

Report of the Committee to Review Undergraduate Biology in the College of Letters and Science

Members:

Associate Professor Jeffrey R. Baylis, Dept. of Zoology
Assistant Professor Craig Berridge, Dept. of Psychology
Professor Thomas Givnish, Dept. of Botany
Assistant Professor Susan Smith, Dept. of Nutritional Science
Professor Millard Susman, Dept of Genetics
Professor Herbert Wang (Chair), Dept. of Geology and Geophysics

Invited Participants:

Dr. Patricia Henrikson, Center for Biology Education
Dr. Lillian Tong, Center for Biology Education

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EXECUTIVE SUMMARY

Background

The biological sciences at UW-Madison are a complex and diverse system of interwoven and overlapping disciplines. Thirty-seven biological sciences majors attract twenty-five percent of undergraduate majors. This abundance of offerings is rooted deeply in the research strengths and different missions of many faculty in several colleges. The Undergraduate Biology Education Committee has an on-going campus-wide responsibility to promote undergraduate programs.

The College of Letters & Science awards approximately 40 percent of the bachelor's degrees in the biological sciences and contributes heavily to the undergraduate instructional program. This report represents a one-time snapshot from the perspective of L&S. Our committee focused on three issues important to the quality of education for undergraduates majoring in any of the biological sciences.

- 1) Access to introductory biology courses for majors.
- 2) Access to intermediate-level biology courses for majors.
- 3) Biological literacy.

Most of the recommendations offered within the report are very specific. They involve issues of curriculum, teaching load, enhancement of undergraduate research opportunities, equipment for undergraduate education, need for field courses, and advising. Taken individually the recommendations are limited in scope. The intended impact of the recommendations as a set is summarized below.

Introductory Biology Courses

- Most biological science majors begin their studies with one of four courses. These courses serve different needs and all should be maintained.
- A survey showed that students are reasonably matched to their course preference. However, Biology 151 continues to show an access problem in spite of the addition of a new lecture section in Fall 1995. Enrollments should continue to be monitored.
- SOAR, cross-college, and L&S advisors should be briefed regularly about each sequence.
- Oversight is needed to ensure that core subjects are covered within each of the introductory sequences.

Intermediate-level Biology Courses

Four intermediate-level biology courses were identified as having significant access problems. They are Zoology/IES/Wildlife Ecology 360, Zoology 430, Zoology 460, and Genetics 466.

- Additional TA and supplies funds need to be allocated.
- Faculty effort should be reallocated on a campus-wide basis to staff high enrollment introductory and intermediate-level courses.
- Reconsider the 100-credit rule to take advantage of campus-wide biology courses and faculty.

Biological Literacy

- The committee reaffirms that the Department of Botany and the Department of Zoology, as part of the Letters and Science mission, should continue to be primary contributors to courses that promote biological literacy on campus.

L&S Teaching Loads

Course access problems lead to issues of priorities in course offerings, teaching load, and college resources.

- Differences in teaching load may need to be accommodated to keep some disciplines strong and competitive within the context of biology nationally.
- The departments of Zoology and Botany should submit a self-study of teaching loads and course responsibilities to the L&S dean's office.

INTRODUCTION

The Committee to Review Undergraduate Biology Education in the College of Letters and Science was charged to conduct a review of undergraduate biology education. Specific questions to be addressed included:

- (1) What are the needs of undergraduate students majoring in the biological sciences, regardless of college?
- (2) What is the value of biological literacy for all students?
- (3) Are L&S biology course offerings and curriculum appropriate?
- (4) Are teaching loads in the biological sciences appropriate and fairly distributed?
- (5) What is the role of biology in a liberal arts education?

The committee held two meetings in Spring 1995, during which the needs for specific data were identified. Most meetings were held weekly in November and December. Many of the data about course enrollments and close outs were obtained from PLAN and registrar's information. Other information about introductory courses for majors was obtained by a survey distributed during the early part of October. The UBEC (Undergraduate Biology Education Committee) report provided a framework for our consideration. Our committee examined three main issues: (1) Access to introductory courses for majors; (2) Access to intermediate-level courses; and (3) Biological literacy.

Issues of curriculum and faculty teaching loads were folded into the core issue of access to introductory and intermediate level courses. Within L&S, Botany and Zoology offer introductory courses for biology majors. Several other departments (including Psychology, Anthropology, and Geology) also offer courses that carry biological sciences credit. The prevailing belief among committee members was that the College of Letters & Science has an obligation and responsibility to provide access to essential introductory and intermediate-level biology courses for majors and to ensure biological literacy for all of its students.

CONTEXT OF THE L & S BIOLOGY INSTRUCTIONAL PROGRAM

Twenty-five percent of all undergraduates major in one of the 37 different biological science majors on the Madison campus. Almost half of these biology majors receive their degrees in the College of Letters and Science. The numbers of BA and BS degrees in biology, broken down by school and college, are shown in Figure 1. Between 1970 and the present, the total number of biology degrees per year has varied from a low of about 1100 to a high of about 1500; however, for most years the total has remained close to an average of about 1250 degrees in all. Most of the schools and colleges granting degrees have also remained fairly constant in the number of degrees awarded, except for the two largest colleges, Letters and Science and CALS. In the early 1970's Letters and Science was easily the most populous. Then from about 1976 to 1982, CALS became the most populous with L&S a close second. Ever since 1982, CALS undergraduate major population has been steadily shrinking while L&S biology majors have swelled to unprecedented numbers. In 1991 L&S biology degrees surpassed the previous high of 594 set 20 years before in 1971; every year since 1991 the number of degrees awarded in biology in L&S has surpassed the 1971 mark. Thus, CALS and L&S have always had the bulk of biology majors on campus, but there have been shifting patterns of majors between these two colleges. Ten undergraduate degrees per year per faculty currently means an advising load of 20 to 30 undergraduate majors per L&S biology faculty. Majors are only part of the picture, however. Zoology and Botany courses serve undergraduates from majors from all across campus; for example, the two departments taught a total of 24,248 undergraduate credit hours in 1994-1995, far more than would be expected from their number of majors.

The Biological Division Executive Committee (Table 1) is the governing body that evaluates all tenure and promotion decisions in the biological division, and evaluates potential course offerings and curriculum decisions. This body is currently elected on a one **person**/one vote basis. Fifty-one percent of the members of the biological division are in the Medical School alone. All of Letters and Science has less than 10% of the membership total in this division. Yet, L&S awards more total biology degrees than any other unit, and far more undergraduate degrees than any other college, school, or program. Thus, biology faculty in Letters and Science are being evaluated by colleagues in schools and colleges with missions vastly different than **their** own. This creates the potential for **more** fundamental discrepancies in evaluation between divisional committee and college than would occur for other Letters and Science departments. It is important that L&S faculty be judged on the basis of their mission. However, issues of equity in workload distribution among similar disciplines in different colleges and differences in appointment type may place L&S at a serious disadvantage in recruiting and retaining the highest quality biology faculty.

Biology Graduates By College

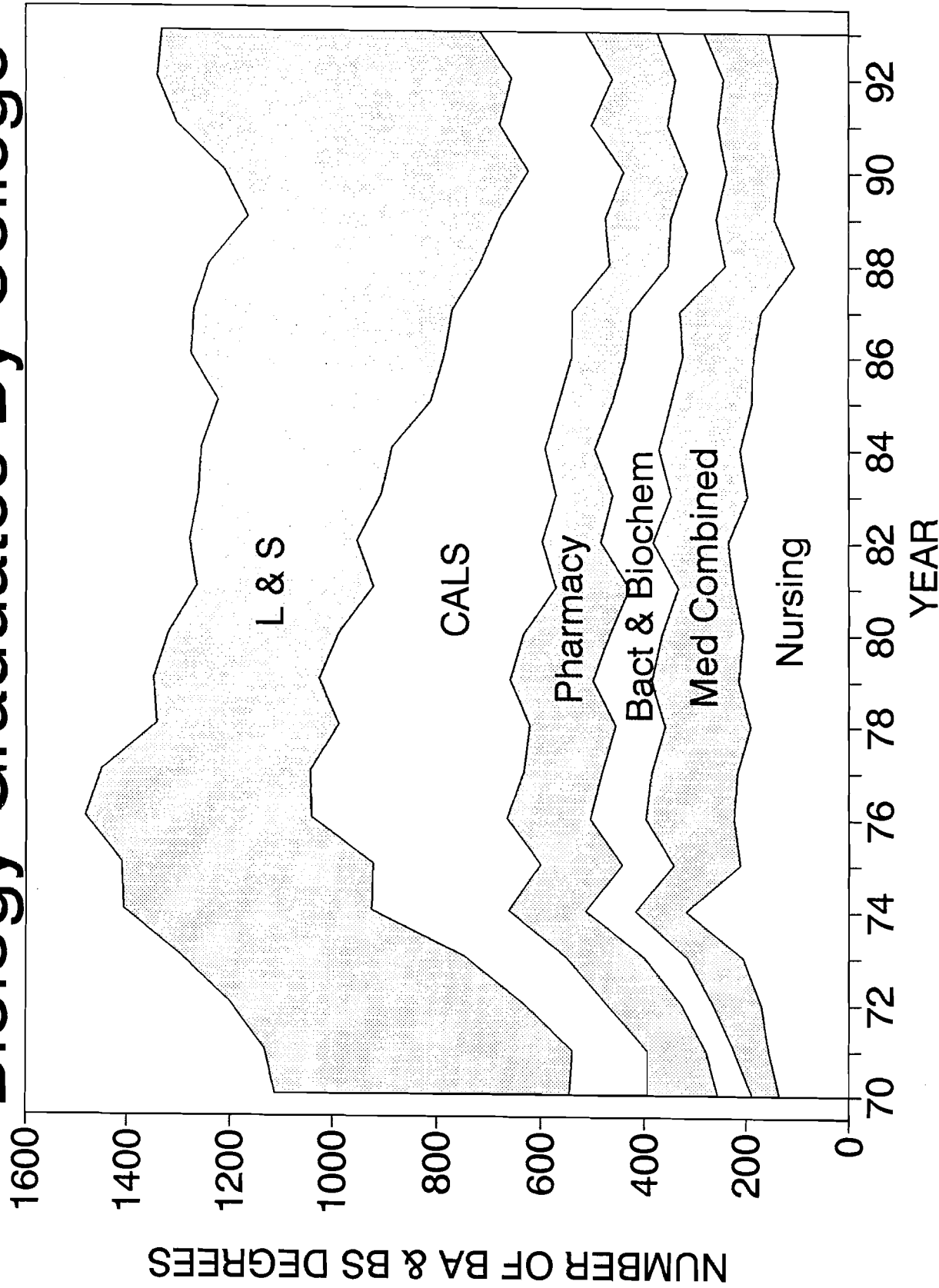


Figure 1. Data are plotted as a stacked area graph of the total number of undergraduate biology majors by College or School from 1970 to 1993.

TABLE 1. VOTING FACULTY MEMBERSHIP IN THE BIOLOGICAL DIVISION BY ADMINISTRATIVE UNIT AND BIOLOGY DEGREES AWARDED IN 1993

	FACULTY MEMBERS	FACULTY % TOTAL	BACHELOR DEGREES	ALL DEGREES
MEDICAL SCHOOL	402	51.5%	43	243
CALS	229	29.3%	374	644
L & S	71	9.1%	617	740*
VET. MED.	53	6.8%	0	68
EDUCATION	9	1.2%	84	101*
NURSING	8	1%	155	227
PHARMACY	8	1%	144	176
ENV. STD.	1		0	53
TOTAL	781	100%	1417	2252

* Totals for Education and Letters and Science estimated from overall college proportions; not all graduate degrees in some departments are 'biology' degrees.

ACCESS TO INTRODUCTORY BIOLOGY COURSES

Four undergraduate biology courses serve as the starting point for most biological sciences majors on campus: Zoology 101-102, Biology 151, Botany 130, and Biocore 301. Roughly 1,450 students were enrolled in these four classes during Fall 1995. Three sources of information --- data provided by the Registrar's Office, the results of a questionnaire we developed and circulated in the four introductory classes, and course syllabi provided by course instructors --- were used to determine the extent and nature of course access problems.

Data from the Registrar's Office on touchtone registration for Fall 1995 showed that Zoology 101 and Botany 130 (which can be used as a sequence to fulfill the introductory biology requirement for many biology majors) currently accommodate most students attempting to register. Zoology 101, with a registration limit of 913, closed out 15 students; Botany 130, with a registration limit of 202, closed out 39 students. Biology 151 continued to show an access problem in spite of the addition of a new lecture section in Fall 1995. With a registration limit of 415, touchtone registration showed that 253 students were closed out (24 were third year and 16 were fourth year students). These data were corrected for duplicates resulting from students who attempted to register under two or more departmental numbers for crosslisted courses.

Biocore received applications from 350 students for Fall 1995 and admitted 160. From that number, 20% did not enroll and students were admitted from the waiting list to fill those places. Ann Burgess (Director of Biocore) does not feel that the four semester program can be enlarged if it is to maintain the same quality.

A questionnaire (Appendix A) was distributed to students enrolled in all beginning biology courses in Fall 1995. The major findings are as follows:

1. Over 90% of the students are enrolled in their first-choice course, with the exception that 37% of those in Botany 130 would rather be in Zoology 101.
2. Only 13% of students (17% [54 students] in Biology 151) claim they were closed out from an introductory biology course in a previous semester.
3. Roughly 60% of students in the four introductory courses plan to major in L&S, while 21% plan to major in the College of Agricultural and Life Sciences (CALs).

We believe that the small number of current Biology 151 students who were closed out in a previous semester, as compared with the large number of closeouts recorded by the registrar, might mean that the "missing" students found alternative majors different from their initial intentions or they may have gone to a different introductory course. Some of the difference may also be due to the impact of Pharmacy's new requirement for Biology 151-152 in place of Zoology 101-102. This year is the first in which significant additional sections of Biology 151 were available, and it is hoped that the bulge of built-up demand reflected in the closeouts will gradually be assimilated. However, Spring 1996 data show that significant numbers of current freshmen and sophomores are being closed out.

Lurking on the 1997 horizon is Psychology's new requirement that its majors must take one semester of introductory biology. A check of the transcripts of all Psychology majors graduating in May 1995 showed that, of 216 graduates, 125 did **not** take one of the introductory biology courses, whereas 91 did (Appendix B). The number of August and December graduates will add to the number. The total number of graduates for 1994-95 was 359. Therefore, it is likely that approximately 200 to 250 more students will take an introductory biology course each year, with the greatest percentage headed for Zoology 101-102. Zoology 101 has this capacity, **if funding for the TA's is provided for Zoo 102.**

RECOMMENDATION 1: The access to introductory courses for biology majors should continue to be monitored.

RECOMMENDATION 2: The current three pathways for an introductory biology course sequence (Botany 130 and Zoology 101-102; Biocore; and Biology 151-152) serve different student needs, and all should be maintained. SOAR advisors should be briefed about each sequence in order to give advice most appropriate for each student.

Curriculum Issues

Some introductory courses, and individual faculty teaching those courses, may not adequately cover a few of the central concepts of biology on which broad agreement exists within the biological sciences community. UBEC's report "Forum on Teaching Biology for Breadth" includes a curriculum for biological literacy (Appendix C). The proposed curriculum for literacy would seem to apply equally to introductory courses for majors. Most introductory courses now cover the recommended topics, at least on their syllabi. However, there are some exceptions to this rule, and some topics are dropped from the lecture schedule in individual sections. These omissions can occur for a variety of reasons. Material more interesting to, or more within the expertise of, a particular course instructor can displace other material. An instructor may not feel qualified to treat a subject, and may be unable to find a suitable expert to cover the material. Certain topics, scheduled toward the end of a course, may regularly be skipped because of consistent overruns during earlier lectures. We note that the spirit of the recommendations below is not to suppress individual creativity or freedom in teaching. The intent is only to ensure a core commonality among the different routes that students take into biological sciences majors.

RECOMMENDATION 3: Department and program curriculum committees (jointly for cross-listed departments) should review course syllabi of all sections every five years for content and consistency.

RECOMMENDATION 4: Curriculum committees should also ensure consistency across different sections of a given course by reviewing course content, examinations, assigned work, and teaching evaluations for each section.

RECOMMENDATION 5: Long-term course coordinators, with oversight by responsible departments, should participate actively to ensure complete coverage of core material in lectures and lab in Zoo 101-102, Bio 151-152, and Bot 130. The role of the course coordinators would be similar to that of the Biocore program director.

RECOMMENDATION 6: Course instructors should be encouraged to use the resources of the diverse biology community to help in preparing lectures on unfamiliar materials. The Center for Biology Education can provide help in identifying colleagues with relevant expertise and in locating information sources. The proposed Office of Undergraduate Biology Programs may be another source of help.

A curriculum issue of concern to the committee was how to maintain enthusiasm for biology among the best freshmen intending to major in a biological science. Currently, freshmen can take "Ways of Knowing Biology", but freshmen and sophomores have difficulty in gaining access to Biology 151-152. This situation may improve as a result of the new sections that have been added. In addition, many of the best undergraduates opt for the Biocore sequence, which they cannot begin until their sophomore year.

INTERMEDIATE LEVEL BIOLOGY COURSES

A total of 14 of the 24 intermediate-level (I or D) courses in Botany and Zoology closed out students in Fall 1995. The data for the four most important of these courses (counting Zoology 430/431 as one course) are shown in Table 2. Intermediate biology courses are under considerable enrollment pressure, and that pressure is sure to increase as a result of adding a new section of Biology 151 in the current academic year. **This is an area of particular concern to the committee, as many of these courses are meant to be preliminary to more advanced courses within specific biology majors. Obviously, students who cannot get into these intermediate courses until they are seniors are unlikely to be able to take the more advanced courses.**

As additional students are admitted to prerequisite introductory biology courses, additional resources must be provided for intermediate courses. It should be noted that the high demand for some of the intermediate courses, e.g., Zoology 360 (Extinction of Species) and Botany/Forestry/Zoology 460 (General Ecology), probably exists because they are required courses for some popular biology programs such as Biological Aspects of Conservation and Wildlife Ecology, and are options for the IES certificate program. Other courses central to biology, e.g., Genetics 466, are required by a large number of biology majors.

Several of the frequently closed-out intermediate courses have a strong field component, e.g., Botany 455, Botany/Forestry/Zoology 460. The committee discussed whether problems of access to these courses might be addressed partly through no-cost changes in the timing of the teaching effort by individual faculty members. Can we encourage additional sections of field courses by time-shifting a portion of a faculty member's academic-year teaching load to the summer session or intersession? For many field-oriented courses, teaching during the summer may also increase the quality of the educational experience for the students, given the brief periods during the spring and fall semesters when most animals and plants are active in Wisconsin. Yet today, faculty who might offer such summer courses, at least on occasion, face the serious disincentive of having to teach their full fall- and spring-semester loads as well, leaving little time for research. Given the relatively high cost of field trips, the committee also raised the question as to whether gift funds for such expenses could be pursued on a campus-wide basis.

We focused on the needs of four high-enrollment courses at the intermediate level (Zoology/IES/Wildlife Ecology 360, Zoology 430, Zoology 460, Genetics 466) for the additional resources required to staff an adequate number of sections. Although, we are concerned about all 14 of the intermediate-level courses that closed out, we chose these four courses because they serve students from multiple majors. In Table 2, the numbers of students closed out were corrected for those closed out in cross-listed departments, and for those who were admitted through a cross-listed department but remained on another's close-out list.

Table 2: Telephone Registration Close-out data, Fall 1995-96, in selected intermediate-level courses required by many biology majors:
 Number of students closed-out (by student level).

Dept (s)	#	Title of Course	Student Level					Total Close-out	Total Enroll
			1	2	3	4	Grad, Special		
Zoo/IES/Wild. Ecol.	360	Extinction of Species	0	24	76	35	5	140	169
Zoology	430	Comparative Anat. of Vertebrates	0	4	24	34	1	63	118
Zoology	431	Comparative Anat. (Lab)	0	3	38	37	3	81	111
Bot/Zoo/Forestry	460	General Ecology	0	9	17	15	9	50	89
Genetics/Bot/Zoo	466	General Genetics	1	24	38	22	10	95	226

Zoology/IES/Wildlife Ecology 360: 140 total closeouts (76 juniors, 35 seniors): For every 0.5 FTE increase in TA support, Extinction of Species can increase enrollment by 60 students. However, IES may withdraw one of the TA's they currently provide for this course next year, creating a net need of 3 TA's.

Zoology 430: 63 total closeouts (24 juniors, 34 seniors). The lab section (Zoology 431) had 81 closeouts (38 juniors, 37 seniors). Enrollment in 430 (Comparative Anatomy) is limited to students who also take 431. Every 0.5 TA FTE added to 431 would admit 32 more students into the course. In addition, it costs \$50 in supplies for each student. Thus, each additional section (32 students) costs 0.5 TA FTE and \$1,600 in supplies.

Botany/Zoology/Forestry 460: 50 total closeouts (17 juniors, 15 seniors). An additional 24 students could be accommodated by adding one section. The added cost would 0.25 TA FTE and roughly \$400 in transportation. Further expansion of General Ecology would require substantial costs because of the added space needed to offer more than 5 sections per week.

Genetics/Botany/Zoology 466: 95 total closeouts (38 juniors, 22 seniors). If the enrollment in Genetics 466 (held in 125 Biochemistry) were increased by 60 students per semester, the Laboratory of Genetics would need funds to support an additional 0.33 TA FTE per semester to handle discussion sections. An increase of 120 students per semester would require that the class be divided into two lecture sections. To handle such a load, the Laboratory of Genetics would need one additional faculty member and funds for two 1/3-time TA's in each semester.

RECOMMENDATION 7: Every effort should be made to accommodate all juniors trying to enroll into the above four high-demand, intermediate-level courses. This recommendation is consistent with the campus and system goal to encourage students to graduate in less time.

RECOMMENDATION 8: A no-cost strategy that would meet a small portion of current needs would be to overbook intermediate courses according to past drop patterns. Most courses are between 85 and 90% of capacity by the 3rd week.

RECOMMENDATION 9: TA and supplies funds needed to alleviate the chronic close-out problems in Zoology 360, Zoology 430/431, Botany/Zoology/Forestry 460, and Genetics/Zoology/Botany 466 should be provided, contingent on a reallocation of faculty effort from (a) - lower enrollment courses (e.g., Zoology 120 [Biology and Society] or Zoology 279 (Field Zoology) and (b) from a "domino effect" created by team-teaching of introductory courses, leaving portions of the teaching loads of individual faculty available for shifting to intermediate-level courses.

RECOMMENDATION 10: Other schools and colleges on campus should be approached to help staff both introductory and upper-level courses. Such an effort should address several questions: (i) Is there any duplication of teaching effort/courses across colleges? (ii) Can we identify barriers that prohibit cross-campus cooperation? And (iii) Are there imbalances in teaching load in the primary departments?

RECOMMENDATION 11: Field courses need to be encouraged through direct funding or flexible arrangements for faculty time.

Another problem with some intermediate courses such as Botany/Zoology/Forestry 460 is that individual faculty involved change from section to section and semester to semester. As noted earlier for the introductory courses, with changing faculty come changes in content, so that some sections may not adequately cover a few of the central concepts of biology in these courses on which broad agreement exists within the biological sciences community.

RECOMMENDATION 12: As with Recommendations 3 & 4, intermediate level courses required by several majors and taught by rotating staff should be regularly reviewed for content and consistency across sections and semesters.

BIOLOGY COURSE STAFFING

We observe a large variance in teaching loads within both Botany and Zoology. Figure 2 shows a two-year average of the number of contact hours/week for individual faculty. Because student credit hours is another important metric for a department, Figure 3 shows these data plotted versus contact hours/week for individual faculty in Botany. Undoubtedly, a number of unique circumstances and histories lie behind the data, as individual faculty play many roles within a department. Lower teaching loads may be necessary based on considerations of equity and competitiveness among similar subdisciplines in other colleges on campus as well as nationally. One solution to course access at both the introductory and intermediate levels is greater participation of faculty at the introductory level, because some faculty currently teaching introductory courses can then shift to intermediate-level courses within their expertise. Increasing course access within these departments should not be accomplished by pressing yet more duties on those faculty carrying above-average teaching loads. Mismatches between faculty interests and beginning and intermediate course teaching needs must be addressed by Zoology and Botany.

RECOMMENDATION 13: Additional rewards for undergraduate instruction need to be implemented in the departments of Zoology and Botany.

RECOMMENDATION 14: The departments of Zoology and Botany should submit a self-study of teaching loads and course responsibilities to the L&S dean's office.

RECOMMENDATION 15: The Division of Biological Sciences should coordinate and pool hires with a view toward matching teaching and research needs and opportunities. The coordination should somehow reflect the differing mission of L&S, CALS, and the Medical School.

CONTACT HRS - 94-96

ALL GRAD & UNDERGRAD COURSES - 2 YR AVG

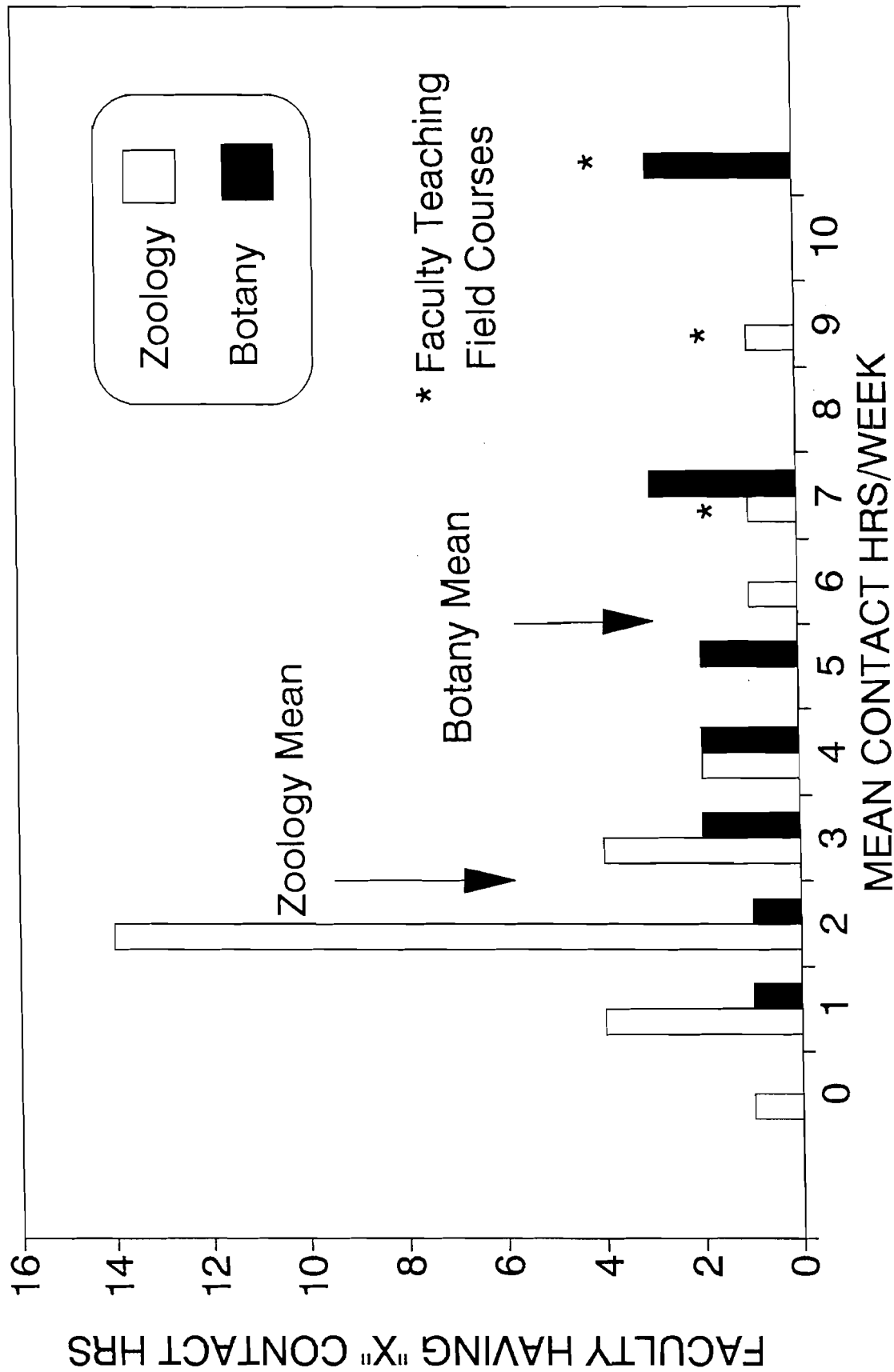


Figure 2. The mean number of contact hours/week taught per semester by individual Zoology and Botany faculty during 1994-96 academic years. Data include all courses except for individual instruction (699; 990) which are omitted. The columns marked with (*) contain faculty members who all taught field courses during this period. However, even without including field courses, they would all fall above the mean in their respective departments. Team-taught lecture courses have total contact hours divided by the number of faculty listed, and the result evenly apportioned to the faculty involved.

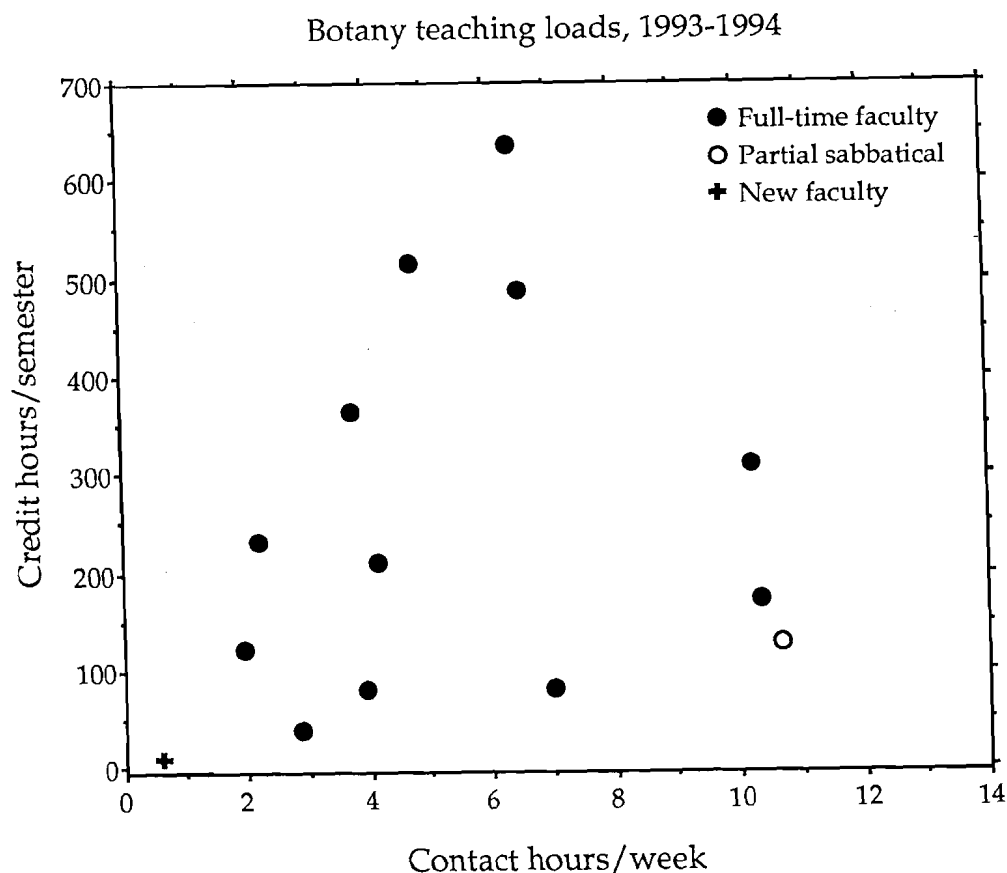


Figure 3

Faculty teaching loads in the Department of Botany, 1993-1994. Each dot represents the average number of contact hours per week and credit hours per semester for an individual faculty member, averaged over four semesters. Both contact hours and credit hours were pro-rated according to the share of a given course for which the faculty member in question was responsible. Special symbols are used to indicate two faculty members with unusual circumstances: one new assistant professor, teaching in his first semester on staff; and one senior faculty member who was on sabbatical for one semester, and consequently did not teach the high-enrollment course he normally leads.

100-CREDIT RULE IN RELATION TO STAFFING

As introductory course enrollment increases, increased demands on intermediate and advanced biology courses are likely to follow, representing a new potential bottleneck. A no-cost response to this would be to increase accessibility to comparable courses offered outside the College. Currently, the greatest barrier to this proposed strategy is the 100-credit rule. UBEC recently recommended eliminating of the 100-credit rule because of its restricting access to the rich academic environment found outside L&S. If this recommendation is not enacted, an alternative would be to permit L&S biological science majors to take an additional 10 credits of biology lecture and/or laboratory course work outside of L&S, that is, change the 100-credit rule to a 90-credit rule, with the stipulation that any credit below 100 L&S credits be associated with a biology course offered outside of L&S. We also recommend that thesis credits and independent study in biology be further excluded from the 100-credit rule. These recommendations are premised on the existence of a strong and diverse biological sciences environment found within the University outside L&S. Reduction of the current restrictions on accessibility of L&S students to this rich resource serves two general purposes. First, the academic environment, and presumably the educational experience, of L&S students is enriched. Second, the potential for the overburdening of intermediate and advanced biology courses is reduced.

RECOMMENDATION 16: We endorse the UBEC recommendation to eliminate the 100-credit rule. We recommend that this rule be reconsidered by the L&S Curriculum Committee or L&S Senate, whichever is appropriate.

RECOMMENDATION 17: UBEC should publicize and encourage all biological science departments outside L&S to list research credits as "C" in the timetable, as such courses are excluded from the 100-credit rule.

EQUIPMENT INFRASTRUCTURE

First-rate laboratory experience is essential to providing a quality undergraduate education in the biological sciences. The equipment infrastructure needs continuous upgrading as new laboratory experiences are incorporated into the curriculum. The needs are for (1) laboratory supplies, such as animal skulls and skeletons for comparative anatomy; (2) new technology, such as gel electrophoresis and recombinant DNA cloning techniques; and (3) technology for teaching, such as computer and microscope image projection in lecture halls.

RECOMMENDATION 18: Sharing equipment among departments can be encouraged by providing a fund for maintenance of shared equipment.

RECOMMENDATION 19: Cooperation among departments and programs can enhance the chances for success with NSF and private foundations for equipment grants to promote undergraduate education. The Center for Biology Education can promote this interaction.

RESEARCH IN THE UNDERGRADUATE BIOLOGY CURRICULUM

The international renown of biology faculty at UW-Madison in their research contributes strongly to undergraduate education. The researcher-teacher brings to the classroom the latest findings and interpretations of a subject to keep our students competitive in a technological world. Incorporating recent research into the undergraduate biology curriculum teaches students how to evaluate critically new information and apply it to solutions of societal concerns. These skills are essential in an increasingly technological world, where scientific pronouncements appear in the press and commercial media without evaluation or context.

In the biological sciences, research skills are best developed in a more individualized setting, such as independent study or the senior thesis. This environment lets students work one-on-one with an established scholar/investigator to analyze and resolve scientific problems. This setting, whether in the outdoors, greenhouse, or laboratory, allows students to assimilate and apply classroom knowledge to new situations, and learn through direct experience how new knowledge is acquired, interpreted, and evaluated in the context of preexisting information. The demands of one-on-one teaching, coupled with the large enrollment of biology majors in L&S, far exceed the resources available in any one department or college. One of the strengths of biological studies at Madison is the diversity of its faculty, distributed through several colleges; students should be encouraged to take advantage of this and to seek research experiences across the campus, rather than restricting their experiences to a single department. Moreover, this diversity allows students to pursue their specific interests and investigate problems at the boundaries between disciplines.

A special strength of the Madison campus is its encouragement of undergraduate participation in research, and this is a drawing card for some of the brightest young biologists in the state and across the country. Their enthusiasm is reflected in the competition for undergraduate research funds (e.g. Hilledale awards), the high enrollment in 399, 681/691, and 699 courses, and the popularity of the freshman courses "Ways of Knowing" and "Ways of Knowing Biology". The direct participation of our best undergraduates in cutting-edge research is essential in their scientific and technical training.

This year's Hilledale Faculty/Student Research Program awarded 32 grants out of 78 applications in the biological sciences. In addition the Howard Hughes Scholars Fellowship Program awarded 12 fellowships out of 65 applicants. Behind each rejected application is an undergraduate interested in doing research.

It should be recognized that the University of Wisconsin at Madison offers students an exceptional opportunity for first-hand experience in scientific research in collaboration with members of a world-class faculty. We have a special mission, within the UW System and at the national and international level, to ensure that our best students continue to have the opportunity to develop into leading scientists through intensive, collaborative research at an early stage in their careers.

RECOMMENDATION 20: Additional gift or grant funds should be sought to provide additional undergraduate research opportunities to supplement the Hilldale and Hughes programs. Faculty should be encouraged to apply for REU (Research Experience for Undergraduates) grants and add-on grants for undergraduate research.

UNDERGRADUATE ADVISING

A major problem for L&S undergraduate biology majors is that many do not seek advice until they are juniors and seniors, when most declare a major (for example, the vast majority of Botany and Zoology majors are juniors and seniors). Advising, if it is to be most effective, is best done early. Mechanisms must be put in place to ensure that undergraduate majors in the biological sciences have adequate advising from the moment they enter the college.

RECOMMENDATION 21: A registration "block" should be placed on all L&S students, which will be removed when they see an advisor to register each semester.

RECOMMENDATION 22: The position of undergraduate biology advisor should be maintained. We think this position needs staff support.

BIOLOGICAL LITERACY AND ROLE OF BIOLOGY IN THE LIBERAL ARTS

The College of Letters and Science has, at its most basic level, the twin objectives of understanding the workings of the natural world and of the hearts and minds of our fellow humans. The complementary nature of these objectives forms part of the basis for a liberal-arts education. Scientific knowledge without an understanding of human nature --- our aspirations, motivations, and needs, our gifts to inspire or tyrannize, our ability to structure societies to achieve our economic, social, and political goals --- is fruitless, and ultimately can lead to a rejection of a scientific world-view. Conversely, an understanding of human nature without science robs us of the insights and tools we need to adapt to changing circumstances, and of the essentially human adventure of understanding the universe in which we live and from where we came.

Among the sciences, biology has undergone a particularly spectacular series of advances in recent decades. We have developed remarkable insights into the genetic code and life at the molecular level, and are on the verge of revolutionary breakthroughs into the key mechanisms bridging genetics and development. These advances provide the basis for an ever-growing series of applications in medicine, genetic engineering, agriculture, mining, and pollution control, many of which would have been unthinkable just a few years ago. At the other end of the biological spectrum, we now understand a great deal about the functioning of natural communities and ecosystems, and are beginning to see how these entities interact with each other and the environmental changes humans have wrought to create troubling trends in the global atmosphere, oceans, and climate which cloud all of our futures, and may help shape societal choices for decades to come.

Consequently, it seems imperative that every undergraduate at the University of Wisconsin should become familiar with the central ideas and approaches of modern biology. These include key aspects of genetics, molecular biology, development, morphology, physiology, ecology, and evolutionary biology, as well as the essentials of critical scientific thought, experimentation, and comparative studies that have been used to develop insights in these fields. From an intellectual point of view, certain fields of biology --- such as genetics, ecology, and especially evolution --- involve phenomena that differ qualitatively from those treated by other sciences and so are quintessentially biological. Other fields --- such as biochemistry, molecular biology, or neurophysiology --- bridge into a variety of other scientific disciplines.

The objectives of biological literacy should be to (1) learn about the current range of our knowledge and understanding of key aspects of fields ranging from molecular biology to ecology and evolution, and how such insights were obtained; (2) acquire a basis for learning about and understanding future developments in biology after graduation; and (3) understand some of the societal issues raised by certain biological phenomena and discoveries. Objectives (1) and (3) are central to the goals of understanding the natural world and their significance for human society; objective (2) is essential for learning how to continue learning --- another core goal of a liberal-arts education in a world that is undergoing profound and extremely rapid technological change.

UBEC provides a specific list of topics that constitute biological literacy (Appendix C). Today, Botany and Zoology deliver courses on biological literacy campus wide. This arrangement seems entirely appropriate; biological literacy is a central component of a liberal-arts education, and it would seem impossible for the College of Letters and Science to fulfill its mission in this regard were Botany and Zoology to depart L&S. The committee believes that Botany and Zoology should continue to provide leadership and direction for biological literacy; their role is complemented by the Center for Biology Education, which serves as a resource center for innovation in biology education. In addition, the committee encourages substantial collaboration among faculty from L&S, CALS and the Medical School in the offering of courses on biological literacy.

RECOMMENDATION 23: Botany and Zoology should remain in L&S.

RECOMMENDATION 24: New courses for breadth are needed in human biology.

RECOMMENDATION 25: The Biological Science Divisional Committee should adopt guidelines for what constitutes breadth. (This committee was deemed more appropriate than the L&S Curriculum Committee.)

RECOMMENDATION 26: The Curriculum Committee of the Biological Sciences Division should ensure that its composition appropriately reflects the differing degrees among Colleges in responsibility/staffing for undergraduate education.

RECOMMENDATION 27: The breadth designation for courses should expire after ten years, and be renewed only after review.

RECOMMENDATION 28: Since a universal laboratory course requirement is impractical, biology courses for breadth should provide students with examples of the process of scientific experimentation, including experimental design, execution, and interpretation.

RECOMMENDATION 29: L&S majors should be permitted to have a second major outside L&S. Issues related to the 100-credit rule will need to be resolved for implementation.

RECOMMENDATION 30: The Biological Aspects of Conservation major should be offered jointly by CALS and L&S.

APPENDIX A
SURVEY OF STUDENTS IN INTRODUCTORY BIOLOGY COURSES (Fall, 1995)

	Composite	Zoo 101	Bio 151	Biocore	Bot 130
Question 1. What introductory biology course are you currently enrolled in?					
	100%	45%	30%	15%	10%
Question 2. What is your class standing?					
Sophomore	53	39	72	68	34
Junior	20	14	20	29	37
Freshman	18	37	1	1	13
Senior	6	7	6	2	14
Question 3. What is your current college?					
L&S	60	53	69	80	22
ALS	21	16	22	16	38
Education	8	14	2	1	6
English Engineering	4	3	6	2	1
Question 4. Why are you taking this course?					
Required by bio major	46	35	66	34	
Breadth	14	26	3	2	12
Recommended by bio major	13	7	9	39	10
Required by non-bio	10	14	6	0	15
Question 5. If you are taking this course for a biological science major, in what college do you expect to complete your major?					
L&S	32	15	48	58	22
Non-Biology major	29	42	17	18	22
ALS	17	12	21	14	38
Med	5	7	3	2	0

Question 6. What was your first choice for an introductory biology course?

Zoo 101-102	40	82	1	0	31
Bot/Zoo 151/152	30	11	82	1	8
Biocore	20	1	16	98	1
Bot 130	8	4	1	0	59

Question 7. Have you attempted to register for one of the courses in Question 6 in a previous semester, but were turned away?

NO	86	86	83	94	88
YES	13	12	17	6	12

Question 8. Have you registered for one of the courses in Question 6 in a previous semester, but dropped or withdrew from the course before completion?

NO	91	92	91	92	93
YES	5	4	7	7	6

Question 9. What are your career goals?

Health Sciences/medicine	49	41	58	79	18
Undecided/other	24	33	20	11	20
Environment/conservation	4	8	10	1	35
Agriculture	3	3	1	0	12

SURVEY HIGHLIGHTS

Q. 1. The survey response rate was over 90% in Bio 151 and Biocore because the surveys were distributed in labs or discussion sections. The response rate was about 67% in Zoo 101 and about 50% in Bot 130 because they were distributed in lecture. Anecdotal evidence is that these percentages approximate lecture attendance. According to the PLAN reports, only Biocore among the four courses was totally closed.

Q. 2. Different class standing patterns of enrollment occur in the different courses. Bio 151 and Biocore are 70% sophomores with another 20 - 30% juniors. The appearance that a significant percentage of juniors in these two courses may be misleading, as many of these students may have junior standing but are in their second year of college. Zoo 101 has a significant percentage of freshmen (37%), which is appropriate for this course. The 37% juniors and 14% of seniors in Bot 130 may be of concern.

Q. 3. The majority of students are in L&S (60% overall) with ALS second at 21%. Bot 130 has a plurality of ALS students.

Q. 6. The diagonal elements of this table suggest a high percentage of students felt that they were enrolled in their first choice introductory biology course. The exception is Bot 130 in which 31% said they would rather be in Zoo 101.

Q. 7. Few students felt they were turned away from a course for which they had tried to register in a previous semester. This result suggests closeouts are not perceived to be too much of a problem.

Q. 9. A health sciences/medicine career is the career objective expressed by nearly half the students. In Bot 130 half the students see a career in environment/conservation or agriculture.

APPENDIX B
BIOLOGY TAKEN BY MAY 1995 PSYCHOLOGY MAJORS

	Totals 216	BA's (140)	BS's (76)
1. No biology from list:	125	93	32
At least one course:	91	47	44
2. Biocore 301:	5	0	5
3. Botany 130:	4	1	3
4. Biology 151:	13	2	11
5. Biology 152:	9	3	6
6. Zoology 101:	71	43	28
7. Zoology 102:	54	33	21

APPENDIX C

Summary: Forum on Teaching Biology for Breadth (1/18/95)

Question 1: What, if any, might be the concepts, information, ways of thinking, etc. that every biologically literate citizen needs to know? (Summary of reports from nine small groups of 5-7 and discussion.)

Concept	Information	Issues
Evolution	Living systems change through time, resulting in diversity (Process of evolution, natural selection, biodiversity)	Preservation of species
Interdependence and Interaction	Ecological interactions (Organism/organism, organism/environment)	Human population explosion, Place in the biosphere, Human-animal interactions
Basic Genetics	Generations of living systems are related to each other by passing on genetic material through reproduction (Molecular genetics)	Genetic engineering, nature vs nurture
Cell biology	Machinery within cells and interactions between cells define the properties of living organisms	
Energy and matter	How living systems generate energy from their foodstuff: Energy and matter is required for maintenance of the organism (Metabolism)	Nutrition
Organization and operation in living systems	Living systems can be complex and require organization and regulation to maintain themselves (Information flow, structure/function, development)	Health and Disease
Ways of Thinking		
Process of science	Process of gaining and evaluating information "Thrill of the hunt"; scientific method (experimental and comparative); quantitative analysis; reasoning (inductive and deductive)	
Progress of science	Science changes with time; modeling and continual revision	Patterns and trends within specific discipline
Critical thinking	Integration of concepts, assessment of scientific information, decision making, healthy skepticism based on reason	Link importance to everyday life and societal issues