

ACS Reform of Introductory Science courses for Non-Majors Course Mini-grants  
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## ***1. Cover Sheet***

**Title:** Bringing Evolution into the curriculum for non-science majors at the University of Richmond.

**Faculty Name:** Dr. Rafael O. de Sá.

**Title, Department, Institution and Mailing Address:** Associate Professor, Department of Biology, University of Richmond, Richmond, VA 23173.

**.Date of Submission:** March 12, 2004.

**Date of Proposed Period of Grant:** Development during summer of 2004 and fall 2004, implementation in Spring 2005.

## ***2. Summary.***

The goal of this proposal is to develop a course that will bring the evolution and evolutionary biology theory and practice into the non-science major's curriculum at the University of Richmond. The course will be developed and taught based on three complementary pedagogical principles that I have tested before and that have been effective in my other courses: strong course content, empirical learning, and critical thinking.

The goal of this course is to provide students with an understanding of evolution and how it shapes our lives and our planet. It covers a broad range of topics including: what is evolution? the importance of evolutionary biology, natural selection and adaptation, origin of life, fossils, plate tectonics, biogeography, the genetics of evolution and biodiversity, human evolution, cultural versus biological evolution.

Assessment of students learning will be performed during the course itself as well as after 6 month to a year of course completion. Assessment during the course will be made using a combined approach of formal tests, students' pre and post course surveys, students' surveys on the general population, and students' analysis of a movie related to evolution. Course assessment will be done by comparing surveys between students in this course with those taking the major's evolution course and with a retention e-mail survey given at least 6 months after the completion of the course.

### ***3. Project Description.***

**Goal:** I consider the subject of Evolution to have foundational position in the training of any undergraduate biology major; furthermore, I consider the scientific understanding of Evolutionary Studies to play a critical and foundational role among college educated citizens. Herein, I propose to develop and implement a course that will focus and will bring Evolution and Evolutionary Biology into the University of Richmond General Education curriculum. This course will provide students with an understanding of evolution and how it shapes our lives and our planet. It will cover a broad range of topics including: what is evolution, the importance of evolutionary biology, its history, origin of the universe and the Earth, origin of life, fossils, plate tectonics, biogeography, human evolution, religion and evolution, and eugenics.

**Course Objectives:** For undergraduates, non-science majors, students: 1) to differentiate between scientific and non-scientific data and theories, the misuses of the evolutionary theory in society, and the role of genetic diversity and methods of methods of assessing it, 2) to understand the theory of evolution and the role (i.e., the strengths and limitations of science) that evolutionary studies play to address current society problems (from the origin and evolution of

HIV, to the mode and tempo of evolution, to the current biodiversity crisis, 3) to our basic knowledge of human evolution. Each course objective will be designed and implemented in 3 course modules (the length of each module will be 4 weeks of lecture and lab).

**Background and Significance:** Every biologist is familiar with Dobzansky's statement "Nothing in biology makes sense except in the light of evolution" (Dobzhansky, 1970). I would extend this statement beyond biology. Evolution and evolutionary theory provides us the opportunity to engage non-science students in understanding the process of scientific discovery and the role and contribution of science to society (Cooper, 2004). Furthermore, it allows us to train and develop the skills of data analysis and the critical thinking of a segment of the students' population, that although they may not become scientists, they will need to evaluate the data and options to make society choices that ever-increasing information based society will provide them.

**Course Plan and Implementation:** The teaching philosophy that characterizes my courses is based on balancing three main principles that I believe are important in science education 1) *Strong Course Content*, 2) *Empirical Learning*, and 3) *Critical Thinking*. I believe that course content is the most critical aspect and the necessary base for efficient teaching. The content of a science course is important if we want the students to truly be educated about a given subject. Once the theoretical background has been established, then the students move on to learn through their eyes and their hands, that is, by observing and doing. Strong laboratory and independent project-based courses are fundamental to exposing students to the scientific method and the excitement of being part of a research and discovery process as well as to develop problem-solving using quantitative methods, statistical analyses, and computer data manipulations where appropriate. Third, I encourage students to critically analyze and question

ideas, data, results, and views, including my own, developing along the road their own logic and power of thought. I have found this to be an effective method to challenge students and, at the same time, engaging them to the point that they want to learn more data and theory, bringing them back to content.

As indicated above the lecture component of this course will cover a broad range of topics (*Strong Course Content*) from the theoretical aspects of evolution, the importance of evolutionary biology, history of Earth and origin of life, fossils, plate tectonics and biogeography, to human evolution. *Empirical learning* will be the focus of laboratories where students will be expected to apply the information learned so far in the course. The class will be divided into teams of two, each member must contribute and the pair will team-present their findings during selected laboratory days. For example, module one would require from the students to learn modern molecular techniques such as DNA amplification (PCR) and DNA sequencing as tools to assess genetic diversity in wild populations. There are available software for simulations on natural selection, genetic drift, etc, which will be incorporated appropriately (e.g., [www.pbs.org/evolution](http://www.pbs.org/evolution)) In Module two, students will construct a “phylogeny of primates” based on molecular data. The module will be modeled after the available example for bears (Maier, 2001). This exercise would serve to link Module 1 (e.g., genetic diversity) to the information in Module 2, furthermore we will carry the theme into module 3, human evolution. Module 2 will require students to learn and use basic statistics, perform searches in the web (e.g. using BLAST) and learn sophisticated phylogenetic software (e.g., PAUP, Swofford, 2002). During the laboratories of the third module each pair will select a prominent hominid fossil to research. Furthermore, we will have model skulls for a variety of primates and hominid fossils in laboratory. Students will have to come up with a set of characters from these models and build a

phylogenetic tree. Subsequently, they would have to attempt to combine and analyzed the morphological and molecular data together. Each team will present their findings in class, however each student must also hand-in a written assignments on their selected topic for two of the modules.

*Critical thinking* will be encouraged throughout the semester; two assignments will be design for this purpose. First students will perform two surveys to better understand the impact of evolution on our everyday lives. Each student will ask 10 adults their views on a number of questions related to evolution and will hand in a typed summary of their findings, the raw data response sheets, and a brief discussion of what the responses seem to indicate about society's knowledge of, and relationship with, evolution. An in-class discussion of the results will follow each survey. Second, each student must write a five-page paper reviewing a movie relating to evolution. Students will be graded on their ability to explain how the movie accurate or inaccurate incorporates evolution, evolutionary theory, evolution and society, etc.

**Related Prior Activities/Research:** I teach the Evolution course for Biology Majors. This course is design for Biology Majors to understand the theory of evolution in itself and its relationships to other courses they take throughout the Biology curriculum. My research program is focused on evolution and phylogenetic reconstruction of frogs using a combined data sets (molecular and morphological).

**Timetable:** I plan to develop a course syllabus (draft), select a textbook (among various options), and develop and try laboratory exercises during the summer 2004. During the fall 2005, based on work done during the summer, I will develop a final course syllabus. The course should then be taught in the Spring 2005.

**Context and Impact:** The development of this course fits with the stated goal for our Science Faculty to shift from our large introductory course for non-majors to develop smaller and subject focused non-majors science course. The goal is to develop non-majors science courses that would benefit from the expertise of our faculty. Currently, the Biology Non-Majors course serves approximately 120 students a semester. The new subject focused courses will provide smaller classes and a broader spectrum of biology for students to choose based on their own curiosity and interests. Each course will consist of a lecture (40 students) and two laboratory sections (20 students each). The smaller classroom size will provide the opportunity for additional interactions with students as well as using a variety of pedagogical approaches and first hand learning activities. In developing the non-majors Evolution course, I will have the assistance of two colleagues, Ms. Maren Reiner and Emily Boone. Ms. Reiner, Director of Biological Laboratories, has extensive experience serving the non-majors students populations at UR and she teaches most of the currently non-majors biology student population. Ms. Boone, Director of Biological Laboratories, teaches the laboratories for our introductory biology majors' courses. I will be working with them during the summer 2004. This collaboration is intended to benefit other aspects of the curriculum. In particular with Ms. Boone we will use Module 2 of this new course as a model to develop a lab unit on evolutionary theory and practice for the majors introductory course. Whereas with Ms. Rainer we will use Module 3 of this new course to develop another non-majors biology course focused on Human Evolution. Ms. Rainer and I may alternative teaching these courses as needed (e.g., during sabbaticals, etc).

**Evidence of Institutional Support.** See letters from Departmental Chair and Academic Dean. As indicated above, the development of this course will impact other courses in the curriculum and it may serve the development of another non-science major course focused on human

evolution. Furthermore, because of their extensive experience with non-majors as well as their role as Directors of Biological Laboratories, I consider the participation and assistance of Ms. Rainer and Ms. Boone pivotal during the summer 2004 for the success of the course in the Spring 2005.

#### ***4. Evaluation and Dissemination.***

**Evaluation.** The success of the students in the course will be assessed in several different ways. Grades will be based on a combination of 2 exams (exam 1 = 20%, final exam = 20%), 2 surveys (each worth 5%), 2 written assignments (each worth 20%), movie critique (worth 10%).

Furthermore, the success of the course itself will be measured by distributing a survey the first day of class and the last day of classes. These surveys will have specific and general questions about Evolution and the role of evolutionary theory in society, and how do the students view the perception of evolution among the general population. The same survey will be given at the end of the semester. Comparisons between these surveys should provide information on the amount of knowledge and understanding that the students had gained throughout the course.

Furthermore, they will also provide an idea of how the students perceptions of the role of evolutionary theory in society, as well as how the students views of the general population, may have shifted.

For comparison, the same surveys will be given in the majors' evolution course that I teach to assess similarities and differences in they way the two students' populations learn the subject. Finally, I anticipate that most of the students that will take the proposed course will not be seniors. Consequently, this will give me the opportunity to assess, at least to some level, the retention of information and concepts after a given period of time. This assessment of retention

will be done by sending an e-mail survey to those students that took the course anywhere between 6 months to a year after they completed the course.

**Dissemination.** We will consider submitting an article to the Journal of “The American Biology Teacher” focusing on mechanisms to strengthen the teaching of evolution throughout the curriculum based on our experience linking 2 and possible 3 courses during this experience. We will present our results at appropriate workshops of ACS and at the National Association of Biology Teachers (NABT).

### ***5. Literature Cited***

Cooper, R.A. 2004. How evolutionary biologists reconstruct history: Patterns and Processes. *The American Biology Teacher* 66(2): 101-108.

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