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Creative Approaches to Teaching Science in an Honors Setting

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There are many reasons to teach science literacy in a University Honors Program. As our program director, Dr. Rosalie Otero, stated when asked why she has made such a strong commitment to incorporating the teaching of science into our program at the University of New Mexico:

> *It is difficult to envision how one will be able to live effectively in the twenty-first century without having achieved scientific literacy. While every educated person will certainly not be a scientist, every educated person must possess sufficient knowledge of the scientific method and of fundamental concepts of the natural sciences to make informed decisions.*

With the growth of the Internet and the biological advances of the genetic revolution, the gap between those citizens who have such mastery of key scientific and technological skills and those who do not will become a critical divide.

A scientifically literate populace will also be important to our future as a nation. As a country we are already confronted with political and social decisions that require that the body politic have the ability to identify the difference between competent science and junk science. These skills are imperative if we are to make informed decisions in both our personal and our public lives. E.O. Wilson has warned:

> *Already half the legislation coming before the United States Congress contains important scientific and technological components. Most of the issues that vex*

> *humanity daily—ethnic conflict, arms escalation, overpopulation, abortion, environment, endemic poverty, to cite several most persistently before us—cannot be solved without integrating knowledge from the natural sciences with that of the social sciences and the humanities. Only fluency across boundaries will provide a clear view of the world as it really is, not as seen through the lens of ideologies and religious dogmas or commanded by myopic response to immediate need. Yet the vast majority of our political leaders are trained exclusively in the social sciences and the humanities, and have little or no knowledge of the natural sciences. The same is true of the public intellectuals, the columnists, the media interrogators, and the think-tank gurus. The best of their analyses are careful and responsible, and sometimes correct, but the substantial base of their wisdom is fragmented and lopsided.* (Wilson, 1999)

If Honors Programs do not accept the challenges outlined by Otero and by Wilson, who can and will? In 1998, the University Honors Program at University of New Mexico demonstrated its awareness of, and its commitment to, addressing these issues. It did so by hiring a full-time faculty member whose background is in the biological sciences. The two years since that time have been both exciting and challenging for myself, as that new faculty member, and for the Honors Program. We have experienced some great successes and still have much to achieve. To help you understand the setting and so that you can evaluate how well this experience can inform your own, I will begin by describing how our program fits in with the rest of the university community.

The University of New Mexico is a large research institution with over 24,000 students. There are excellent science departments—biology, geology, chemistry, etc.—but the Honors Program has focused primarily, as most seem to, on the humanities. In 1996, the university moved to a tenure-track system for Honors faculty, and all hires since then have been hired at the rank of Assistant Professor.

At UNM, honors are awarded in each department. In Biology, for example, there are no specific honors classes, but a biology student can graduate with Biology Honors by conducting research and writing an undergraduate research thesis. This student may well be one who does not especially like the humanities and would prefer to avoid classes outside his/her field. This student may elect to be a part of the University Honors Program because it offers some specific advantages. He/she will take 21 hours in the Honors Program. These units can satisfy several of the student's general education requirements (i.e., humanities, social science, and arts requirements) without him or her having to attend the very large lectures offered through these departments. Biology, chemistry, and math majors are also often looking for elective classes that will allow them to delve more deeply into some aspect of their major or to investigate an interdisciplinary approach to some topic. For example, the opportunity to discuss the historical, ethical, or political implications of their work is often lacking in the science curriculum, and, as an interdisciplinary program, Honors Program classes offer this opportunity.

Another Honors student is one we might identify as well-rounded. This student likes a wide range of topics, and the Honors Program allows him/her to pursue interests across a broad spectrum. Often, such a student liked science in high school but decided to follow another career path. Many such students are heading to law school or to MBA programs. They are interested in topic courses that allow them to satisfy their broad interests or that infuse their primary major with very different skills and proficiencies.

The third student group is made up of those who are anxious to take science in an Honors setting because they need one course to fulfill their lab science requirement for graduation. These are the science-averse students who have done well in school but who never liked science and would avoid it if at all possible. Because they write and read well, they are comfortable with the Honors format and they hope the experience won't be too painful in the Honors Program.

Such diversity of student needs means there are diverse curriculum needs as well. This reality places great demands on curriculum development but also provides for some especially rich rewards.

CURRICULUM DEVELOPMENT

LABS

One of the first things I did was to apply for lab credit hours for the Honors Program. Within the first year, lab credits were approved by the university, and we are now able to satisfy the needs of those science-averse Honors students. They can now tackle science in a small seminar setting rather than the large lecture format so familiar at big universities. The lab format fits the Honors teaching method very well. Historically, labs are hands-on and interactive. The least successful aspect of many traditional science labs is that students experience them not as experiments of discovery but as lab demonstrations that are failures if they don't come out as outlined in the lab manual. The small setting and the participation of the faculty member rather than a first- or second-year graduate student allow greater flexibility in an honors lab, and our students can experience the lab as a dynamic and exciting class rather than a highly structured exercise.

The major challenge to presenting good labs is one of gathering instrumentation and proper facilities for the class itself. During our recent move to a new facility we made some gains in this area. We designed one classroom that has the basics: a sink, running water, fans, cabinets for equipment, and a small refrigerator. While these are important strides, for now we work with very limited equipment. We still have important needs such as a hood, more appropriate lab tables and stools, and better microscopes. While these limitations are at times frustrating, we have worked to make our lack of equipment a strength rather than a weakness. We have been able to succeed in part because of the generosity of members of the Biology Department, who often provide space or short-term loans, and in part because Honors students are very good at devising things.

In the first lab class I offered, students were required to propose and then design the experiments they would do. They were required to secure any needed equipment and to carry out the experiment. Finally, they had to present the experiment and its results to members of the seminar who had not elected to participate in the lab. The students needed a centrifuge and were unable to borrow one. They also decided that future classes should have a centrifuge. So, they

decided that their first assignment was to build a functional piece of equipment from a kitchen blender. The students learned a great deal about the design and manufacture of scientific instrumentation. While our new centrifuge looks a bit unusual, it is perfectly balanced and has been a great hit in class. After its fabrication, these same students used it to carry out their first experiment: the extraction of DNA from several fruits and meats.

COURSE TOPICS

Probably the most challenging aspect of curriculum development in this setting is the need to design courses appropriate to the diverse student population we serve. Since our students differ so much in their knowledge and understanding of scientific material, I have designed and taught several courses that range in focus from minimal science to complex biological topics and in-depth scientific concepts. These topics are then coupled with an investigation of the ethical and political consequences associated with them. These courses are:

Writing the Earth (200 level, writing and reading nature writing from North America). This course introduces biological thinking as well as creative writing and teaches basic field observation techniques. Several basic biological concepts are incorporated. Students learn about taxonomy, use of field guides, and some evolutionary thought while they are learning to write and are reading about the American landscape.

Natural History of the Southwest (300 level, includes a lab and field work). This course teaches a variety of biological concepts and skills while focusing on the Southwest region in which our students live. Students are required to keep field notes and to learn observational skills. They learn about regional biomes and habitats and about particular organisms as diverse as biotic crusts, beetles, birds and plants. They complete the course by presenting a symposium on local conservation issues to the university community.

Biodiversity, Our Natural Heritage (300 level, no lab at present, but this may change). This course presents the fundamentals of ecology and conservation biology and

incorporates political and social issues. Students read and analyze two books—*Diversity of Life* by E.O. Wilson and *The End of Evolution* by Peter Ward— as they discuss evolution and the third great extinction in process now. We discuss the development of an environmental ethic, and each student becomes an expert on one group of endangered organisms, presenting the social, cultural, and political issues as well as the biological issues surrounding that group's endangerment.

Biodiversity and Natural History of Tropical Australia (300 level, a field course offered in Australia in alternate summers). This course introduces the unique fauna and flora of Australia as it teaches the fundamentals of ecology and the discipline of scientific research. Students learn to conduct individual scientific inquiries. (Shepherd, 1999; Also, visit our web site: http://www.unm.edu/~austral.)

Cloning and Genetic Engineering (300 level, lab available to students willing to be self-directed). This class strives to teach the biological fundamentals of genetics to a broad range of students, not just biology majors, and it explores the ethical and moral issues that modern genetics and embryology bring to the table for both modern scientists and modern citizens.

Senior Option (400 level, senior capstone experience). Students may complete a senior thesis or a community science-based project. Either option is based in science research or science teaching. Students pursuing the thesis option must submit their thesis in the format of an appropriate refereed journal. They are strongly encouraged to consider publication of this work. As with other students completing a thesis in Honors, they must present a professional oral defense of that work. Students choosing community service are encouraged to do substantive work such as volunteering at the museum of natural history or developing a science course for local high school or primary school children. These students must also present an oral report of the results of this work. (Examples of student work and additional information about any of these classes can be found on my web site: http://www.unm.edu/~microart.)

STUDENT DIVERSITY BUILDS COMMITMENT AND ENRICHES COURSE CONTENT

I would argue that the diversity of needs and skills of our students is one of the great strengths of Honors science classes if they are well designed. Special attention must be given to assure that assignments and readings are developed and assessed with the idea of making use of each student's strengths and interests. This makes the first several class meetings especially important.

As an example, in "Biodiversity: Our Natural Heritage," we read and discuss Wilson's *Diversity of Life*. Several chapters are quite advanced for the average student so I am careful to choose more advanced students to tackle the discussion of these readings. I begin the semester with a brief writing assignment in which I ask all the students to tell me what biology courses they have had, and I ask several basic questions that allow me to assess their competence. In the biodiversity class, I might ask questions about the species-area curve and the Hardy-Weinberg Principle. Papers are not graded, but I read them before I assign students to lead discussions on particular chapters. For a chapter as difficult as that dealing with population genetics, I lead the discussion if there is no qualified student in the class. Students who are not proficient in the topics are required to provide specific questions that can form the basis for the discussion.

Final oral and written projects also differ markedly depending on student interests and strengths. How projects are graded differs as a result. In my first class on cloning and genetic engineering, one student was particularly interested in law and intellectual property rights. He wanted to explore the implications of the genetic revolution for this area of law. My expectations for his final assignment were therefore different from those arrived at with another student, who focused on dealing with the applications of genetic engineering technology on third world farming practices. While each student was required to demonstrate a firm understanding of the science involved, each also became an expert in a very different literature. In so doing, each added a vital perspective to the overall class discussion.

Another context in which diverse student backgrounds and interests can prove beneficial is team projects. I always pair students

with different skill levels, and students with a higher level of mastery are expected to mentor their less trained teammates. I emphasize that the lead student will learn a great deal in the process of teaching, and I acknowledge that I expect more from him/her in overall mastery. As a result of this practice I have been able to identify important holes in more advanced students' understanding of complex topics and have been able to assist them in closing those gaps, thus providing a useful service to those students preparing to take the MCAT or GRE. Students generally become quite committed to this format because of these perceived benefits.

Although I was initially concerned students might see the small differences in expectations as unfair, to date they have been quite comfortable with those differences. They are quite aware that a biology major can be expected to bring a greater depth to a biology topic. Also, many of the students who did not have a background in biology have proven quite able and have surprised and pleased their fellow classmates with the degree to which they gained proficiency. Overall, students have reported in their evaluations that the courses have been quite successful, and I have truly enjoyed teaching them. Beyond that, in a university with an overall retention rate of approximately 80% for its best undergraduates, Honors students complete their undergraduate degree at the rate of 98%, and many of the students in these classes are continuing on to graduate school.

CONCLUSION

There are several major goals that confront science educators in the twenty-first century. The first, and undoubtedly most recognized, is that we "need to teach more students more science" (Tobias, 1990). The second is that we must ensure that those students who will be future science practitioners achieve a real fluency in their chosen fields. At the same time, future scientists must not complete their undergraduate careers unaware of or unprepared to face the political and ethical issues associated with their work. The last goal, as recently defined by Wilson (1999), is for science faculty to join with faculty from other branches of academia to establish formats that allow students to engage in the quest for the unification of knowledge.

University Honors Programs are especially well suited to address these challenges if we are willing to push the envelope of interdisciplinary studies to include substantive science topics. In doing so, we will also enliven our existing programs as we welcome a greater diversity of students. It is in Honors that the gifted non-scientist is lurking. It is in Honors that science majors can stretch to embrace other modes of thought, and it is uniquely in Honors that we are able to encourage dialogues between diverse intellectual cultures—dialogues that we can only hope will continue throughout the lifetimes of our students.

LITERATURE CITED

Shepherd, Ursula, L. 1999. "Biological Diversity of Tropical Australia: A Summer Field Experience for Honors Undergraduates." *The National Honors Report* 20 (2): 36-39.

Tobias, Sheila. 1990. *They're Not Dumb, They're Different.* Research Corporation, Tucson, AZ.

Ward, Peter, D. 1994. *The End of Evolution: On Mass Extinctions and the Preservation of Biodiversity.* Bantam Books, New York, NY.

Wilson, E.O. 1992. *The Diversity of Life.* Norton and Company, New York, NY.

—.1999. *Consilience: The Unity of Knowledge.* Vantage Books, New York, NY.

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