How To Do It

Nonmajors' Biology: Enhanced Curricular Considerations

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We are often guilty, as science instructors, of making the assumption that students share our enthusiasm for biology. Since we "know" that students inherently share this affection, we further assume that our students are interested in learning the complex and wondrous details of the knowledge we possess. However, it comes as no great shock to anyone involved in undergraduate instruction that nonmajor undergraduates may not entirely reflect our fervor for biology. In fact, significant numbers of college students believe that biology has very little to do with their personal lives (Ewing, Campbell & Brown 1987).

The typical collegiate science course, unfortunately, lends credibility to such a belief. Larson (1982) alluded to this by noting that science courses are often "bogged-down" with specialized jargon, symbols, arithmetic metaphors and minute details that can discourage or even "turn-off" nonmajor students. Certainly one approach to increasing the popularity of a collegiate science course is to reduce the demand placed upon students for abstract reasoning and quantitative skill, while providing reinforcement in the form of "easy" grades (Garmon, Madeley & Lockhart 1974).

Should we treat an introductory nonmajors course differently from a majors course, in order to improve nonmajors' attitudes toward biology? We believe that the answer is yes, but not at the expense of content integrity. The content is far too important in the development of a more comprehensive understanding of biology. Besides, an increasingly scientific and technologic society demands that students be "scientifically" literate in order to make important and informed future choices (Kormondy 1985). A maintenance of content integrity does not, however, preclude us from listening to and addressing the concerns, attitudes, beliefs and interests of nonmajor students.

Nonmajors' Biology

Hans Andersen, a recent president of National Science Teachers Association, proposed a more holistic approach to science teaching in dealing with the needs of nonmajors (Andersen 1978). In this approach, he accurately portrays science as a discipline with many dimensions: aesthetic, empirical, futuristic, historical, philosophical and technological. Thus, if we consider nonmajors' "interest orientation," we can hope to match such interests to one or more of the above dimensions. For example, he suggests that assignment options for a study of evolution matched to interests might include those in the chart below:

Assignment Option	*Student Interest Orientation*
—Read a contemporary article on genetic engineering;	—Technological
—Report on a study of paintings depicting evolution;	—Aesthetic
—Study the biological and creationist positions on evolution; or	—Philosophical
—Investigate the Hardy-Weinberg Law application to population genetics, etc.	—Empirical

That science instructors should consider nonmajors' interests was also recognized by Harms and Yager (1981) when they established four critical areas of instruction related to the development of scientific literacy. These four areas were: (1) academic preparation [content integrity]; (2) personal relevance; (3) societal issues; and (4) career awareness. Indeed, to consider the special needs of nonmajors, one hopes to overcome a longstanding criticism that science instruction fails to consider the individual differences among such students (Scharmann & Harty 1986; Ronning, McCurdy & Ballinger 1984).

Rationale & Course Evolution

This paper describes a successful attempt to design a meaningful, personally relevant and pedagogically sound general biology program for nonmajors at Indiana University of Pennsylvania (IUP). Realizing that a general biology course may be the last chance to influence nonmajors' attitudes about science and their environment, as well as instill a more unbiased and informed decision-making ability, IUP proceeded with the development of a novel general biology course. The general biology team abandoned the traditional "simple-to-complex" sequence (i.e. atomic bonding, molecular structure, macromolecules, the cell, taxonomy, anatomy,

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physiology, etc.). Instead, the team devised a "familiar-to-unfamiliar" curriculum philosophy consisting of three major points.

The *first* and most important goal was to retain content integrity, yet integrate that content with student interests: the environment, the individual, the species and the complex mechanisms that allow these three to function, evolve and exist together. The *second* major philosophical component of the new program was to increase direct student involvement. Laboratories and field exercises were written by the general biology team, specific to the local environment, and designed to maximize students' direct "hands-on" involvement with natural biological settings. Finally, the *third* priority was to conduct at least half of the laboratory aspect of the course at field-based locations.

Transportation Considerations

A major initial problem was getting nearly 1200 students to the field-based sites each week. This required the development and maintenance of a system of transportation. This "system" consists of eight 15-passenger vans, initially leased and eventually purchased, with cooperation and assistance from each of the major local car dealerships. Thus, for each of the 50 laboratory sections conducted each week, as many as six vans convey students from campus to field and back. The remaining two vans are used both for other field-based courses and also to serve as replacements in case of repair or break down to one or more of the regularly scheduled six vans.

Contextual Setting & Program Implementation

Indiana University of Pennsylvania (IUP) is an institution of more than 12,000 students located on the western edge of the Allegheny Mountains northeast of Pittsburgh. Therefore, its rural setting provides fairly easy access to very diverse ecosystems and opportunities for field experience. These ecosystems include: freshwater streams of varied orders, small lakes and ponds, oak/hickory hardwood forest and remnant white pine/hemlock virgin stands, major rivers and Lake Erie. In addition, a wealth of environmentally stressed areas exist nearby (such as those produced by strip- and deep-coal mining, acid mine drainage, farm abandonment, gas and oil drilling, and acid rain caused by fossil fuel power generation.

General biology at IUP is a two-semester, eight-credit course with three hours of lecture and two hours of laboratory per week. Lecture sections consist of groups of 96 to 120 students enrolled in 10 sections. Laboratory sections are small, with a maximum of 24 students enrolled in 48–50 sections. Thus, with the current faculty teaching load at IUP, it is both common and preferred by team members whenever possible to teach the same students in lecture and laboratory (i.e. an instructor with 96 lecture students would teach those same students in four lab sections). Laboratories are planned and taught by faculty, with graduate assistants often incorporated into the program as apprentice instructors and/or as assistants in course materials preparation. Undergraduate biology majors also assist in the set-up and break-down of weekly laboratories. In addition, laboratory assistants often drive the second van to weekly field locations.

The operation of general biology at IUP is controlled by a team of eight to 10 faculty who regularly lecture and teach laboratories. The composition of this team fluctuates moderately, but remains stable because of a core of individuals who possess diverse backgrounds, sub-discipline specialties and a sincere interest in the development, ongoing revision and advancement of the program. Headed by a director, the team meets bimonthly to deliberate the concerns of the program. These concerns vary, but typically deal with lecture content and sequence of topics, selection of a textbook consistent with the goals of the program, development and scheduling of laboratory exercises, ordering of supplies and equipment, individual student concerns and progress, and ongoing transportation arrangements for field-based activity.

The sequence consists of two courses, General Biology I and General Biology II. General Biology I is offered in the fall semester as well as during the first half of summer sessions, while General Biology II is offered during the spring term and the second half of the summer sessions. Thus, during a given academic year, the sequence is open for enrollment to provide students the opportunity to complete the courses during a contiguous academic year.

Lecture Topics for General Biology I & II

The lecture portion of the course begins with *ecology* for three reasons. First, it coincides with field-based exercises that must take advantage of the late summer and early fall weather. Second, it attempts to reflect a recognition by nonmajors for more familiar environmental locales. Third, it provides opportunities to examine, in greater detail, factors that influence those local environments. Thus, the first seven weeks of scheduled laboratory time are field-based exercises and the remaining six are conducted indoors (obviously, because of more inclement weather). The remainder of the lecture topics for General Biology I are more orthodox and traditional: chemistry—of life; cells—structure, function, transport and reproduction; genetics—Mendelian, molecular and human; and physiology—the major systems, digestion, respiratory, circulatory, excretory and endocrine.

The General Biology II phase of the course sequence must be preceded by a passing grade in General Biology I. The lecture topics are a continuation of the material covered in General Biology I. Four major biological themes are delineated in General Biology II including: neurobiology and animal behavior; evolution and the origin of life; asexual and sexual reproduction—plants and animals; and embryological development.

Field-Based & Laboratory Activities (General Biology I)

The field/laboratory topical sequence for General Biology I is listed with a brief description in Table 1. All of the exercises have been written by members of the General Biology team and have been published by the Kendall-Hunt Publishing Company: "General Biology Laboratory Manual." The manual is revised when required, in order to improve existing exercises and incorporate newly written ones. Any profits accrued from the sale of the manual are placed in a fund with the University Foundation and are utilized exclusively at the discretion of the team to improve the general biology program. The fund allows the team the freedom to purchase items that are difficult to acquire through the university budget. The experiences are consistent with and complement the material being presented in lecture.

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Laboratory & "Elective" Experiences (General Biology II)

The laboratory experiences in General Biology II are of two types: regularly scheduled laboratories and special topics "elective" experiences. The "formal" laboratories, in similar fashion to General Biology I, complement the material being presented in lecture (see Table 2). These "formal" laboratories consist of six indoor exercises and a winter field trip. This winter field trip occurs at a variety of sites, to provide students with an opportunity to examine and compare abiotic and biotic conditions at locations they had previously seen and were familiar with, from the fall semester.

Elective Experiences

The "elective" program was designed to allow students to become involved in biological activities that are of more specific interest to them. The activities (see Table 3) are both field and "in-lab" in nature. The elective experiences vary in length from individual two-hour seminars to all-day activities; some are even conducted as entire weekend events. Students are required to enroll and participate in a minimum of 10 contact hours of elective program activity.

Each hour of elective activity is considered equivalent to four points. Since the "formal" laboratory component of General Biology II comprises 60 percent of a student's laboratory grade, as a consequence, the "elective" program contributes the remain-

Table 1. Laboratory exercises covered in General Biology I

Laboratory/Field Topic	*Annotated Description*
Organization; Topographic Maps	This laboratory develops skills in the use of the topographic maps as it relates to field studies in biology and the distribution of organisms.
Trophic Levels	By actually collecting organisms from a given area, students construct a food web, discuss how each relates to all the others and develop an appreciation for the complexity and interrelationships that exist in nature.
Population I and II	Students demonstrate an understanding of the techniques for estimating the size of biological populations by the mark and recapture method. The Lincoln-Petersen estimate and calculation of *standard error* are used to predict the population estimate.
Stream Ecology	This field activity involves the examination of a small cold water stream. The students compare riffles and pools, contrast physical and chemical limiting factors, and collect and compare common stream organisms.
Ecological Succession	Students are given the opportunity to observe the orderly sequence of change in habitats over time. Examples of both primary and secondary succession are included.
The Cell	The objective of this laboratory is to give students the opportunity to observe examples of plant and animal cells and develop the skills necessary to prepare slides and utilize the microscope.
Mendelian Genetics	With the aid of "model" chromosomes, students experience random assortment during the process of gamete formation and fertilization by combining gametes. Students gain practice in solving basic genetic problems involving monohybrid, dihybrid, sex-linkage and incomplete dominance.
Biological Variation	Making use of organisms taken from local field sites, students investigate and quantify variation among organisms and variation between specimens from different habitats.
Human Circulatory System	Students monitor pulse rate and blood pressure of their classmates during varied levels of physical stress.
Frog Dissection	Using preserved frogs, students become familiar with the internal and external anatomy by dissection and inspection.
Contemporary Biology	Students collect, on a weekly basis, a set of articles dealing with biological topics from newspapers and magazines. They are required to select at least one article for oral presentation to their classmates.

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Table 2. Laboratory exercises covered in General Biology II

Laboratory/Field Topic	*Annotated Description*
Organization; Fermentation	With an understanding of the processes of fermentation, students design and conduct exercises to produce wine, yogurt and sauerkraut.
Physiological Effects of Temperature	This laboratory is designed to enable the students to observe the physiological responses animals (i.e., fish) exhibit when subjected to environmental changes.
Winter Field Trip	Students are provided with an opportunity to return to habitats they visited in the fall semester to observe the variability of adaptations required to survive under harsh winter conditions.
The Nervous System	Students experimentally illustrate the various principles of sensory receptors, reflex arcs, and effector cells and muscular action.
Animal Behavior	In this laboratory students present various stimuli to Betta fish and record and describe the resulting behavioral responses.
Plant Reproduction	This laboratory exposes students to the modes of reproduction found in plants, with special emphasis on Angiosperms. Fruit and flower structure are studied.
Evolution	Students uncover the principle of divergent evolution (speciation) by constructing a phylogenetic representation using hypothetical "caminalcules".
Elective Program	See text and Table 3.

ing 40 percent. Therefore, a student can receive a maximum of 40 points for completing the elective laboratory program.

In order for an individual student to accumulate 40 points, the students select laboratory offerings consisting of combinations of two, three or more hours, that total 10 hours of combined laboratory activity. Alternatively, some students obtain all 40 points through participation in an activity that requires 10 or more consecutive hours to complete. The wealth of activity options is delineated in Table 3.

Students are provided with a comprehensive listing of elective program activities (similar to Table 3) several weeks prior to the completion of the "formal" laboratory sequence. Because of the high demand for popular trips (i.e. National Zoo and Smithsonian Museum in Washington, D.C.), seats must be filled using a lottery system. Students are requested to indicate their interest in either a 40- or 32-point elective activity by completing a lottery card for one (and only one) of these high demand offerings. If a student is, by random selection, chosen for one of these activities, he/she is guaranteed a space and transportation. Students neither participating in nor selected in the lottery still need to select activity options that total 40 points. In addition, those students selected for a 32-point activity, 24-point activity, etc., respectively still need 8 points and 16 points to complete their 40-points of enrollment. In either of these instances, such students must attend a one-day (Saturday) registration to indicate their personal preferences by signing their name and listing their social security number (proxy sign-up is not permitted) for only those elective offerings with available space. Spaces for non-lottery elective activity options are filled on a first-come basis. There are usually 40 to 50 different elective program activities from which students may make selections to complete their individualized "elective" programs. These offerings vary from year to year depending on the specific interests of the faculty involved and the demand by students for particular activities, some having been offered in previous years.

The "elective" program is extremely well received by the students, because it allows them the freedom to design their own individual program by selecting experiences that they perceive are of personal relevance or that might seem interesting to learn about. In addition, without the threat of having to perform well on an exam or quiz, most students tend to be more relaxed about asking questions, attempting activity-specific tasks, or volunteering answers to questions. Finally, the program is also well received by the faculty involved, because it permits them opportunities to offer experiences in their areas of special expertise and to try out new laboratory exercises or field experiences. It also allows them to teach a laboratory or field exercise for students who, by their own choice, are attending that lab/field exercise as a result of expressed personal interest.

Points awarded to students participating and completing a specific activity are left to the discretion of the individual faculty member conducting the experience; however, any "evaluation" tends to be informal. Points are reported to participating students' lecture instructors on an all or nothing basis. A rationale for this informal evaluation is simple. The members of the General Biology team, committed to attitudinal development in addition to assessing achievement, feel that the elective program should enhance the development of positive attitudes toward science through participation in student-selected experiences with *no* assessment of achievement differences among participating students. Students making reasonable attempts at performing activity-specific tasks receive full credit; students abusing this privilege receive no credit.

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Table 3. The Elective Program Options

Option Number	*Field/Laboratory Title*	*Points Awarded*	*Minimum Hours Required*
1	Cleveland Zoological Park/Sea World[f]	40	10
2	Cook Forest Natural Area[f]	40	10
3	National Zoo and Smithsonian Museum[f]	40	10
4	Human Sexuality[c]	40	10
5	Wildlife Research Facility[f]	40	10
6	Marine Biology - Wallops Island, VA[f]	40	10
7	Pollution Control[f/c]	32	8
8	Physical Rehabilitation Center[f]	32	8
9	Pittsburgh Zoo[f]	32	8
10	Simulated Nuclear Power Plant[f/c]	32	8
11	Carnegie Museum of Natural History[f]	32	8
12	Pittsburgh Aviary[f]	28	7
13	Animal Diversity and Adaptation[f] (Pittsburgh Zoo)	24	6
14	Exceptional Children and their Training Program[f/c]	20	5
15	Phipps Conservatory[f]	16	4
16	Microbes: Examination of Food Utensils[c]	16	4
17	Microbes of the Throat[c]	16	4
18	Microbes of the Skin[c]	16	4
19	Microbes: Testing of Antiseptics and Disinfectants[c]	16	4
20	Sun Cliff Nature Hike[f]	12	3
21	Dinosaurs: Their Lives and Times[f]	12	3
22	Physiological Responses to Stress Testing[c]	12	3
23	Pond Ecology[f]	12	3
24	Nature Photography[f/c]	12	3
25	Evolution: A History of Controversy[c]	12	3
26	Creation, Evolution, or Both?[c]	12	3
27	Sociobiology and Biological Determinism[c]	12	3
28	Dinosaur Controversies[c]	12	3
29	Cave Trip[f]	12	3
30	Neurobiology in Action[c]	12	3
31	Good Blood-Bad Blood: How Healthy Is Your Blood?[c]	12	3
32	Every Breath You Take: Human Lung Function[c]	12	3
33	Fossil Collecting[f]	12 or 8	2–3
34	Biomedical Ethics, Technology, Society and Our Biofuture[c]	8	2
35	Nature Printing[c/f]	8	2
36	The Age of the Earth: Darwin Was Right[c]	8	2
37	The Environmental Effects of Coal Surface Mining in Pennsylvania[c]	8	2
38	Get to Know Your Eyes[c]	8	2
39	Clinical Laboratory Testing[c]	8	2
40	Biology of Amphibians[c]	8	2
41	Biology of Reptiles[c]	8	2
42	Environments of the Southwestern U.S.[c]	8	2
43	Man's Impact on Species[c]	8	2
44	Stream Ecosystems Impact[c]	8	2
45	Keystone Power Plant Operation (Coal-fired)[f]	8	2
46	Biological Problems in Haiti[c]	8	2
47	Human Genetics[c]	8	2
48	Genetic Engineering[c]	8	2
49	Nature and Birding Hike[f]	8	2
50	Fauna of Argentina[c]	8	2

[f] = field-based activity
[c] = campus-based laboratory/activity

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Summary & Concluding Comments

The attempt at IUP has been to create, for the general biology program, a curricular organization that is centered around a "familiar-to-unfamiliar" theme. Secondly, this thematic organization is well grounded in cognitive learning theory as it is applied to science education (BSCS 1987; Harms & Yager 1981; Ausubel 1968). Whereas memorization of unfamiliar terms often occurs in a curricular organization based on a traditional "simple-to-complex" theme, students often learn to use terms in an applied context in the "familiar-to-unfamiliar" theme (Rubin & Tamir 1988; Lawson 1988; Scharmann & Harty 1986; Andersen 1978; Kolodiy 1974; Ausubel 1968). The reasoning behind such a statement is simple—if students are presented with content information that they can immediately relate to prior personal knowledge and/or past experience, they are apt to integrate that information with more regularity—rather than seeing no personal relevance for the information, learning it by rote memorization for the test and forgetting it.

With respect to the field experiences and "elective" program as enhanced curricular options, evidence for the success of either, compared with more traditional laboratory programs, is indirect. However, through "formal" student evaluations, "informal" student comments and the continuous enrollment of nearly 1200 students each semester, it is obvious that students appreciate the attempt by the General Biology team to respond to their interests and concerns.

The General Biology team has gone to great lengths over the past several years to ensure that the content integrity of the two-semester sequence of General Biology is not compromised. The "elective" program does perhaps compromise some academic rigor, but only to a minor extent. Instead, such a compromise is more than compensated for in the expression of positive student attitudes toward biology. And, because the program is ultimately geared for nonmajors, attitude development is perhaps equal to, if not more important than, content achievement. This is especially true if we expect students to make future "scientifically literate" decisions. Certainly, we would rather have students making informed decisions on the basis of both positive experiences and positive attitudes toward biology rather than making decisions based on lack of personal relevance and a potentially negative attitude. Indeed, even a brief scan of the wealth of activities offered in the "elective" laboratory program (Table 3) indicates that a match exists between the activities offered and each of the potential dimensions of "interest-orientation" as they were defined by Andersen (1978). In addition, Table 3 also illustrates opportunities for each of the four critical areas of instruction necessary for enhancing scientific literacy development as delineated by Harms and Yager (1981).

The General Biology curriculum is not without its critics, even from faculty within the IUP Biology Department. Several faculty members have expressed concern for the curricular organization, stating, "How can you teach them ecology when they do not possess the foundational 'building blocks' of molecular and cellular biology?" Others have criticized the "elective" laboratory program, stating, "Many students winning lottery seats only care about getting the 40-points 'out-of-the-way' in one trip" or "There's no formal evaluation of students in the 'elective' program."

However, when a critic is invited to become a member of the General Biology team, that faculty member has either withdrawn one or more criticisms, or through participation in the program, becomes one of its strongest advocates. And, as a final thought, many members of the General Biology team have overheard biology majors, who are restricted from taking the courses, make the comment, "Why don't we ever get to do the 'interesting, worthwhile and practical' things that the nonmajors get to do in General Biology I & II?"

Notes

1. The time commitment for an individual faculty member in the IUP General Biology program is no different than it is for a more traditional curricular organization.
2. Institutions without 8–10 faculty members would not be at a severe disadvantage in attempting to implement the enhanced curricular considerations discussed in this article. The only potential limitation might be the diversity and number of elective program alternatives; however, fewer than 8–10 faculty should also be consistent with fewer than 1,200 students and therefore, a sufficient match between interest-orientations and elective program alternatives would likely still be possible.

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