching strategies discovered during this course, we plan to publish our findings in the pedagogical literature. We will also share any relevant data with national organizations (such as AAAS, NCSE, SSE and ASN) to disseminate findings to other science teachers interested in effective teaching tools.

If we can provide any other information on Jevin West or this project proposal, please feel free to contact us.

Sincerely,

Carl Bergstrom (cbergst@u.washington.edu) & Ben Kerr (kerrb@u.washington.edu)