

Collaborative Research: Expanding Evolutionary Studies in American Higher Education

Project Summary

Intellectual merits of the proposed activity: One of the most conspicuous failures of STEM education in America is the failure to effectively teach evolution. This proposal diagnoses the problem and presents a solution in the form of EvoS, a campus-wide evolutionary studies program developed at Binghamton University (State University of New York). EvoS reaches students from all majors early in their academic careers, engages their interest by making evolution relevant to human affairs in addition to biological subjects, and provides the means to develop both depth and breadth throughout their academic careers. EvoS also facilitates faculty training, especially for subject areas outside the biological sciences, where most faculty did not receive evolutionary training during their own academic careers.

Versions of EvoS can be replicated at most institutions of higher education, from community colleges to the largest research universities. A sister program has already been established at SUNY New Paltz, a four-year liberal arts college. This proposal requests funds to develop the programs at Binghamton and New Paltz and to create a nationwide consortium of programs. The initial consortium will include 9 institutions that are already working with us and the infrastructure funded by the grant will enable the consortium to be expanded indefinitely.

Including community colleges in the consortium will extend evolutionary training to groups underrepresented in higher education and will provide a mechanism for recruiting minorities from community colleges to four-year colleges and universities. An infrastructure for community-based research from an evolutionary perspective being developed at Binghamton University provides an additional recruitment mechanism among high school students.

Broader impacts resulting from the proposed activity: EvoS provides a model for increasing the acceptance of evolutionary theory among the general public and extending it beyond the biological sciences to the human behavioral sciences and humanities. Accomplishing these goals at a national scale will have wide-ranging societal impacts. In addition, EvoS accomplishes many of NSF's goals for STEM education in general. Faculty, graduate students, and undergraduate students from all subject areas function as a single intellectual community. Professional competence (depth) is increased along with an ability to transcend disciplinary boundaries (breadth). The humanities are integrated with the human-related sciences and the biological sciences. Undergraduate students are taught to function like graduate students from the very beginning and their training is as relevant to nonacademic in addition to academic careers. Minority and other students who do not envision scientific careers for themselves can become interested, especially by participating in community-based research. Finally, we demonstrate and address a strong need for faculty training in evolution for most subject areas outside of biology.

Summary of reviews of last year's proposal

Last year's version of this proposal was reviewed by a panel of experts in the biological sciences in addition to an interdisciplinary science panel. Fourteen external reviews were received; nine rated the proposal as "very good," four as "good," and one as "fair." The panel summaries identified the following strengths and weaknesses.

Strengths

- Teaching evolution across the curriculum is a laudable goal.
- PI's have done a good job identifying and describing the problem.
- PI's have an excellent combination of expertise and resources available for the project.
- Novel approach for effectively teaching evolution.
- Potential to educate and engage students in the relevance of evolution to societal issues.
- PI's are enthusiastic and have a documented history of stimulating institutional change.
- Project includes faculty development in disciplines outside biology.

Weaknesses

- Concern about overreaching the applicability of evolutionary theory in some disciplines.
- Concern that program's approach to evolution is biased toward adaptationism.
- The national consortium concept needs to be elucidated.
- Assessment and dissemination plans need to be described in more detail.
- Participation of community colleges needs to be a stronger component.
- Class design needs to be described in more detail.

The current version of the proposal addresses these shortcomings to the best of our ability.

Introduction

Arguably the most conspicuous failure of STEM education in America is the failure to effectively teach evolution. Polls consistently show that roughly half of US adults believe that humans did not evolve from earlier species. Rejection of evolution extends to beliefs about the origin of other species, the fossil record as evidence for evolution, and general attitudes about science.

Why does evolutionary training fail so dismally? What can higher education do about it? This proposal is based on a success story in evolutionary training at the college level; a campus-wide program called EvoS (short for *Evolutionary Studies*) that was initiated at Binghamton University (State University of New York) in 2003 (<http://evolution.binghamton.edu/evos/>). EvoS is directed by David Sloan Wilson (one of the PIs) and reaches hundreds of undergraduate students, whose involvement ranges from a single course to a multiple-course curriculum. The training provided by EvoS increases both professional competence in specific subject areas (depth) and the ability to integrate across subject areas (breadth). It is highly relevant to students who will leave academia upon graduating, in addition to those who will remain within academia. It also provides a mechanism for faculty training. From an initial core of faculty centered in biology and anthropology, EvoS now includes over 50 faculty participants that represent virtually every human-related subject area in addition to the biological sciences. Finally, EvoS is highly replicable because it can be assembled from parts that are present at most colleges and universities.

EvoS has generated widespread interest in creating similar programs elsewhere, especially since the publication of an article in *Public Library of Science (PLoS) Biology* titled "Evolution for Everyone: How to increase acceptance of, interest in, and knowledge about evolution" (Wilson

2005). A second EvoS program has already been initiated at SUNY New Paltz, a four-year liberal arts college, which is coordinated by Glenn Geher and Jennifer Waldo (the other PIs; <http://www.newpaltz.edu/evos/index.html>). The purpose of this Phase II CCLI proposal is to develop the Binghamton and New Paltz programs to their full potential and to create a nationwide consortium of programs, starting with colleagues at nine institutions who are already working with us. These institutions span the range from community colleges to major research universities (Albright College, Broome Community College, California State at Fullerton, Cornell University, Grand Valley State College, New England University, Northern Illinois University, Palomar College, and SUNY Oswego), illustrating the degree to which a consortium can have a national impact on evolutionary training in undergraduate education. In addition to its focus on evolutionary training, EvoS accomplishes many of NSF's goals for STEM education in general, as we will describe in more detail below.

The proposal is organized into the following sections: 1) A diagnosis of the problems facing evolutionary training in higher education; 2) EvoS-Binghamton as a solution to these problems at a midsize research university; 3) EvoS-New Paltz as a demonstration of how the program can be implemented at a four-year liberal arts college; 4) How CCLI funds will be used to develop the two existing programs to their full potential; 5) How CCLI funds will be used to create a nationwide consortium.

The problems facing evolutionary training in higher education

Evolutionary theory has already unified the biological sciences, enabling Theodosius Dobzhansky to make his famous remark in 1973 that “nothing in biology makes sense except in the light of evolution.” It is common for evolutionary biologists to switch from one organism to another (e.g. from primates to birds) or from one subject to another (e.g., social behavior to speciation) during the course of their scientific careers. This kind of integration is remarkable, given the extreme specialization that characterizes so much of the rest of science. It is possible because all organisms and subjects are being approached from a single theoretical perspective.

For most of the 20th century, however, evolutionary theory has been *confined* to the biological sciences and a few specialized human-related subjects, such as biological anthropology and human genetics. For most other human-related subjects—which means most departments on a college campus—evolutionary theory is virtually absent from the college curriculum, as political scientist Ian Lustick (2005) notes in a recent article:

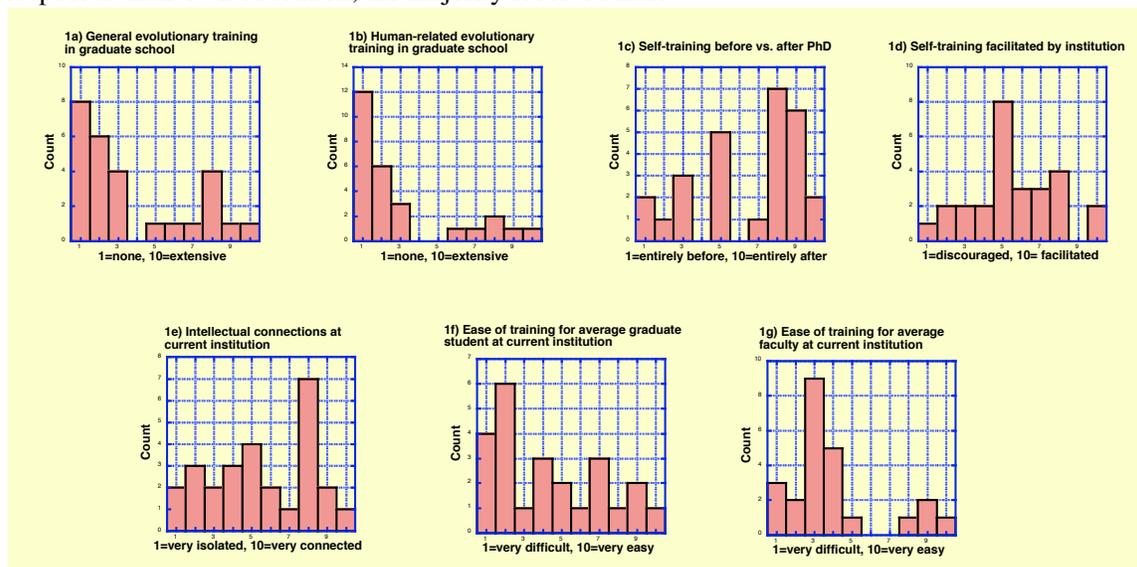
Of course social scientists have no objection to applying evolutionary theory in the life sciences—biology, zoology, botany, etc. Nevertheless, the idea of applying evolutionary thinking to social science problems commonly evokes strong negative reactions. In effect, social scientists treat the life sciences as enclosed within a kind of impermeable wall. Inside the wall, evolutionary thinking is deemed capable of producing powerful and astonishing truths. Outside the wall, in the realm of human behavior, applications of evolutionary thinking are typically treated as irrelevant at best; usually as pernicious, wrong, and downright dangerous.

Skepticism about evolution in relation to human affairs is so old that it is embedded in the very fabric of disciplines such as cultural anthropology, economics, political science, psychology, and sociology. Even when members of these disciplines become highly scientific, their perspectives are likely to be based on theoretical frameworks such as rational choice theory, complex systems theory, general learning theory, or micro-theories that are designed for the study of specific

subjects without extending beyond them. These theoretical frameworks are assumed to be *consistent* with evolutionary theory, in a way that does not require much detailed *knowledge* of evolutionary theory. A common formulation is that biology sets broad limits on how people behave, such as the desires to eat and mate, while learning and culture determine what people do within these broad limits—as if learning, culture, and their outcomes themselves don't need to be understood from an evolutionary perspective.

This situation is rapidly changing, mostly within the last ten or fifteen years. Evolutionary theory is now being applied to virtually every human-related subject area. To document this trend, one of us (Wilson, 2007a) conducted an analysis of the journal *Behavioral and Brain Sciences (BBS)*, which was chosen for two reasons: a) It is one of the most rigorously peer-reviewed and influential journals, with an ISI impact factor that is ranked first among 40 behavioral sciences journals and 7th among 198 neurosciences journals; b) Its coverage of subject areas is exceptionally diverse, from neuroscience to cultural anthropology. *BBS* therefore serves as a microcosm for contemporary research in the human behavioral and social sciences. During the period 2000-2004, 31.5% of the target articles in *BBS* were based upon evolutionary theory, for topics as diverse as religion, schizophrenia, infant crying, language, food transfer in hunter-gatherer societies, facial expression, empathy, vision, brain evolution, decision-making, phobias, mating, cultural evolution, and dreams. This fact by itself demonstrates that studying our own species from an evolutionary perspective is not fringe science (as often portrayed in the public media) or future science, but has already arrived. *Any college or university that fails to teach evolution in relation to human affairs is out of touch with current scientific research.*

In addition to tallying the proportion of target articles that rely upon evolutionary theory, a survey was e-mailed to the authors to find out about their evolutionary training and their assessment of their current institutions, as shown in Figure 1 (N=28 of 46 authors e-mailed). With respect to their own education, the majority received little



training in general evolution (Figure 1a) and even less that was oriented toward human-related topics (Figure 1b). Their personal efforts to learn about evolution took place largely after they received their PhDs (Figure 1c). Most regarded their academic institutions as neutral with respect to facilitating their personal efforts (Figure 1d). With respect to their own current academic environment, they span the range from feeling highly isolated to highly connected (Figure 1e). The last two graphs are most informative from the standpoint of this proposal: Apart from their *own* intellectual environment—which might be confined to a small group of faculty and students--

most *BBS* authors estimated that the *average* student in a human-related subject at their current institution would have a very difficult time learning about evolution (Figure 1f) and that the average faculty member would fare only slightly better (Figure 1g). Even though *BBS* is not a perfect microcosm of the human behavioral and social sciences, we are confident that the results would be confirmed by a similar analysis of journals such as *Science*, *Nature*, *PNAS*, *Journal of Personality and Social Psychology*, or *Current Anthropology*.

To summarize, evolutionary theory has been confined to the biological sciences and a few human-related subject areas for most of the 20th century. The situation is rapidly changing as far as current scientific research is concerned, *but these changes are not reflected in the structure of higher education*. The *BBS* authors who responded to our survey are at the forefront of human-related evolutionary research. If *they* are largely self-trained, sometimes feel isolated within their own institutions, and anticipate difficulties for the average student and faculty member at their institutions, then the situation at other colleges and universities is probably even more bleak.

Teaching evolution in relation to human affairs is connected to basic acceptance of the theory. The most disturbing fact about public awareness of evolution is not that roughly 50% of Americans don't believe the theory, but that nearly 100% don't connect it to matters of importance in their everyday lives. As long as evolution is framed in terms of remote subjects such as fossils, dinosaurs, and human origins, accepting or rejecting it is *inconsequential*. Some relevance can be established through biological examples such as antibiotic resistance in disease organisms, but much more can be established by relating evolutionary theory to the length and breadth of human affairs. The theory becomes *acceptable* as soon as it becomes *unthreatening*, *explanatory*, and *useful* for understanding the human condition and improving human welfare in a practical sense (Wilson 2005, 2007b).

EvoS: A successful program for teaching evolution at a campus-wide scale

EvoS is arguably the first comprehensive effort to address the problems outlined above on a campus-wide scale. It is designed to: a) introduce evolution to students from all majors, as early as possible in their academic careers; b) include human-related subjects in addition to biological subjects from the very beginning; c) provide the means for students to continue their evolutionary training throughout their academic careers; d) increase professional competence in specific subject areas (depth); e) increase the ability to integrate across subject areas (breadth); f) facilitate faculty training and collaborative research, in contrast to the experience of the *BBS* authors who were forced to learn about evolution on their own. These elements are described in detail in Wilson (2005, 2007b) and will be summarized here:

A basic “Evolution for Everyone” course available to all majors. This large enrollment course (N=app. 150) is organized around the theme of *a single set of principles that can explain a vast diversity of phenomena*. The basic principles of evolutionary theory are taught during the first part of the course, followed by a number of modules on specific topics. Each module includes inquiry-based activities in addition to lecture material. Human-related subjects are combined with biological subjects from the very beginning. Students also choose their own subjects to explore from an evolutionary perspective, culminating in a poster session emulating a scientific conference, to which the university community is invited. The poster session demonstrates how many different subjects can be approached from an evolutionary perspective and also shows the students that they are part of a larger intellectual community of undergraduate students, graduate students, and faculty from all departments who attend the poster session.

Since most EvoS programs in the consortium will include a basic *Evolution for Everyone* course, we will describe in detail how we provide inquiry-based training, even in a 100-level large enrollment course. At Binghamton, we recruit the best students from previous classes to serve as undergraduate teaching assistants, supervised by the instructor and a single graduate student TA assigned to the course. We use a sufficient number of undergraduate TAs to achieve a high TA/student ratio in discussion sections. A cadre of smart, excited undergraduates from previous classes helping to teach the students of the current class is highly effective pedagogically. The undergraduate TAs also enable us to conduct inquiry-based learning experiences during the lecture periods.

An example is a module on experimental economics from an evolutionary perspective. Experimental economists have developed a number of elegant games to study human social preferences concerning cooperation, trust, risk, discounting the future, and punishing social transgressions (e.g., Fehr and Fischbacher 2003). Each of these subjects can be approached from an evolutionary perspective, especially when evolution is construed more broadly than genetic evolution. Game theorists refer to a “replicator dynamic” as any process whereby the most successful behavioral strategy increases in frequency over time (Gintis et al. 2005). In addition to genetic evolution, this can also include learning, imitation, and other processes of fast-paced behavioral and cultural change, vastly expanding the scope of evolutionary theory. After explaining these ideas in lecture format, we have the entire class play an experimental economics game during the lecture period, by indicating on paper how they would behave in a two-person sequential prisoner’s dilemma (a game in which each player has an opportunity to cooperate or defect against their partner), both with and without an opportunity for punishment. In keeping with the protocol of experimental economics games, a pair of responses is drawn at random at the end of the lecture period and those students are paid real money according to how they played the game. Thanks to our large number of TA’s, the data from the whole class can be rapidly entered into the computer and analyzed by the instructor and graduate TA in time to present the results during the next lecture period, along with a tutorial on statistical analysis. In addition, individual differences in how the students played the game are related to individual differences in personality variables, based on data taken during a previous module on personality from an evolutionary perspective. In this fashion, modules on seemingly different subjects become integrated with each other. All class exercises are approved by Binghamton University’s human subject review board, providing an opportunity to discuss how research on humans is regulated at universities.

A quantitative assessment of the course in 2004 (reported in Wilson 2005; details available upon request) yielded the following results: a) students reported a large shift in their positive attitudes about evolution, especially in relation to human affairs, in before-and-after surveys and anonymous course evaluations; b) the course succeeded across the spectrum of religious belief, political belief, and amount of previous science training, at least among the students who took the course; c) student improvement included not only specific knowledge of evolution but also general critical thinking skills, as measured both by survey items and by an increase in the frequency of words indicative of cognitive operations in their essays over the course of the semester.

The possibility that evolutionary training might increase general thinking skills makes sense when we consider that *the entire class is an exercise in applying the same basic principles to a diversity of specific subjects*. Once the students become accustomed to this way of thinking, they apply it to subjects of their own choice, including other classes and their everyday lives. In addition to our quantitative assessment, this “new way of thinking” is amply reflected in anonymous verbal evaluations such as: “*It revolutionized my way of viewing problems.*” “*I have always agreed*

with evolution but I did not know how much of everyday life was affected by it.” “I came into class not knowing a lot about evolution. I now have an entirely new outlook on how evolution can be applied to many aspects of life.”

A multi-course program that can be taken in parallel with any major without imposing a prohibitive additional workload. For students who wish to continue their evolutionary training, EvoS facilitates their interests by providing a menu of courses, special topics seminars, and research opportunities across departments. Full participation in EvoS requires taking 20 credits and results in a certificate along with one’s diploma. Unlike a major or a second minor, courses that qualify for the EvoS certificate can also count toward one’s degree, minimizing additional workload and maximizing the integration of evolutionary theory with the primary interests of the students. To date 130 undergraduate students at Binghamton have earned or are in the process of earning the EvoS certificate.

At the inception of the program, most of the courses were already being taught but were not visible to students from other departments. Merely gathering them together into a single program was a simple but important first step. Additional courses were then created, driven by student interest and faculty who became interested in collaborating with each other. An example is a two-course sequence on cultural evolution, co-taught by archeologist William Isbell and evolutionist David Sloan Wilson. The first course covered theories of cultural evolution in anthropology, from the 19th century to the present (e.g., Carniero 2003). The second course covered recent theories of cultural evolution developed by scientists across a variety of disciplines, including anthropology, computer science, economics, evolutionary biology, and psychology (e.g., Richerson and Boyd 2005, Hammerstein 2003). These courses were attended by students from five different departments.

An individualized approach to achieve professional *depth*. Students who decide to earn the certificate meet with a faculty participant of EvoS to discuss the most appropriate courses from the EvoS course offerings. This enables the curriculum to be tailored to the career interests of each individual. For example, a pre-med student might want to concentrate on courses relevant to Darwinian medicine, while a political science major might choose courses on game theory and cultural evolution. This individualized approach is important because evolutionary theory can be taken in so many different directions.

The EvoS seminar series. A campus-wide seminar series brings distinguished external speakers to campus at approximately 2-week intervals. The topics span the length and breadth of the biological sciences, the human behavioral and social sciences, and the humanities. One seminar on cancer as an evolutionary process might be followed by another on human moral psychology. The speakers include some of the most distinguished members of their respective fields in addition to up-and-coming young scientists (see Binghamton’s EvoS website for the current roster). The seminars are not watered down for a general audience but are similar to what the speakers would give in departmental seminars at other universities. The reason that so many topics can be comprehended and enjoyed by a single audience is because everyone is speaking a common theoretical language. In other words, the seminar series embodies the theme of *a single set of basic principles that can explain a vast diversity of phenomena*, just like the introductory course. This kind of integration already exists within the biological sciences, as previously mentioned; what’s new is for it to be extended to all human-related subjects.

A course built around the EvoS seminar series, to achieve *breadth* for each student. Students who are earning the certificate are required to take a 2-credit “Current topics in evolutionary studies” course built around the EvoS seminar series for at least two semesters. The course

requires reading one or more articles and writing a commentary in preparation for each seminar, attending the seminar, and attending a casual dinner (pizza and beverages) and continuing focused discussion with the speaker after the seminar. This course provides an unparalleled opportunity for undergraduate students to interact directly with some of the most dynamic scientists of our age, repeated for approximately 20 different topics over the course of two semesters. It also gives undergraduate students a chance to interact with each other, graduate students, and faculty in a socially pleasant but intellectually focused setting. This course has become enormously popular and many of the students describe it as their best academic experience.

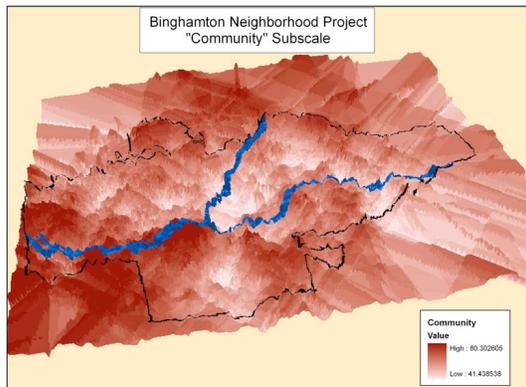
Faculty training. Unlike the majority of BBS authors described earlier, who had to acquire their evolutionary expertise on their own, EvoS provides multiple opportunities for faculty to explore the relevance of evolutionary theory for their respective subject areas. Most EvoS seminar speakers are co-hosted with the most relevant department, enabling the members of that department to interact with a respected member of their own field who has already adopted the evolutionary perspective. Faculty who become sufficiently interested can join a campus-wide network of peers, audit or co-teach courses, and ultimately begin to employ the evolutionary perspective in their own work. During its first four years, the program has grown from a core of 20 faculty centered in the Biology and Anthropology Departments to over 50 faculty representing virtually every academic unit on campus. EvoS has been especially effective at fostering interdisciplinary research collaborations with opportunities for undergraduate participation, as described in more detail below

Integrating the humanities and the sciences. Academic fields associated with the humanities are as amenable to evolutionary analysis as fields associated with the human-related sciences. Activities such as music, dance, the visual arts, and narrative, are culturally universal (although diverse in their specific expression), appear early in life, and—like sex—do not require incentives to perform because they are so pleasurable in their own right. In other words, they have all the earmarks of genetically evolved adaptations (Baumeister 2005, Wilson, Van Vugt, and O’Gorman 2008). Far from superfluous, they play an essential role in defining groups, bonding their members together, coordinating their activities, and facilitating the social transmission of acquired information. Harvard historian Daniel Smail (2007) argues for an evolutionary approach to history in his book *Toward a Deep History of Humankind*. One of the PIs (DSW) is involved in establishing the new fields of Literary Darwinism (Gottschall and Wilson 2005) and Evolutionary Religious Studies (Wilson 2002, <http://evolution.binghamton.edu/religion/>).

A recently created course titled “Evolutionary Approaches to Literature and Cinema” (English 283R) illustrates how EvoS is integrating the sciences and humanities at the level of undergraduate education. The purpose of the course (from the syllabus) is to “reframe our understanding of the nature, function, and centrality of story telling in human affairs...These questions will be approached through recent evolutionary and scientific theory and methodologies in an effort to understand storytelling’s ancient and contemporary roles in our individual and collective lives.” In addition to learning about a new conceptual framework, students will also learn about how quantification and basic scientific methodology can be used to ask questions in the humanities. For example, their reaction to works of literature and cinema will be measured quantitatively and related to individual differences in personality variables, as described previously for the “Evolution for Everyone” course. Quantification does not replace traditional critique and analysis, but provides an important complement. This course quickly filled (N=75) the first time it was offered, illustrating the degree of student interest.

Facilitating interdisciplinary research that includes undergraduate participation. By providing a common theoretical language and opportunities for intellectual exchange, EvoS has proven highly successful at incubating collaborative research across disciplines in areas as diverse as animal behavior, molecular biology, community ecology, experimental economics, political science, computer science, cultural anthropology, and clinical psychology. In recognition of its research potential, EvoS was recently given the status of an Institute for Advanced Studies within Binghamton University, in addition to its original status as a teaching program. The Institute and academic program are connected, however, as collaborative projects among EvoS faculty provide research opportunities for EvoS undergraduate students.

An outstanding example of such synergy is the Binghamton Neighborhood Project (BNP), which is designed to provide a general infrastructure for community-based research from an evolutionary perspective (<http://evolution.binghamton.edu/bnp/>). Since evolution is fundamentally about organisms in relation to their environment, it makes sense to study humans in relation to their everyday environments. Most human-related research fails to take such an ecological approach, even though it is obvious from the standpoint of evolutionary theory. Our objective is to remedy the situation by creating an accumulating database that provides a foundation for naturalistic studies in our own community. An example is provided in figure 2,



which shows a GIS (Geographical Information Systems) map of the city of Binghamton (city limits outlined in black; the blue ribbons are the Susquehanna and Chenango Rivers, which meet in downtown Binghamton). The peaks (dark) and valleys (light) represent variation in the quality of neighborhoods within the city, as assessed by a survey of approximately 2000 public school students in grades 6-12 in cooperation with the Binghamton City School District. The continuous surface is created by a method called kriging, which generates a value for each location based on extrapolated values from neighboring data points. This variation

has been validated and extended by four additional datasets, all of which involved undergraduate participation. In one validation study, students dropped stamped addressed envelopes on the sidewalks at random locations throughout the city and used the return rates as an estimate of the propensity of residents to perform a small act of kindness. In another more ambitious study, graduate students and undergraduate assistants are visiting the 9th grade social studies classes and playing the same kinds of experimental economics games described earlier for the “Evolution for Everyone” class. Variation in the capacity for trust, as measured by the 2-person sequential prisoner’s dilemma game, correlates with neighborhood quality as measured by the student surveys, the lost letter method, and additional validation studies. This accumulating database in turn is being used to study specific topics such as academic performance, juvenile violence, and obesity.

To summarize, it is widely accepted that evolutionary theory provides a unifying theoretical framework for all aspects of biology. The same framework is now being extended to all human-related subjects, but these very recent scientific developments are not yet reflected in higher education. EvoS is arguably the first program that comprehensively addresses this problem at a campus-wide scale. It has proven to be highly successful at Binghamton University. The next question is whether it can be imported to other colleges and universities.

EvoS-New Paltz: Implementing the program at a four-year liberal arts college

SUNY-New Paltz is a teaching-oriented liberal arts college that has a reputation as one of the best colleges for the arts within the SUNY system. Science faculty are expected to be research-active and Masters programs are offered by a few departments, but the primary focus is on undergraduate education. The fact that a version of EvoS has been successfully implemented at SUNY New Paltz demonstrates that the program does not require a research university.

EvoS-New Paltz was initiated by Glenn Geher (co-PI of this proposal), an evolutionary psychologist who maintains an active research program. When he learned about the EvoS program at Binghamton, he immediately recognized its importance and became convinced that New Paltz could benefit from implementing its own such program. By May of 2005, he created a committee of 10 faculty members from seven departments and two students charged with developing and implementing an EvoS program. DSW made a site visit in the summer of 2005 to consult with the committee and top administrators about the program, which formally began in Fall 2007. Even before the formal inception of the program, the EvoS committee organized a Darwin Day event in February 2007 that included a public lecture, a panel discussion on evolutionary thought across academic disciplines, and a theatrical production of *Inherit the Wind* followed by a discussion of creationism and intelligent design. During the same period, with the support of the incipient EvoS community, Geher spearheaded the formation of the Northeastern Evolutionary Psychology Society (NEEPS), which held its first annual meeting at New Paltz on April 12-14, 2007. Jennifer Waldo (the third PI of this proposal) is on the faculty of the Biology Department of New Paltz and enthusiastically became involved in the running of the program. Waldo combines training in evolution at the molecular level with experience integrating evolution into the science curriculum at the high school level.

EvoS-New Paltz offers a number of lessons for implementing versions of EvoS at other institutions. First, even though New Paltz is not a research university, there was still a core of 10 faculty across 7 departments who were eager to come together to form a campus-wide evolutionary studies program. We think that this will be true for most colleges and universities. In fact, EvoS can be especially effective at small colleges by creating a critical mass of faculty sharing a common theoretical framework, which might not exist in a single department.

Second, the top administrators were highly supportive of the program from the beginning. Most college and university administrations recognize the importance of integration across disciplines and welcome initiatives such as EvoS. Moreover, at least some administrators appreciate that evolutionary theory offers the same kind of integration for human-related subjects that has already become established for the biological sciences.

Third, the program could be initiated largely from “existing parts”—faculty already interested, courses already being taught, existing mechanisms for creating interdisciplinary programs, and existing intramural financial resources. This provides a viable starting point for growing the program based on a positive feedback process, similar to EvoS-Binghamton. During its first year, EvoS-New Paltz has attracted several new faculty participants and has sufficiently impressed the administration that they have agreed to support the EvoS seminar series for the next three years. We are confident that similar “existing parts” at many colleges and universities.

Finally, student interest is as gratifying at New Paltz as at Binghamton. What drives student interest is not a particular instructor or even a particular pedagogical technique, *but learning about evolution as a set of basic principles that can be applied to a vast diversity of phenomena*—including the human-related issues most relevant to the students’ lives. Thus, we

are not surprised that student evaluations at New Paltz of Geher's Evolutionary Psychology course (a core course in the New Paltz program) include comments such as "*I wish there were more similar courses within the department,*" "*this was my all-time favorite class. I hope that eventually you have the opportunity to broaden the program,*" and "*I appreciate Dr. Geher's efforts to implement an evolutionary studies program. I would definitely like to see more classes like this one.*"

Does EvoS overreach the applicability of evolutionary theory or provide an account of evolution biased toward adaptationism? We end this section by addressing two concerns expressed in the panel summaries of last year's proposal. The human-related academic disciplines include many theoretical frameworks, past and present, including functionalism, Marxism, Freudian psychology, behaviorism, rational choice theory, postmodernism, and micro-theories designed to address specific subjects without claiming generality. Some were developed without reference to evolution, others were regarded as consistent with evolution by their developers (e.g. Freudian psychology), and still others were regarded as alternatives to evolution by their developers (e.g., postmodernism). None of these original conceptualizations can be taken at face value. Instead, the assumptions of each framework must be examined to see how they relate to modern evolutionary theory.

To pick one example, the tradition of functionalism assumes that entire societies can be regarded as like single organisms in their structure and function. It was developed during the early 20th century at a time when "sociological" approaches were conceptualized as different from "evolutionary" approaches (e.g. Evans-Pritchard 1965). From a modern perspective, it is obvious that an evolutionary account is required to decide whether societies can become like organisms. As a second example, rational choice theory assumes that all aspects of human behavior can be explained in terms of individual utility maximization. When pressed for an explanation, most rational choice theorists invoke genetic and/or cultural evolution—those who failed to maximize their utilities were not among our ancestors. As it turns out, many economists have decided that rational choice theory is just plain wrong—a single minimalistic principle such utility maximization cannot explain the length and breadth of human behavior. The field of experimental economics makes a more complicated set of assumptions about the social preferences that drive human behavior, but these assumptions also require a naturalistic explanation in terms of genetic and/or cultural evolution.

The common assumption that "learning" and "culture" stand as alternatives to "biology" and "evolution" is especially in need of rethinking. Both learning and the capacity for culture are complex adaptations that evolved by genetic evolution and count as evolutionary processes in their own right, in both humans and nonhuman species. Learning and culture are manifestly important in our species, but that does not make them non-biological or non-evolutionary! In general, the fact that the human-related academic disciplines are not conceptually integrated requires a careful examination of assumptions on a case-by-case basis. When this is done, the major issues can usually be framed within evolutionary theory more productively than when they were conceptualized as alternatives to evolutionary theory.

With respect to adaptationism, some evolutionists might be biased toward adaptationist interpretations of human behavior, but it is difficult to make this case for the field as a whole. As one of many examples that could be chosen, in a collaborative project on religion, a team of evolutionists (including DSW) working with a team of religious scholars derived a protocol for testing six major evolutionary hypotheses about religious conceptions of the afterlife, three of which are non-adaptationist (<http://evolution.binghamton.edu/religion>). In general, a campus-wide evolutionary studies program such as EvoS goes beyond the biases of any particular

researcher and amply reflects the fact that there is more to evolution than adaptation. Indeed, one member of the nationwide consortium that we propose to form is David Buller, chair of the Department of Philosophy at Northern Illinois University, whose book *Adapting Minds: Evolutionary Psychology and the Persistent Quest for Human Nature* (MIT Press, 2005) is a thorough and often critical examination of the field of evolutionary psychology.

PROPOSED ACTIVITIES

Both of the current EvoS programs were initiated and operate on the strength of internal funding, which indicates the degree to which they are valued by our administrators. However, external funding is required to develop the programs to their full potential and to facilitate the creation of a nationwide consortium. Investing in the two existing programs will establish them as models for what can be accomplished elsewhere. The consortium can be facilitated by providing centralized services and an infrastructure for communication and sharing resources.

Developing the two existing programs

Major personnel: One month summer salary/yr is requested for each of the PIs. In addition, a half-time coordinator position is requested for the Binghamton-EvoS program and for managing the consortium. Currently, intramural funding at Binghamton provides only a few hours per week of secretarial help, forcing most of the administrative duties on faculty, especially the director (DSW). Managing Binghamton's expanding EvoS program and the consortium will be prohibitive without a coordinator.

Course and undergraduate research development: In its capacity as an Institute for Advanced Studies, EvoS-Binghamton is provided a small budget to facilitate research that leads to external funding. Because we have so many faculty participants, we were able to organize a competitive pilot research program. This mechanism worked very well, stimulating faculty to write proposals and enabling us to select the best. We therefore request funds to implement a similar competitive program for the development of new courses and research experiences for undergraduates. It is fitting for an evolutionary studies program to employ the basic evolutionary algorithm of variation-and-selection in its own development.

The EvoS seminar series and current topics course: Funds are requested to enhance the EvoS seminar series and the associated course at both Binghamton and New Paltz. In addition to enhancing the regular seminar series, we will invite one nationally prominent speaker per semester to give an evening public address to the general public in addition to the community. The dinner/discussion following each afternoon seminar will be enhanced by holding it in a larger space and providing better food. It is difficult to overestimate the importance of providing a *social* experience, in addition to an *intellectual* experience, as part of a campus-wide program such as this. The dinner/discussion following each seminar is where undergraduate students who have become interested in evolution meet each other, mingle with graduate students and faculty, and have a focused discussion with world-class scientists, for which they have prepared by reading, writing, and attending the seminar. As previously mentioned, many EvoS students describe this as their best intellectual experience at college, so funds for enhancing the experience are highly cost-effective.

Developing a nationwide consortium

Nine separate institutions, from major research universities to community colleges, have contacted us for advice about how to develop versions of EvoS (letters provided in appendix). This degree of interest suggests that a nationwide consortium can be established with CCLI funding, to facilitate these and additional institutions in the future. The following plan is based on discussions with our prospective partners on how to best facilitate their efforts.

An electronic journal. We request funds for the development of an electronic interdisciplinary academic journal dealing with evolutionary studies in higher education. The necessary expertise is provided by Alice Andrews (Psychology Department at New Paltz), who is editor-in-chief of *Entelechy* (<http://www.entelechyjournal.com/>), an electronic journal dedicated to scholarship in the humanities informed by evolution, including contributions by undergraduate students in addition to faculty. The electronic journal would transcend the typical information-providing function of print journals and, as such, could include Blog and listserv components so that members of the multiple EvoS programs could share a common EvoS community regardless of geographic locale. Microsoft FrontPage will be used to create metadata for each webpage; FrontPage allows the designer/programmer to create metatags for titles, descriptions, and subjects. These metatags with descriptive metadata not only result in higher ranking in search results, but will also fulfill the National Science Digital Library's requirements for indexing and cataloging.

Site visits. During the inception of the New Paltz program, a site visit by DSW was instrumental for sharing ideas and gaining the interest of the Administration. It can also be useful for faculty to visit Binghamton or New Paltz to observe EvoS in action. Funds are budgeted for site visits in both directions.

Startup packages. To facilitate the creation of new programs, especially at smaller institutions, we will offer startup packages of up to \$2,500. We think that this will be especially effective as an incentive for administrators committing their own intramural funds over the longer term. The startup packages will be awarded on a competitive basis and will require a clear demonstration that the initial investment will lead to the establishment of a permanent program. In addition to providing financial assistance, the startup packages will provide a sign of achievement and recognition for the newly created programs.

Workshops in association with national society meetings. Electronic interactions do not entirely replace face-to-face interactions. Every year we will select a major academic society and organize a symposium at their annual meeting (for example, the Society for the Study of Evolution, the Human Behavior and Evolution Society, or the Modern Language Association). Each symposium will introduce EvoS to a different sector of the academic community, while simultaneously giving us a chance to interact with each other.

Teaching “Evolution for Everyone” in a coordinated fashion. A key element of most programs will be a course similar to “Evolution for Everyone” targeted for students from all majors as early as possible in their college careers. Although instructors at different institutions will have their own ideas about how to organize such a course, they can coordinate their efforts by adhering to the theme of *a single set of basic principles that can explain a vast diversity of phenomena*. If the first part of each course is reserved for teaching basic principles, followed by applications, then modules can be developed and shared across institutions. We have already described a module on experimental economics that includes readings, a powerpoint presentation,

an experiment, and an approved human subject review board application for the experiment. Any member of the consortium could use this module in their class (although they would need to get approval from their own review board) and develop modules of their own for others to use. Modules can also be used simultaneously across classes to create a single meta-class.

An archive of EvoS seminars. With permission of the speakers, EvoS seminars will be taped and digitally combined with the PowerPoint presentation to be made available through the internet. Binghamton University's Center for Learning and Teaching (CLT) already has this capacity, so funds are requested only for hourly costs for personnel. Our Center can also process the tapes from seminars given at other EvoS programs. As a prototype, philosopher Elliott Sober's spring 2005 seminar titled "Intelligent design—an alternative to evolutionary theory?" can now be accessed through Binghamton's EvoS website (<http://evolution.binghamton.edu/evos/Seminar%20Archive.html>). The Archive will be highly valuable for courses and for members of the consortium who do not have the resources to bring major speakers to their campuses.

Whole program assessment and shared assessment services. EvoS is clearly succeeding in terms of student evaluations and interest at all levels, from freshmen without any science background to senior administrators. A quantitative assessment of the "Evolution for Everyone" class was described earlier. It was developed in consultation with two experts on evolution education and science pedagogy: Dr. Brian Alters, Tomlinson Chair of Science Education and Director of McGill University's Evolution Education Research Center; and Dr. Craig Nelson, emeritus professor of biology at the University of Indiana, Bloomington (Alters and Alters 2001, Alters and Nelson 2002, Nelson 1994, 2000, Ingram and Nelson 2006). With CCLI funding, we will develop an assessment plan that tracks EvoS students across multiple courses and post-graduation in addition to assessing individual courses. We will also create a consortium-wide assessment committee to widen our pool of expertise and compare programs across institutions.

We are especially interested in testing the hypothesis that evolutionary training increases general critical thinking skills, academic performance, and career attainment post-graduation. The rationale for this hypothesis is that applying a small set of basic principles to a diversity phenomena is inherently a domain-general process that can be transferred from one class to the next and beyond the classroom to everyday life. In addition, whenever disparate facts come together to form a meaningful framework, they become easier to remember and to work with creatively. It is common for EvoS students to report to us that their general academic performance improved after learning about evolution because they "made connections" that they were not making before. Some even report their frustration that these connections are not being made by their instructors in non-EvoS courses! If domain-general effects of evolutionary training can be rigorously documented, then this will obviously be important for STEM education in general.

Our program-wide assessment plan has been designed and will be carried out in collaboration with Dr. Sean McKittrick, Assistant Provost for Curriculum, Instruction, and Assessment at Binghamton University. Dr. McKittrick is involved with the assessment of all students and programs at Binghamton University, which means that EvoS students can be compared with non-EvoS students at a variety of scales. Starting with the initiation of the grant, students who join the EvoS program will be invited to participate in a multi-year assessment, with financial compensation for each set of surveys taken annually. A sample of 50 will be matched with a comparable sample of students who have not entered the program. Both groups will be given the following surveys at yearly intervals, in accordance with human subject review procedures.

- Three surveys already being employed at the single-class level (or updated equivalents), measuring political and religious attitudes, belief in evolution as a scientifically validated process, and a “learning context” questionnaire measuring general thinking skills (Griffith and Chapman 1982, Otto et al. 2006).
- A survey that distinguishes between *performance goal orientation* (striving to demonstrate competence, such as a good grade in a class) and *learning goal orientation* (striving to understand something new and increase competence, even if initially a novice; Button, Mathieu, and Zajac, 1996). We expect that involvement with EvoS will increase learning goal orientation.
- A writing sample that will be analyzed both in terms of frequency of words indicative of cognitive operations (as described earlier for the assessment of the “Evolution for Everyone” class) and a protocol developed by the SUNY General Education Assessment Review Group (GEAR) to evaluate general education programs across the 57-campus SUNY system (www.cortland.edu/GEAR/). A training procedure has been developed to evaluate writing samples for elements of critical thinking, such as the ability to identify target arguments, to articulate the conclusion of an argument, and to evaluate logical support and reasonableness of the premises for an argument. Using this protocol will enable us to directly assess the critical thinking skills of EvoS students in comparison with a number of control groups, including the students matched with each EvoS student, the general student population of the same school, and the student populations at different schools in the SUNY system.
- An annual survey will be sent for five years post-graduation to assess post-graduate education, career advancement, and career change. Compensation fees after the period of the grant will be covered from intramural sources.

In addition to annual assessments, the academic performance of EvoS students in each of their courses will be tracked in comparison to other students in the same course. Since most courses that qualify for EvoS credits are not restricted to EvoS students, this affords another frame of comparison. Information about academic performance will be gathered by Dr. McKittrick and the Registrar’s office, assuring confidentiality in accordance with human subject review procedures. These statistics will be compiled into a report annually, reviewed by the EvoS executive committee with the Binghamton University administration, and included in the NSF reporting process.

Once a consortium exists, this assessment plan will be discussed with the assessment committee, modified as warranted, and made available to the other institutions. The surveys will be made available on the internet and the multi-institution database will be maintained at Binghamton University. Writing samples can be sent to Binghamton to be analyzed by our evaluators (for a processing fee) or personnel can be trained at other institutions by holding a single workshop. A standardized assessment plan is one of the most important benefits of the consortium that will be enabled by this proposal.

Using community colleges and community-based research to reach under-represented groups. An important feature of this proposal is that community colleges are included in the consortium. More students attend community colleges than four-year colleges and universities. In addition, community colleges usually have a higher proportion of ethnic minorities and other underrepresented groups in higher education, such as individuals of all ethnicities who are first in their families to attend college (as described in the National Center for Education Statistics Report # NCES 2005-171 2005). Evolutionary training at the community college level therefore automatically extends STEM education to underrepresented groups. In addition, we plan to

develop a framework for recruiting underrepresented groups from community colleges to attend four-year colleges and universities with EvoS programs.

These plans have been developed in consultation with faculty at two community colleges who have extensive experience teaching evolution: Dr. Richard Firenze is Chair of the Biology Department of Broome Community College (BCC) in Binghamton, New York. He is a founding member of EvoS-Binghamton and an advocate of evolution education in his own right (Firenze 1997). Dr. Phillip de Barros is Professor of Anthropology and coordinator of the Archeology program at Palomar College in San Marcos, California. He recently organized a successful campus-wide event titled “Exploring Darwin at Palomar College” and is interested in becoming a member of the consortium. Both are well connected to associations of community colleges, such as the Empire State Association of Two Year Colleges, as outlined in Dr. Firenze’s letter (see appendix).

The most important first step is to offer a basic “Evolution for Everyone” course that satisfies the science requirement of a community college associate’s degree. This course is likely to be highly popular and effective among community college students for the same reason that it succeeds among all majors at a four-year college. As members of the consortium, community college teachers will have access to ready-to-use modules, an archive of EvoS seminars, and other resources that would be difficult to acquire on their own. Starting in fall 2008, CCLI funds will be used to coordinate the teaching of “Evolution for Everyone” between Binghamton University and BCC, using the same modules at the same time and treating the students as part of a single class.

Most community colleges have mechanisms for promoting interdisciplinary dialogues that provide opportunities for a multi-course curriculum, albeit more limited than at four-year colleges and universities. Another way to nurture the interests of community college students, minority and otherwise, is to facilitate their transition to four-year colleges and universities with full-fledged EvoS programs. The nationwide NIH program “Bridges to the Baccalaureate” provides stipends for minority students at community colleges to work in the laboratories of university faculty as a steppingstone toward switching to a full college degree and post-graduate education. In the experience of both Dr. Firenze and Dr. de Barros, it is often difficult to identify qualified and interested students. EvoS can bring more students into the program, especially those who do not currently identify with science, by showing them how evolution in particular and science in general can be brought to bear on the problems of everyday life that already concern them. Starting in fall 2008, we will start using the “Evolution for Everyone” course taught at BCC as a recruitment tool for placing minority students in the laboratories of EvoS faculty at Binghamton, as a prototype that can be adopted by other members of the consortium.

Community-based research provides another opportunity for minority recruitment at the high school level. In research described on p. 8, EvoS graduate and undergraduate students are visiting the classrooms of high school students to play experimental economics games and explain what they mean in terms of human social preferences and variation among neighborhoods. The high school students are fascinated by the material and socially identify with the college students, who are themselves ethnically diverse. CCLI funds are budgeted to involve high school students in the Binghamton Neighborhood Project as a form of scientific research that is maximally relevant to their own lives, which they can continue by attending college.

On the relationship between EvoS and the general goals of STEM education.

Although EvoS is designed as a comprehensive solution to evolutionary training at the college level, it also achieves the more general goals of STEM education, as described in the CCLI

program solicitation and supporting documents. For example, Project Kaleidoscope's 2006 Report on Reports II includes the following recommendations for "urgent action":

- Support those students demonstrating promise for success as they enter into and pursue undergraduate studies (EvoS reaches students early and nurtures their development throughout their academic careers).
- Give each undergraduate the opportunity for personal experience with inquiry-based learning (as with the "Evolution for Everyone" course and direct contact with scientists in the "current topics" course built around the EvoS seminar series).
- Extend research opportunities beyond the classroom and campus (as with the Binghamton Neighborhood Project).
- Connect student learning in STEM fields to the world beyond the campus (as with the theme of *one set of principles applied to a vast diversity of phenomena*, resulting in student evaluations such as "*I now have an entirely new outlook on how evolution can be applied to many aspects of life.*").
- Build regional collaborations of academe, business, and civic groups (a central goal of the Binghamton Neighborhood Project).
- Respond to contemporary calls for interdisciplinarity by nurturing and rewarding faculty who make the kind of cross-discipline connections they hope their students will make (exemplified by the large number of EvoS faculty participants and growing number of research and teaching collaborations).

There is a reason why evolutionary training also achieves the general goals of STEM education. These goals require a *common language* that can be spoken across disciplines. Evolutionary theory provides an exceptionally powerful common language, enabling the same kind of integration that already exists in the biological sciences to be extended to all human-related subjects--in the classroom, the campus, and beyond. EvoS provides a proof of concept that can be developed to its full potential with NSF CCLI funding.

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