

**Introductory Biology
Botany/Zoology 151 and 152**

Self-study, 2004-05 Academic Year

**Prepared for the College of Letters and Science and
The Institute for Cross-college Biology Education**

**Prepared by the Faculty and Staff of Introductory Biology
University of Wisconsin-Madison**

August 1, 2005

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Executive Summary

Introductory Biology (Botany/Zoology 151-152) is a two-semester, 10-credit sequence that teaches the principles, practices, and ways of thinking at the core of modern biology to approximately 900 students in four sections each semester. The academic staff and budget of this introductory course sequence are administered by the Department of Zoology, though the teaching faculty and the students are drawn from many units. Approximately one third of the professors are from the Botany Department, one third are from Zoology, one fourth are from departments in the College of Agriculture and Life Sciences (CALS), and the small remainder come from the Schools of Medicine and Veterinary Medicine.

Fueled by strong interest in the life sciences among the University of Wisconsin (UW) student body, the course has grown and developed over the past ten years into a keystone course with connections to 67 degree programs and over 200 discreet academic plans (majors) across campus. Pressure on enrollment continues; a fifth section of 151-152 will be added in the fall of 2005.

Concomitant with the growth in 151-152 was an increased realization that undergraduate biology education at UW would benefit from the addition of new administrative structure. The Institute for Cross College Biology Education (ICBE) was founded for this purpose. Shortly after ICBE was formed, its director, Tom Sharkey (Botany) asked 151-152 to consider undergoing a program review to assess its current strengths and weakness, and future challenges. In December 2004, the faculty and staff involved in the courses decided to proceed with this review; this document comprises the self-study component of the review process. Information needs were identified at subsequent "all course" meetings, and subcommittees were formed to address each need. In June, 2005, the subcommittees (made up of 151-152 faculty and staff) submitted their reports, which course co-chairs Monica Turner (Zoology) and Edgar Spalding (Botany) used to create the following self-study review document with much help from Jean Heitz, Sharon Stern, and other academic staff members from Zoology. The sections of the review document mirror the review subcommittees. Findings or results of the self-study deserving special attention are highlighted under each of these headings.

Course Overview

Course goals as stated by the course faculty and staff, are as follows.

Introductory Biology 151-152 will provide students with a solid foundation in the fundamental concepts and knowledge base of modern biology and help students develop the skills that are integral to the process of science. This course provides a coherent framework for understanding biology and prepares students for their upper-level courses. We hope also to encourage in students an intellectual excitement for biology and for science in general.

The detailed structure of the courses (content, administration, budget, governance, etc.) is reviewed, with emphasis on its evolution during the past 10 years. The faculty and staff that teach 151-152 are uncommonly dedicated and innovative and the review document highlights examples of how this translates into a superb course. The dedication is especially noteworthy because some lecturers come to the course largely as volunteers. Maintaining the pool of

committed professors and adding to it in times of growth is a challenge to continued success of the course sequence.

Facilities and instructional resource needs

Many of the 151-152 facilities, especially the laboratories, are modern and adequate or exceptional. Other facilities, particularly laboratory prep space and staff office space, are woefully inadequate. The same can be said for the supplies and equipment budget. These inadequacies impair the quality of the course for the students and the morale of very hard-working staff and TAs.

Comparisons with other courses on and off campus

The course is impressive and cost-effective when compared to a large science course containing a lab on this campus (Chem 103-104) or to introductory biology courses at other comparable universities (surveys were used to obtain data from six peer institutions). Unique features of our Introductory Biology sequence include having leading faculty teaching in their area of expertise and the strong emphasis on engaging introductory students in research. Based on services provided to students (for example 151-152 offers undergraduate research options not offered in any of these other programs), 151-152 appears to be under-supported (both in budget and number of TAs) compared to other programs.

Effectiveness in preparing students for upper-level courses

Surveys of students and teachers of upper-level courses for which 151-152 may be prerequisite produced information about how well prepared 151-152 course alumni are. In general, the results indicated that students were reasonably prepared for more advanced study; students who took both 151 and 152 reported better preparation for their upper-level courses compared to students who only took 152. One interesting finding is that 152 students who do mentored research subsequently participate in university research to a significantly greater extent than peers who did not take this option. Thus, not only does 152 put a large number of students into research labs, it also increases the likelihood they will continue doing research. Although instructors usually do not know which introductory course was taken by specific students, the need for more math, quantification and analysis in the introductory biology courses was a common sentiment among the surveyed instructors.

Course format alternatives

Advantages and disadvantages of alternative structures for lecture, lab, discussion, coordinator roles, and course evaluation are presented. Brainstorming about how the course could be structured differently did not identify a clear winning motive for any substantive change such as increasing lecture size or folding discussion exercises into the lab experience, etc. Discussions on potential mechanisms for reorganization of the 151-152 course structure will continue into the near future. One strong conclusion is that professors teaching material close to their area of expertise is a strength of 151-152. Students in this course learn from experts. Clear mechanisms for experimenting with new approaches within the course are needed.

Summary

Key strengths that we wish to maintain are highlighted. We also recognize challenges in two key areas: (1) course content and structure (balancing diversity and consistency across different sections of the course, and integrating across biological topics within the two-semester sequence; integrating lecture material and laboratory experiences; and the relative weighting of process and content), and (2) course administration (faculty recruitment, clarifying lines of responsibility, addressing critical space and resource needs, and reducing TA workloads). We welcome all feedback, but particularly seek suggestions on how to best address these issues in the coming decade.

Introduction to the Self-Study

The faculty and staff of Botany/Zoology 151-152 (Introductory Biology) have prepared this self-assessment as part of a voluntary program review initiated in fall 2004 by the newly created Institute for Cross-college Biology Education (ICBE).

During the past decade, 151-152 has grown substantially in both size and complexity to meet the increasing interest in biology among the UW student body. The 151-152 course sequence has expanded to the point where it is now an indispensable gateway into the many diverse majors that require introductory biology. This growth has brought with it significant challenges and opportunities. The efforts of the staff, administration, and faculty have led to successes of which the university can be proud, and yet there are always challenges to be met and improvements that can be made. The purpose of this very timely review is to identify and assess the strengths and weaknesses of the course at present and to guide its evolution into the future.

The process. The decision to proceed with the review was made at a meeting on December 22, 2004 that included course staff and teaching faculty, Associate L&S Dean Herb Wang, L&S Academic Planner Elaine Klein, and ICBE Director Tom Sharkey. The goals and procedures of a review were discussed, and a letter from Tom Sharkey and Herb Wang to the course chairs formally initiated the review. The self-study component of the review process began with a course faculty-staff meeting on January 18, 2005. During this and a subsequent meeting (March 29, 2005), information needs and a mechanism for obtaining what was needed were identified. Subcommittees of faculty and staff were formed for each of the following categories:

1. Course overview
2. Facilities and instructional resource needs
3. Comparisons with other courses on and off campus
4. Effectiveness in preparing students for upper-level courses
5. Course format alternatives

Reporting out and general discussion among faculty-staff occurred at our May 20, 2005 course meeting. A deadline of June 15 was set for completion of the subcommittee reports, which form the backbone of this review document. The entire document was augmented, assembled, and edited by course co-chairs Monica Turner and Edgar Spalding, (professors of Zoology and Botany, respectively) with a great deal of help from Jean Heitz (lead Course Coordinator) and Sharon Stern (Zoology Instructional Program Manager). A draft of the document was emailed to all the faculty and staff who participate in the course with a request for comment on July 30. The document was revised and then submitted to Tom Sharkey on August 4, 2005.

I. Course Overview

(Subcommittee: Bob Goodman, Jean Heitz, Edgar Spalding, Sharon Stern, Monica Turner)

Introduction

Botany/Zoology 151-152 is a two-semester, 10-credit sequence designed to provide a comprehensive introduction to modern biology at the University of Wisconsin-Madison. It is primarily a course sequence for biological science majors though it can be taken by any student. The second semester (152) is writing-intensive and satisfies the university's General Education Comm B requirement. The present format accommodates 900 students each semester. Student distribution in the last academic year was typical of recent years, with 64% of the students coming from the College of Letters and Science (L&S), 27% from CALS, and 9% from other units.

The course has a broad reach on campus. According to Assistant Dean Michael Pflieger (L&S, Student Academic Affairs), 151-152 serves approximately 67 degree programs and over 200 discreet academic plans (majors) across campus. Over 90% of CALS students must take introductory biology for their major, and a great many use 151-152 to fulfill that requirement. Twenty majors in L&S and the Institute for Environmental Studies certificate require introductory biology and 151-152 is a common means of satisfying that requirement. The courses are taken by many pre-Pharmacy students and health science majors. The courses satisfy breadth requirements in many schools and colleges such as Education, Kinesiology, Engineering, Human Ecology, and all L&S undergraduate degrees. The pervasiveness of 151-152 in the requirements of programs across campus and the number of students in the sequence each semester combine to create a large impact. It is by all accounts an important course on this campus.

The evolution of the format, operation, and goals of the courses has been significantly influenced by the recommendations of the Hearn Committee, which in 1991 reviewed the biological sciences on the UW-Madison campus and recommended that a strong introductory course sequence for biology majors be established, one that included laboratory and field work and which led to students engaging with professors in the research enterprise. More details of the Hearn Committee report can be retrieved here: http://www.botany.wisc.edu/spalding/151-152/supplemental_data.htm.

The next section of this review document describes the current features of the courses.

Course Goals and Objectives

Scientific understanding builds on historical knowledge, which includes both factual information and the process by which those facts were discovered. In 151-152, we strive to provide the foundation upon which a student's biological knowledge and understanding grow. The course recognizes explicitly that both process and content are crucial parts of this foundation.

The statement of course goals was newly developed during the 2003-04 academic year through a series of faculty-staff meetings:

Introductory Biology 151-152 will provide students with a solid foundation in the fundamental concepts and knowledge base of modern biology and help students develop the skills that are integral to the process of science. This course provides a coherent framework for understanding biology and prepares students for their upper-level courses. We hope also to encourage in students an intellectual excitement for biology and for science in general.

In addition to this broad statement of goals, the faculty collectively developed a listing of more specific goals that reflected both process (skills students should develop) and content (material they should master).

Course structure

Typically taken in the sophomore year, this course sequence offers exposure to:

1. Three (50-minute) lectures each week for two (15-week) semesters in modern biology by leading research faculty at UW-Madison
2. One (75-minute) intensive discussion section each week
3. One (3-hour) inquiry-based laboratory each week
4. Independent research mentored by one of the hundreds of life sciences faculty at UW-Madison.

The course is organized into sections taught and staffed by a cohort of faculty, TAs, and academic staff. Typically, three faculty, one coordinator, and five teaching assistants operate as a unit to offer a section of each course to 220 students.

In Introductory Biology 151, the typical semester includes five weeks on the chemistry of life, cell biology, and metabolism; five weeks on genetics and the molecular basis of life; and five weeks on evolution and diversity, often focused more on microbial diversity. Introductory Biology 152 includes five weeks each on plant biology (evolution, structure, and physiology); animal physiology (structure and function of vertebrates), and ecology (population, community, and ecosystem ecology).

The lecture syllabi are loosely standardized among sections of a course by use of a common textbook and as a result of annual or biennial discussions among lecturing faculty and staff about learning goals and objectives. In recent years, there has also been a notable increase in the sharing of instructional materials among the faculty teaching the same topics. However, a significant degree of independence is accorded to lecturing faculty in terms of material covered, pace, learning goals, and interaction with discussions and labs. Faculty in a given section meet weekly with TAs and the coordinator to plan the next week's discussion. Some faculty also meet with the TAs and coordinator to discuss and plan the lab experiences. More typically, the coordinator and TAs run the labs with minor input from the faculty.

Samples of recent syllabi and the learning goals developed by the faculty during the past two years are provided at the following website:

http://www.botany.wisc.edu/spalding/151-152/supplemental_data.htm

Students, approximately 220 in each section, attend three 50-minute lectures per week. Lectures are typically oral presentations by professors using chalk board and computer projection. Active learning exercises, short quizzes, or interactive learning technologies (such as "clickers") are also

incorporated into some lectures. Students meet weekly in smaller groups (20 students) for a 75-minute discussion period each week. Discussions support lecture by providing students with opportunities to solidify concepts that were introduced in lecture through use of problem sets, novel examples, or question-and-answer periods. Discussions also provide students with regular feedback on their progress and exam practice through short quizzes in discussion sections and are sometimes used to extend concepts from lecture by introducing new applications. In addition, discussion exercises are often designed to facilitate integration of concepts that build through the course sequence.

Laboratories meet weekly for three hours. Laboratory exercises are typically inquiry-based, and modules often extend over a 3-week period. Laboratories introduce students to the process of science, and emphasize critical thinking and hypothesis creation/testing more than modern experimental techniques. Lab exercises have been designed to mirror “real life” problems. As such, laboratories allow students to apply the scientific method to design and execute experiments to investigate open-ended questions.

A distinctive and perhaps unique feature of Introductory Biology 151-152 at UW-Madison has been its intensive introduction to independent studies, including mentored laboratory research, for hundreds of students each year. About halfway through 151, students are advised that, in 152, they will be required to do an independent project. They are further advised that they have the option of doing either library-based research or independent mentored research. Coordinators assist those interested in the mentored research option by helping students locate a laboratory and mentor with whom to study the following semester. During the semester of independent study, in addition to 152, these students register for 2 credits of independent study (typically a 299, 399 or 699 course in the department of the mentor) and devote 10 or more hours per week outside scheduled course time to their research.

All students prepare a draft proposal (about week 5 of the semester), a first draft (about week 8 or 9) and a final paper (week 14) detailing their research. In addition, at the end of the semester in 152, each student presents a poster describing his/her research. All students present their research during their final lab period (week 15). Mentored students also present their posters at a course-sponsored public research symposium in either Union South or the Memorial Union.

The numbers of students and mentors involved in independent research in Introductory Biology 152 have increased greatly over the years. During the May 2005 poster session at Great Hall of the Memorial Union over 180 students presented their research. Since 1996 approximately 1300 students in 152 have been involved in mentored research. See the above-mentioned website for a listing of 1300 student/mentor pairs who worked together between May, 1996 and May, 2005.

Demand and enrollment

Student interest in the biological sciences and the demand for access to introductory biology has grown steadily for the past 15 years. In response, enrollment in 151-152 has increased from one section of about 200 students per semester in 1985-86 to four sections of nearly 900 students per semester in 2004-05, as shown in Figure 1.

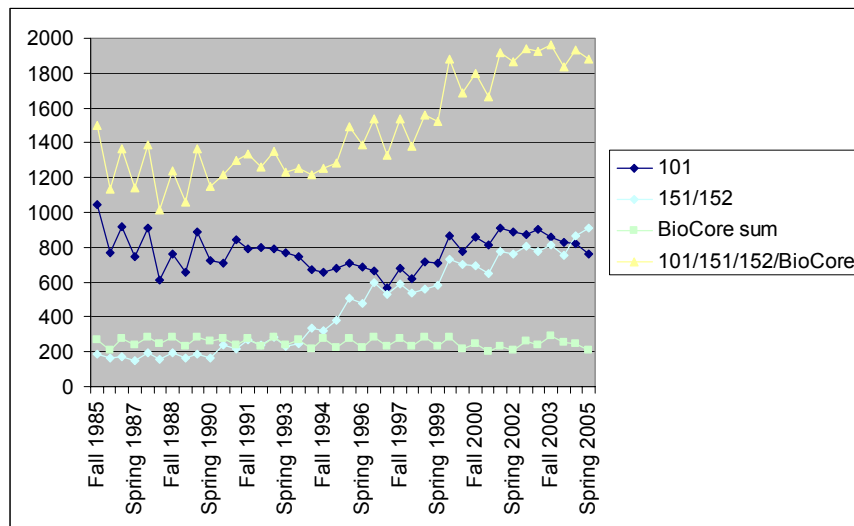


Figure 1. Number of students enrolled in each semester of 151-152 compared with Zoology 101, or all Biocore courses.

Thus, in a typical recent year, three sections of 220 students completed 151 in the fall and 152 in the spring while one section of 220 students completed 152 in the fall and a new cohort began 151 in the spring. In total, these four sections of 151-152 involve 12 faculty lecturers, 4 coordinators, and 20 TAs each semester. In 2005-06, responsive to continuing demand for these courses and with support from the newly established Institute for Cross-college Biology Education (ICBE), a fifth section of the course will be offered, making Introductory Biology 151-152 available to more than 1000 students per year by the spring of 2006.

A summary of the growth of Introductory Biology 151-152 between 1995 and 2005 follows.

1. **1990-91**—the original single section of 151-152 was expanded from 224 students to 289 students by adding a second lab classroom to the course.
2. **Spring 1994**—a new (2nd) lecture section of 151-152 was added, providing a spring/fall sequence of the course. With each lecture capped at ~220 students, this brought the total to ~ 440 students per semester. Student could now begin the course sequence in either fall or spring whereas prior to this time they could only begin in the fall.
3. **1995-96**—another (3rd) lecture section of fall 151-spring 152 was added, increasing maximum enrollment to 660 students per semester.
4. **1999-00**—another (4th) lecture section (fall 151-spring 152) was added, increasing the maximum enrollment to 860 students per semester.
5. **Spring 2005**—the Biology 151 lecture section was increased to 300 students in preparation for adding a fifth section of 152 in fall of 2005. This will bring our maximum enrollment to 1080 students per semester, with three sections available as a fall-spring sequence and two sections available as a spring/fall sequence.

Faculty recruitment

With the growth of the course, the recruitment of faculty lecturers has become an acute issue in course management. One of the key strengths of Introductory Biology 151-152 has been the broad range of scientific talent and scope of biological expertise represented among the faculty committed to teaching these courses. Faculty in the core departments of the College of Letters and Sciences (L&S) (Botany and Zoology) who lecture in these courses do so in partial fulfillment of their teaching assignments in their respective departments. But the 151-152 courses have grown so much in recent years that these two departments alone cannot fulfill the demand for faculty lecturers. In recent years, in addition to Botany and Zoology (L&S departments), lecturers have participated from Anatomy, Physiology, and OBGYN from the Medical School, Agronomy, Bacteriology, Entomology, Dairy Science, Genetics, Horticulture, Landscape Architecture and Plant Pathology, and Agronomy from the College of Agriculture and Life Sciences (CAL S); and AHABS from the School of Veterinary Medicine.

Students taking these courses come not only from L&S, but a significant percentage also come from CAL S. Recognizing this, in recent years funding from CAL S has been provided for TA and laboratory support. However, participation by CAL S faculty as lecturers has largely been by “campus citizen”-minded faculty who take on these responsibilities over and above their teaching obligations to their own departments. As the courses grow in demand, recruitment of faculty from outside L&S has become a critical component of course success.

Table 1 lists recent faculty participants in the courses with their tenure home department indicated after their names in parentheses.

Table 1. Lecture staffing of 151 (top row) and 152 (bottom row) in recent semesters.

	Fall '01	Spr '02	Fall '02	Spr '03	Fall '03	Spr '04	Fall '04	Spr '05
1 5 1	Kirsch (Z) Fernandez (B) Bleecker (B) Gargas (B) Graham (B) Rouse (PP) Duello (OB) Triplett (A)	Martin (Z) Bement (Z) Weimer (BT) Jeanne (E)	Blair (Z) Bleecker Boughman (Z) Fernandez Graham Gargas Kirsch Lee (Z) Triplett	Martin Bleiweiss (Z) Weimer Jeanne	Fernandez Bleecker Kirsch Blair Graham Rouse	Gargas Grinblat (Z) Jeanne Sharkey	Fernandez Glasner (AH) Kirsch Graham Gargas Lee Sharkey Baum (B) Goodman Perna (AH)	Sharkey Grinblat Gargas Jeanne
1 5 2	Spalding (B) Wiltbank (DS) Rouse (PP)	Kirsch Fernandez Abbott (OB) Dodson (Z) Wiltbank Triplett (A) Stretton (Z) Allen (B) Vierstra (H)	Rouse Spalding Gammie (Z)	Abbott Allen Dodson Fernandez Goodman (PP) Kirsch Stretton Vierstra Wiltbank	Spalding Wiltbank Turner (Z)	Fernandez Abbott Kirsch Vierstra (G) Stretton Dodson	Rouse Gammie Spalding	Fernandez Abbott Kirsch Dodson Vierstra Stretton Allen Rouse Stafford (L)

Key to Department codes: **A**, Agronomy; **AH**, Animal Health and Biomedical Sciences; **B**, Botany; **BT**, Bacteriology; **DS**, Dairy Sciences; **E**, Entomology; **G**, Genetics; **H**, Horticulture; **OB**, Obstetrics and Gynecology; **PP**, Plant Pathology; **Z**, Zoology; **L**, Lecturer

Administrative organization and evolution of course leadership

Introductory Biology 151-152 is located as a sub-department in the Department of Zoology in the College of Letters & Sciences. The course is cross-listed with Botany and Zoology, with Zoology being the “primary” department. (All UW courses that are cross listed have a single primary department.) Being “primary” Zoology bears responsibility for budget, personnel hiring and supervision, provision of space for laboratories, discussions, and offices, as well as administrative support (e.g., timetable, supplies, equipment maintenance, etc.). This administrative structure is depicted in the organization chart shown in Figure 2. Some administrative functions (e.g., managing the course wait list) have recently been handled by ICBE. Day-to-day operations center on the Lead Coordinator (Jean Heitz) and her supervisor, the Zoology Instructional Program Manager (Sharon Stern). The co-chairs of the course, currently one professor each from Botany (Edgar Spalding) and Zoology (Monica Turner), are consulted when any issue out of the ordinary arises. The course coordinators (Brian Manske, Brian Parks, and Carlos Peralta) whom Jean supervises and the Instructional Laboratory Specialist (Rebecca Seabul) are also Zoology staff members. Zoology administratively handles the hiring of coordinators and TAs, usually with input from a committee with representation of other invested units and the co-chairs.

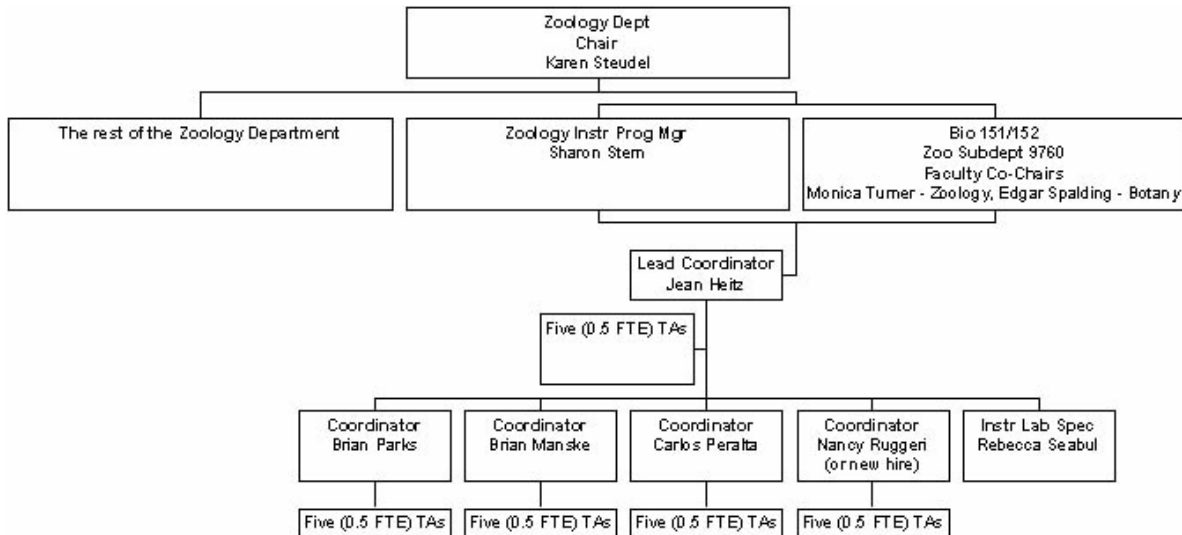


Figure 2. Current administrative structure for Introductory Biology 151-152.

The organizational chart above depicts Zoology’s administrative role, however, major decisions about the course (e.g., increasing numbers of sections) are made in consultation with the chairs of both Botany and Zoology, the course co-chairs, an L&S dean, and most recently also with ICBE. In addition, approximately one-third of the TA positions are allocated through Botany, even though Zoology administers the TAs. There has also been an increasing contribution of the College of Agriculture and Life Sciences in terms of funding and lecturers, and the connection of the course to the Institute for Cross-College Biology Education is evolving.

In contrast to the administrative responsibility, responsibility for pedagogy and course content - what is taught and how - resides with the faculty who teach in Introductory Biology and the coordinators. It is remarkable that so many professors who teach 15 lectures in the course each year attend three course meetings each year to discuss issues facing the course. Faculty governance certainly applies in the case of 151-152. Complete consensus is often not possible

with such a large group, so many decisions are made by a majority vote. A chart that reflects the way in which decisions are reached regarding course content or format changes looks more like Figure 3.

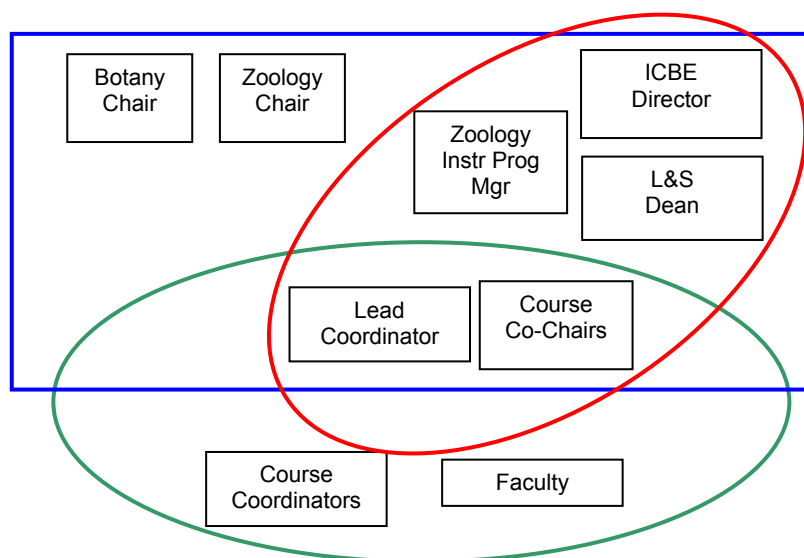


Figure 3. Diagram of decision-making groups color coded for different scenarios. The green oval includes the individuals who collectively make decisions about course format, pedagogy, textbooks, and classroom policies. The red oval includes the individuals involved in managing the enrollment, section capacities, waitlists, and some budgetary matters. The blue rectangle includes the individuals who would undoubtedly be involved in any major changes that would affect the way in which resources such as TA lines are allocated or other fundamental changes in the way the course operates.

Leadership of this course has evolved over the past decade as the course has increased in size. Prior to 1995, when there was only one section of the course, Jean Heitz worked with the course faculty, the Chairs of Zoology and Botany, and the Deans of L&S and CALS to oversee and administer 151-152. As 151-152 became larger, a more structured hierarchy was proposed. We briefly describe these transitions and the evolution of the course (including innovations, changes and experiments) with each.

Barry Bavister (AHABS) was appointed faculty coordinator for the courses in 1995 and served in this role through the 1996-97 academic year.

1. During his tenure, funding for the courses, previously supplied solely by L&S, was supplemented by monies from CALS to support approximately 1/3 of the budget (at that time, \$100,000).
2. During the 1995/1996 academic year, we experimented with having one of our labs located in Russell Labs (Rm 187), located on the west side of campus. Due to difficulties with moving shared equipment, supplies and specimens, this room was used to teach only 151. The coordinators for those sections (Jan Cheetham and Jean Heitz) had to physically move their offices from Noland Hall to Russell Labs in alternate semesters. Space limitations (discussion rooms, prep rooms, etc.) and difficulties in sharing physical and intellectual resources made this set up very

difficult for both the staff and students. As a result, the labs were consolidated into Noland Hall again in the fall of 1996.

3. To help alleviate enrollment pressure, a section of 151 was offered during the 8-week summer session in 1996. However, only 11 students completed the course.

In 1997, the Deans of L&S and CALS along with the faculty and staff of 15/152 recommended a change in leadership. From 1997-2000, Linda Graham (Botany) and Tony Stretton (Zoology) served as Co-chairs.

1. Two additional lab rooms were remodeled during their tenure. Room 267 was remodeled in 1997 using ILM funding. In 1999, Governor Tommy Thompson provided Governor's Initiative monies to remodel Room 226 Noland into a 4th lab for the course. This allowed expansion to 860 students maximum per semester.
2. Working with the Deans of L&S, under their tenure first Jean Heitz' position was increased from academic (9 months) to annual (12 months) to reflect the reality of the position. Shortly after, the other coordinator positions also became annual.
3. Much of the co-chairs' energy was put into finding new faculty to fill teaching roles in the added lecture sections.

Monica Turner (Zoology) and Robert Goodman (Plant Pathology) were elected as the next co-chairs in 2000 and served in this capacity through spring 2005. Edgar Spalding (Botany) replaced Robert Goodman in April 2005 with Goodman's move to another institution. A number of new initiatives were made to clarify duties and roles of faculty, staff, and TAs, increase the "ownership" of faculty in the courses, make more coherent and convergent the elements of the courses (lectures, discussions and laboratories), and increase the accountability and performance culture among staff and TAs. These initiatives are briefly described here, with documents appended as indicated.

1. Faculty meetings/retreats

Regular meetings of the faculty teaching in the course have been held during the past several years, typically near the beginning of each semester and at the end of the academic year (i.e., August, January and May). Meetings are designed to address issues affecting the course as a whole. The August and January retreat meetings have in recent years focused on central concepts to be included in development of the course syllabuses, as well as the overall pedagogy and learning goals for the courses. The May meeting agenda includes consideration of the textbook to be used the following year. The increase in numbers of faculty meetings from generally one per year to three has increased opportunities for dialogue, coordination and collegiality among the faculty, and an increased sense of faculty ownership of the courses.

In addition, several efforts have been tried to increase faculty and staff interactions. For example, one year we had thinly attended but quite lively monthly late-afternoon "pedagogy at the Fluno pub" meetings to discuss subject matter content, pedagogical issues, or other aspects of the courses. There have also been workshops focused on pedagogy that have included nationally respected experts and which were open to all course staff; Jean Heitz has typically led these efforts.

2. Course management challenges

The rapid growth of this course during a 10-yr time span has produced some growing pains. Introductory Biology has evolved from a single section led largely by Jean Heitz and a small group of faculty to a five-section course involving 24-30 faculty, 5 coordinators and 25 TAs each year. It became increasingly difficult for all involved to be familiar with who does what, and the supervisory lines were ambiguous. For example, the coordinators are academic staff who not only report to the faculty they teach with and to the faculty co-chairs of the course, but also to a lead coordinator who reports administratively to the Instructional Program Manager of the Department of Zoology. Course co-chairs may or may not include faculty within the Zoology Department, which administers the course. This created confusion that was exacerbated by the rapid growth of the course. Furthermore, the lack of a shared understanding of the division of responsibilities among faculty, staff and TAs produced variable expectations that engendered some discontent regarding inequities in workloads and accountability.

During the 2003-04 academic year, we enlisted the assistance of a representative of the newly created Ombuds Office to seek guidance on how best to address these challenges. This representative met individually with each course coordinator and attended meetings with small groups of faculty, groups of TAs, and the all-staff meetings. The following action items were implemented based in part on her feedback.

3. Roles and responsibilities

A document that delineates the roles and responsibilities of faculty, coordinators, and TAs was drafted, offered for feedback, revised, and eventually distributed to all concerned. This document, which can be revised as needed, proved very useful not only in clarifying and standardizing the expectations of all involved in teaching the courses, but also to help new faculty, staff and TAs integrate into the courses. The ten page document is too large for an appendix but can be retrieved at the supplemental data website given on p. .

4. Hiring and supervision of course staff

The organizational structure of the course is complex—perhaps too complex. In academic 2000-2001, a performance review process following standard university procedures was adopted. This involved a written self-evaluation by each coordinator, written evaluations from faculty and TAs, and a meeting between the lead coordinator, the Instructional Program manager in Zoology, and the coordinator being reviewed. In 2003-04 this process was modified such that the coordinators now meet in a one-on-four meeting between the coordinator being interviewed, the lead coordinator, the course co-chairs and the Zoology Instructional Program Manager (Sharon Stern). TAs also receive performance evaluations, both in the context of the student course evaluations (see below) as well as from the faculty and coordinator with whom each works.

5. Written summer goals for coordinators

Three of the four current coordinators positions are annual (12-month) appointments (calculated as 11 months salary spread over 12 months to allow for one month of vacation per year). The fourth coordinator is on a 10-month appointment. Summer provides a time for significant enhancement of course materials (e.g., laboratory exercises) and professional development for course coordinators; excluding vacation time, it also represents a personnel resource of 6 to 8 person months. In the past, the expectations of coordinators during the summer months were not

managed closely. Beginning in 2003, the faculty co-chairs meet with the coordinators at the end of the academic year (May) to set summer goals. Progress and accomplishments are then reviewed in a joint meeting at the end of each summer. This practice is continuing.

6. Exploring alternative course structures

There has been an ongoing (and sometimes spirited) discussion among course faculty and staff about how to best allocate effort so that we provide an excellent experience for the students while making efficient use of personnel. These have been done in the spirit of “adaptive management”, where we evaluate the effectiveness of alternative strategies and then decide whether or not to continue them into the future. We have done this with both the TA assignments and with alternative lecture sizes, as discussed below. A more complete consideration of alternative structures was developed as part of this self-study (see Section V).

a. TA appointments and workload. Several different formats for TA appointments and assignments have been tried over recent years. These have in part been driven by concerns over the high workload of the TAs who teach in the course. Appointments at 50% and 33% have been used, and alternative division of responsibilities (“lab” TAs and “discussion” TAs vs. TA assignments that include both lab and discussion each week) have been tried as experiments. When responsibilities were divided as either lecture or lab, the TAs found their teaching to be more challenging because they were disconnected from the other parts of the course. In addition, the TAs had a much greater total number of students to get to know. The students also found this arrangement difficult—they could not expect answers from lab TAs about lecture or discussion material, and they had more instructional staff with whom to interact. The consensus of faculty, staff and students was that this division of effort was not effective. Beginning in spring semester 2004, a standard 50% TA assignment was adopted, with each TA having a total of 40 students, comprising two student cohorts that met in discussion and lab (20 at a time) each week.

A TA workload analysis was also conducted in the 2003-04 academic year. Interviews were held with a number of TAs, who monitored their work effort over the semester. The results are summarized in a document on the website. These results showed that most teaching assistants worked more hours than they should. TAs with a 50% and 33% appointments are expected to work, on average, 360 and 240 hours, respectively, over the course of the semester. The problem appears to be more severe with the lower percentage positions, hence our move toward a standard of 50% appointments. We remain concerned that the workload associated with graduate TAs in this course remains high and we continue to experiment with slight variations to the work assignments in an effort to address this issue.

b. Lecture size The standard size of a section of 151 or 152 is approximately 220 students. This size was determined by the recommendation from a faculty poll conducted by UBEC and CBE in 1992, and because it was our general feeling that teaching ~200 students still allowed us to generate a sense of community in the classroom. However, an unfortunate combination of sabbatical leaves, retirements and absences from campus, left us unable to fill all the faculty lecture slots in 151 for the fall of 2003. Two of the 151 lectures in the timetable were scheduled to meet at the same time. To alleviate the shortage in faculty, we decided to combine the two lectures. This also allowed us to test the difference between having 200 vs. 400 students

in a section, as increasing the size of lecture is one potential mechanism for reducing the number of faculty needed. Given the opportunity to test the 400-student section we discovered:

- The general administrative load increased exponentially rather than arithmetically. The number of emails to coordinators and faculty increased dramatically and most of these had to do with logistics rather than pedagogy.
- The level of student participation in lecture dropped dramatically. It was also very difficult for faculty members to get students to respond in class.
- The number of miscommunications increased dramatically. Although we tried our best to keep the students informed both on a course-specific webct site and by weekly class emails, it appeared that the incorrect rumor mill was often faster.
- As a whole (with one exception) the faculty involved voted to go back to 200 student lectures.

The course staff (faculty, coordinators and TAs) voted overwhelmingly to return to the 220-section lecture size in May 2004. We note, however, that in spring of 2005 we have run a 300-student section; this was the only mechanism for quickly increasing access to the course when resources were made available by ICBE to achieve this.

7. Faculty and staff innovation

A number of faculty and staff have contributed innovations to the course in recent years; we highlight several examples here.

a. Recent Laboratory Innovations The content and philosophy of learning approaches for the laboratories typically have been the responsibility of the lead coordinator, Jean Heitz, using laboratory manuals that she has authored. In recent years, some faculty have originated new laboratory exercises that were incorporated into at least some sections of the course.

1. Ecology lab—Stanley Dodson (Zoology) worked with the coordinators to develop a field lab in “lawn ecology”. This lab uses all of the techniques and methodologies used in traditional ecological research. However, it is adapted to use on campus lawn areas because the large number of students we have could prove detrimental to more sensitive woodland lots, etc. This lab, like the others in the course was developed to be inquiry based and addresses the question, “How does disturbance affect the ecology of a system?” It was used in labs in the Spring semesters of 2004 and 2005. Improvements were made from one semester to the next based on the experience gained. Of particular note is that Dr. Dodson effectively integrated an understanding of what the students would be doing in the lab with what they would do in both lecture and discussion. This made for a solid integrated understanding of both ecological principles and processes.
2. Evolution/Phylogeny lab – David Baum (Botany) worked with the coordinators during the Fall semester 2004 to integrate a lab he was developing on molecular phylogeny and evolution. Although there were some computer glitches to overcome, this lab was also used to integrate both evolutionary principles and processes/methods into lecture, discussion and lab, again providing students with an integrated and solid understanding. The TAs and Coordinator of the Spring 151 section (2005) further modified this and used

it again. While, as is true of all new labs, this lab still needs some refining, it has great potential for not only teaching students molecular phylogeny, but for helping them see how molecular genetics and other information learned earlier in the course can be applied to systematics.

b. Interactive Learning On-Line The T4 Interactive Lessons in Biology innovation – Robert Jeanne (Entomology) worked with other faculty and staff of 151-152 to develop a T4 grant that was funded through the Chancellors Initiative and DoIt. These Innovative Interactive Lessons in Biology can be accessed at the following URL: <http://ats.doit.wisc.edu/biology/lessons.htm>. The modules are designed to address key concepts in each of the major sections of the course. Preliminary analysis indicates that these are very effective for students who would otherwise get grades of C or below. During the spring semester of 2005, Jean Heitz, Michelle Capes and Bob Jeanne conducted another study to determine the effectiveness of the Speciation tutorial on student understanding. These results indicated that among the students who completed the tutorial, the students who averaged less than 80% on the first two exams scored 11% better on the final exam ($p = 0.01$). No other group of students showed any significant increase in final exam scores compared to their previous average exam scores. A poster containing the results of this survey is available at http://www.botany.wisc.edu/spalding/151-152/supplemental_data.htm.

c. Biology 151-152 Lab Manuals- Jean Heitz is the primary author of the Practicing Biology Lab Manuals for use in Biology 151-152 and Experiencing Biology Lab Manual for Biology 152. These are published locally at Bob's Copy Shop because it allows us to quickly modify or add to the manuals from semester to semester. The other coordinators have all had editorial input into the manuals.

d. Practicing Biology Workbook- Jean Heitz (Lead Coordinator) wrote this book of active learning and other discussion exercises during the summer of 2003. Published by Benjamin Cummings, the workbook contains one or two activities for each of the 55 chapters in their majors' text book Biology by Neil Campbell and Jane Reece. The activities focus on key ideas or concepts that students often find difficult to understand. An on-line Instructors Guide contains the answers to the questions as well as information on commonly held misconceptions students have and how to use the exercises to overcome these.

e. Instructional Resource Base on Learn@UW for 151-152 for TAs, Faculty and Staff- During the 2004/2005 academic year, Jean Heitz and the other coordinators developed a resource base for TAs, coordinators and faculty on line. This contains copies of lab exercises, instructors' notes for each exercise, samples of discussion exercises (including the full text of the Practicing Biology Workbook Instructor's Guide), and many other resources that are useful to both new and experienced instructors of lab and discussion. The development of this will continue.

f. Instructional Information Site for Faculty and Staff- The Biology 151-152 Instructional Information site on Learn@UW – During the 2004/2005 academic year Jean Heitz developed this resource base for faculty and coordinators of Bio 151-152. It contains historical documentation pertaining to the internal review of 151-152 as well as sample power point

lectures and exams provided by lecturers in 151-152. The development of this site will also continue.

Course assessment/evaluation

All teaching personnel are evaluated by the students using forms that accommodate numerical and written answers to questions about effectiveness, fairness, and accessibility of the teacher. In the case of lecturers, the results are used in the annual review of faculty performance by home departments. The evaluations of temporary lecturers, on which the course relies in times of staffing shortfalls, are sometimes consulted by course staff to assess their performance if rehiring them is being considered. The coordinator evaluations by students are used in their annual performance reviews. TAs also assess the coordinators under whom they worked. TA assessments are used by the individual as a source of positive feedback and constructive criticism and by home departments for data in award nominations.

Grade distribution in courses

The overall average student grade (lecture, discussion and lab) in both courses is in the vicinity of 3.0 GPA. A survey of recent section totals showed overall averages of 2.90, 3.01, 3.01, 2.98, 3.20, 2.74, 3.38, 3.08, and 3.19. The grades in the lecture component are invariably lower than the lab/discussion component. Grade summaries can be retrieved at the following url.
http://registrar.wisc.edu/students/acadrecords/enrollment_reports/distrib.php

Budget structure (current) for Botany/Zoology 151-152

The annual budget of the courses as presently structured is **\$509,000** absent the salaries of the lecturers. The budget is presented in the following four categories.

A. Teaching Assistants \$250,000
20 (0.5 FTE) TAs per semester @ \$6,250 per semester (on average): \$125,000 per semester or \$250,000 per year. In some circumstances, a mix of 0.5 and 0.33 FTE TAs increases the number of individual TAs working in the course.

B. Lab Preparation Assistant (1.0 FTE) \$21,000
For the past several years, our budget included provision for a half-time prep assistant. We were not able to find anyone willing to accept the job at this salary and thus hired hourly helpers to assist with the course. 0.5 FTE (\$10,500) of this is to be supported by Governor's Initiative funding.

As of fall 2004, the coordinators teach the new 11th lab/disc section added to each section of 151-152. In exchange, Tom Sharkey (ICBE) agreed to provide the additional funding, approximately \$10,000, required to hire a full-time lab-prep person.

The lab-prep assistant helps all four course coordinators with the day-to-day operational, clerical and developmental aspects of the laboratory and discussion portions of the course. Duties performed by the lab prep assistant include helping the course coordinators trouble shoot labs, prepare solutions, maintain equipment including student computers and microscopes, culture bacteria and plants, prepare samples, organize and maintain inventories of supplies and equipment, obtain library materials, photocopy discussion, lab and exam materials, enter course

grades into the computer system, and make trips to local vendors to obtain materials. The addition of this position has made it possible for the coordinators to have more contact time with students and TAs.

<i>C. Operating Costs (Supplies and Expenses)</i>	\$28,000
Section I	\$7,000
Section II	\$7,000
Section III	\$7,000 (to be supported by Governor's Initiative Funding)
Section IV	\$7,000 (Supplemented by \$3500 from ICBE when this section of 151 was expanded to 300 students in spring of 2005. An additional line item of \$7000 will be added when the 5 th section is added in fall of 2005.)

Total = \$28,000 (+ either \$3500 in spring 2005 or \$7000 in fall 2005)

In spring of 2005, with approximately 900 students per semester enrolled in the courses, the supplies cost per student is approximately \$15.55 per semester. This must cover all supplies and expenses for lecture, lab and discussion in the course, as well as for basic office supplies for TAs and coordinators. Xeroxing costs alone (student exams, handouts, etc.) can range from \$6,000 to \$9,000 per year.

D. Coordinators' Salaries \$210,000

There are currently 4 coordinators in Bio 151-152. The total salary for all 4 combined is approximately \$210,000. Three of the four are hired on an annual basis and one is on a 10 month salary basis. Addition of a 5th full section in Fall of 2005 will require addition of a 5th coordinator with a base salary of approx. \$37,000 on a 10 month basis.

The total annual budget for the courses is: **\$509,000.**

II. Facility and Instructional Resources

(Subcommittee including Doug Rouse, Rebecca Seabul, Carlos Peralta)

An analysis of facilities and instructional resources was conducted in the spring of 2005. In doing this the committee polled faculty and coordinators in 151-152 to determine their instructional resource needs for lecture, labs and discussions. In addition, they did an analysis of existing space facilities, i.e. space available for labs, preparation space, office space, etc. These were compared to the space facilities available in Biocore. The figures indicate that 151-152 is woefully lacking in space, especially preparation and office space. In addition, lab and discussion space are the primary limiting factors on student enrollment in the course sequence.

The 151-152 lectures are held in large lecture halls such as 132 Noland Hall, 145 Birge Hall, and sometimes 105 Psychology. However, all other physical facilities are located in Noland Hall, home of the Department of Zoology. All laboratory and discussion sections meet in Noland Hall. Coordinators and TAs have their offices in Noland Hall. All lab preparation work takes place in Noland Hall. The following is a description of the present facilities and instructional resources available to the courses and an assessment of their (in)adequacies.

Total available space

The space currently available to Introductory Biology 151-152 totals of 5597 ft². This amounts to 6.0 ft² per student. For comparison, Biocore has a total area of 6263 square feet, or 22.37 ft² per student. However, a more insightful comparison can be obtained by comparing the amount of space available in regard to space function and utilization.

Category	Biocore	151-152
Total area (ft ²)	6263	5997
Total students per semester	280	1000
Area-to-student ratio (ft ² /student)	22.37	6.00
Total prep space (ft ²)	1516	262
Total coord. office space (ft ²)	662	607
Number of coordinators	4	5
Total plant growth/exp. set up/storage space (ft ²)	882	680
Total additional storage space (ft ²)	61	0
Total TA office space (ft ²)	192	122
Number of TAs	13	25
Total teaching lab space	2950	4326
Number of labs	3	5

Teaching Labs

There are four teaching labs. Remodeling and upgrading a fifth lab is in progress, with completion expected at the end of August. Realistically, the new lab might not be ready until October or even later.

The four remodeled 151-152 labs are, by most standards, very adequate and modern. They are organized to facilitate and promote group work. At the same time, the lab layout also allows for more traditional activities such as standard wet labs, presentations, demonstrations, etc. The recent purchase of new computers (seven for each lab) and LCD projectors (one for each lab) has greatly improved the effectiveness of our teaching labs.

Budget

The budget allocated for maintaining and operating the laboratories, discussion rooms, and office space is surprisingly low: \$15.50 per student per semester. This amount must cover all day-to-day supplies and equipment expenditures associated with the Course including but not limited to: laboratories supplies and equipment, discussion and lecture materials, office supplies, any equipment repair costs, all photocopying, any furnishings, any computer repairs, any computer hardware and software update, and any miscellaneous expenses. The funds available for consumables are, frankly, not adequate. In addition, there are no guaranteed funds to replace computers every few years and to periodically bring in needed technical assistance, eg. microscope maintenance.

Prep Space - a very serious concern

In 1994, when the course acquired two new labs (rooms 215 and 223), room 216 was made available for preparation and support. This 262 square foot room is the only true prep space, and it serves multiple purposes. This room is the managing center of the labs and discussions and a staging area for many of the activities, and it also serves as a communication hub. Most of the prep work is done there. Most items that need to be easily available as well as some records are stored there. Rebecca's office is located there. The only refrigerator and the only easily accessible microwave are in room 216. Room 216 is also the main "parking" area for the lab carts. The carts provide space and supplies for the project at hand, but they take space away from and interfere with other projects. Lab cart traffic jams are all too common in 216.

Room 216 has not grown since 1994 but course enrollment has more than doubled. This small room was not adequate even in 1994 when there were only two lecture sections (approximately 400 students), and it now handles the preparations for nearly 1000 students in five lecture sections. To make matters worse, the actual available counter space is only 24 square feet. It is often necessary to prepare for two or more different labs at the same time. The situation on Fridays is beyond critical. Lots of equipment, dirty glassware, chemicals, demo set ups, specimens, and many other items from the ending week compete with the materials that will be used the coming week.

To accommodate the ever-increasing number of students, labs now take place on Friday afternoons. In the past, the lab space itself could be used to prepare for the next week, but this is not possible when the current week's laboratory sections are meeting there. The meager counter

space in 216 and the carts represent the only space available. As a result, coordinators must often come in on weekends to prep the labs.

Facilities within the prep space are also severely limited. No fume hood is available, and this is a serious health and safety concern. Access to an autoclave and a dishwasher is on the third floor rather than nearby. Another problem in 216 is the size and location of the sink. It is too small and it is placed too close to the end of the counter. The drying oven in 216 is more than 30 years old and will need to be replaced soon.

No lounge-type area is available to the people who work in the course. Room 216, the inadequate prep room, is the only place food can be refrigerated or heated.

This is a good opportunity to praise the help that Dave Hoffman has provided. He has built and installed several cabinets and shelves. One of our summer projects is, with Dave's help again, to reorganize 216 to try to improve the situation there. His prompt and very efficient help has allowed us to operate at relatively low cost for equipment innovation and repairs. If we move to another building, we will need another Dave or an appropriate source of funding to pay the actual cost of repairing equipment, small remodeling projects, and the design and construction of devices needed for experiments.

Storage space - a serious concern

The courses depend on easy access to equipment, supplies, and materials. In addition to 216, three other rooms hold some of this "stuff." Two of the rooms (223A and 267A) can only be reached by going through a teaching lab. If a lab section is in progress, the facility cannot be accessed until the labs are over. Room 270 serves as a plant growth chamber as well as a storage area. This room is always humid, dusty, and warm. It also gets some fumes that corrode some types of material (rubber for example). These conditions limit the type of things we can store there. To alleviate the storage problems, coordinators store some course records and some course equipment in their offices.

The items being stored may not be used on a daily basis but cannot be discarded because they serve a useful 'salvage' purpose. Scavenging for materials that can be used in the labs is a necessary practice and such a *modus operandi* requires storage space. The recent acquisition of several dozen dissecting pans that someone dumped in the basement, which were in better shape than those the courses had been using, is a good example of how resourceful coordinators can and must be.

TA office space - a serious concern

There is currently one TA office, 220 square feet. There may be up to 25 TAs assigned to this room. This is absolutely inadequate. To make matters worse, the desks and chairs were new in 1970. All file cabinets and bookshelves are of the same vintage or have been bought used at SWAP.

Records Storage

The storage problem described above is exacerbated by the requirement that we retain some documents (e.g., student records) for a few years after each course has ended. Further

complications are the fragility of most documents and the need to safeguard the confidential information contained in those documents.

Meeting facilities

A course of this size and complexity regularly needs to use meeting facilities. There is no meeting space other than the labs. Room 163 Noland which is under Zoology control and is designated for faculty meetings for the Zoology Department is the only such room in the building.

Waiting/study room

There is no place for students to wait when they need to talk to course staff. Near exam time or at the end of the semester, it is not unusual to see many students waiting in the hall outside TA and coordinator offices. As the enrollment increases, this situation only gets worse. A waiting room that could also serve as a student study area would be a very welcome addition to the course.

Equipment

There is currently enough equipment to teach two of the same lab exercises simultaneously. It may be possible to teach three identical labs simultaneously by having students double or triple up use of various pieces of equipment (but any broken or misplaced items could make operations untenable). As the course enrollment keeps increasing, there will be a higher likelihood that more than two of the same labs will be taught at the same time.

As new labs are designed and implemented (which is encouraged), budget support is needed for obtaining the appropriate equipment and supplies to run three sections at the same time with provisions for spare items/equipment etc. At this time, the budget has no line item for new equipment purchase or for equipment replacement.

At this time, the budget has no line item for regular replacement/upgrading of computers and computer peripherals for both student and coordinator use. Software upgrade and new software packages are also a periodic expense that must also be included as “supplies.”

III. Comparison with Other Courses at UW-Madison and Comparable Institutions

(Subcommittee: Edgar Spalding, Brian Parks, Carol Lee)

Courses arise and evolve to meet local needs, guided by the perspectives of the principal teachers and staff and the needs of the entities the course serves. This is as it should be, but such a mechanism for course evolution does not necessarily involve a calibration step in which the course compares itself to others with similar missions and goals. It would be sensible for a course sequence like 151-152 that has undergone a period of rapid growth to attempt a calibration of itself against similar courses. The present review was considered an opportunity to assess how 151-152 compares to other large science courses on campus, and to other introductory biology courses at similar institutions. A subcommittee consisting of Brian Parks (course coordinator of 151-152), Carol Lee (assistant professor of Zoology and lecturer in 151), and Edgar Spalding (professor of Botany and lecturer in 152) was charged with creating a survey and using it to obtain information about the structure, space requirements, and costs of courses that may be meaningfully and instructively compared to 151-152. The text of the survey used to elicit feedback and the tabulated results can be retrieved here:

http://www.botany.wisc.edu/spalding/151-152/supplemental_data.htm

The most salient points to emerge from this interesting exercise are summarized below.

For on-campus comparisons, the subcommittee chose Chemistry 103-104 and Physics 103-104. Both are large introductory science courses relied on by various majors across campus, and they include a lab. Information from Physics was too thin in most categories, particularly in budget information, to be useful but Chemistry, via Gery Essenmacher, provided detailed answers to our most important questions, enabling meaningful comparisons. Chem 103-104 teaches approximately twice as many students each year as 151-152. Fewer faculty members participate in the course because each professor teaches more than the 5-week block typical of a 151-152 professor, and because the lecture sizes are larger. The number of TAs is slightly higher in Chem 103-104 than in 151-152 when expressed relative to the number of students enrolled. Analysis of the budgets, which did not include the salaries of professors, indicates that the cost per Chem 103-104 student is \$222. The cost per 151-152 student is \$283. Both semesters of Chem 103-104 are 4 credit courses, whereas 151-152 semesters are each 5 credits. **On a per credit basis, the non-faculty cost of teaching a 151-152 student (\$57) is essentially equal to that of a Chem 103-104 student (\$56).** A striking result of this survey is the high degree of similarity between 151-152 and Chem 103-104 in terms structure and cost. A biologist might use convergent evolution as an analogy to explain this – a similar accommodation of common realities arrived at independently.

For comparison to off-campus introductory biology courses, the sub-committee solicited information from a few universities deemed to be like Wisconsin because they were either a land-grant Big Ten campus with an agriculture school and a liberal arts unit, or a large research campus with a medical school. The universities contacted were Michigan State (which contains the elite Lyman Briggs School), Penn State, University of Michigan, UC-Davis, University of Texas, and the University of Washington. One salient result is that introductory biology is offered in very different formats at universities you might think face similar constraints and issues. Basic formats range from a single semester (Michigan) to four semesters (Penn State).

Texas and Michigan State (including the Lyman Briggs School) both use a two semester sequence for introductory biology and therefore may be the easiest to compare with 151-152. The regular introductory biology course at Michigan State (not the Lyman Briggs School version) handles 1000 students, same as 151-152, and includes lab and discussion sections. A similar number of TAs participate in the course, which is taught in similar-sized lectures. Many fewer faculty teach the lectures because one professor teaches either all or half of a course by themselves, in contrast to the 151-152 model in which three professors typically teach one third of each course. Wisconsin appears to be the only university that employs the model of three professors per course, each teaching the material closest to their specific discipline. **Not including professor salaries in the calculations, the cost per student at Michigan State is \$340, significantly higher than 151-152 (\$283).** Texas, the other university with the two semester format, employs a large number of apparently non-tenure track professors to teach many small-sized lectures. The total number of students taught in the course (2400 per year) is much higher than 151-152 and the cost per student is low (\$150 per student per semester). However, the low cost is surely due to the fact that the Texas course does not include a lab, which is a separate course). Excluding the cost of the 151-152 labs would definitely reduce the cost per student below that of the Texas course. The other estimates of cost per student we obtained were based on quarters and course structures that were difficult to compare to 151-152.

The survey we sent also requested information about learning goals, pedagogy, the incorporation of technology in the classroom, and the integration of research experiences into the curriculum. In most cases, the responses were similar to 151-152 activities and methods. However, none of the responses gave evidence of integrating a research experience similar to the Mentored Research component of 152. Correspondence the subcommittee members exchanged with counterparts at the other institutions more than once led to the admission that the 151-152 sequence was impressive. In fact, the Associate Dean of Biological Sciences responsible for undergraduate education at the University of Minnesota ultimately returned no information, saying she was embarrassed at the state of affairs at her campus, and that they were going to embark a reform of the introductory biology curriculum there. The overall take home message from the survey of peer courses and institutions is that teaching introductory biology is a complicated endeavor that no two places do exactly the same way. Nonetheless, the 151-152 course at Wisconsin compares very favorably with its peers. The unique features of having experts teach their areas of expertise and a research experience in the curriculum do not come at an inordinate cost in terms of content, throughput, or dollars.

IV. Preparation of 151-152 Students for Upper Level Biology Courses

(Subcommittee: Steve Gammie, Janet Branshaw, Stanley Dodson, Nicole Perna, Jennie Boughman, Rick Vierstra)

The charge of our subgroup was to determine how well we are preparing students to take upper level courses. We realized that there would be two useful approaches for examining this question. The first approach was to ask students who are taking upper level courses how well they feel 151-152 prepared them. We targeted 6 upper level courses and using this approach we were able to compare student preparation from 151-152 to both Biocore and Zoology 101/102. We used scantron forms and asked the students now that they have taken an upper level course, how well do they rank their introductory biology course using a 4.0 scale. We also asked them to indicate how well they were prepared for the specific upper level course in which the survey was conducted. We were able to get numeric feedback also on how well they thought intro labs prepared them for upper level labs. We also obtained data on how many additional semesters they had conducted independent research. An important part of the survey was that we allowed them to provide handwritten comments on the strengths and weaknesses of their introductory biology course and if they have any suggestions for improvements. The text of the survey questions, a spreadsheet containing the data extracted from the scantron response forms, and a summary of all the handwritten comments specific for 151-152 may be retrieved at <http://www.botany.wisc.edu/spalding/151-152/supplemental-data.htm>. (Comments for other courses are not included, but could be provided). In our survey, we also were able to distinguish between those students who just took 152 (usually students who took high school AP biology) and those who took both semesters. The numbers for the 152-only students were 25 total in our survey. In the initial sections below, all 151-152 and 152-only responses are presented together, but in a separate section below differences in response between the two groups are presented.

The second approach was to ask instructors of upper level courses about strengths and deficiencies that they regularly observe in their students. The main limitation of this approach is that students in upper levels course could have received training from either Biocore, Zoology 101/102, Botany/Zoology 151-152, or from another campus. Hence, the instructors have little idea about where the students got their specific introductory biology training. Thus any strengths or weakness identified by instructors can be used as generally important information, but it is still unclear how much those comments apply to 151-152 students. A summary of these comments is also retrievable from the above mentioned website.

Main findings from student surveys

Overall, for all courses combined, in response to the question of how well would you rate your introductory biology course now that you have taken an upper level course, 151-152 students gave the course a score of 3.12 (1-4 scale), so the grade rank would be between a B and an AB. In comparison, Biocore scored much higher (3.51), whereas zoology 101/102 or intro courses from another school scored about the same (both 3.07). As a reminder, Biocore is a 4 semester sequence, one semester of which is an independent research project, and Zoology 101-102 is just one semester. (Note: The Biocore independent project is a different kind of independent project, involving class work on the Biocore prairie and not with mentors outside of Biocore. In addition, Biocore classes are capped at 125 students.) Thus, all things being equal,

one would expect ratings for preparation for upper level courses to be highest in Biocore (4 semesters), followed by 151-152 (2 semesters), followed by Zoology 101/102 (1 semester).

We also asked how many other upper level courses the students had taken to see if this affected their response. Combining all data points, students gave their intro course the least favorable rating if this was their first semester taking an upper level course (3.0 out of 4.0) and this went up to about 3.14 if they had any additional upper level courses but did not differ depending on how many they had taken. This trend equally affected all groups.

Overall, for all courses combined, in response to the question of how well their intro biology course prepared them for the specific course in which the survey was taken, 151-152 students gave the course a ranking of 2.02 (this was on a scale from 1-3; 1 = it was poor preparation for this course; 2 = it was adequate preparation; 3 = it was excellent preparation). Thus, 151-152 was considered adequate. Compared to other courses, Biocore again ranked best (2.5) – halfway between adequate and excellent preparation. Zoology 101/102 ranked at 1.9 (about the same as 151-152).

Regarding how well the students thought their introductory lab prepared them for the upper level lab course they are currently taking, 151-152 gave a score of 1.87 (below adequate). Compared to other courses, Biocore scored the best with a rating of 2.4 and interestingly, Zoology 101/102 that is a single semester course scored slightly above 151-152 with a score of 1.92. The handwritten evaluations for 151-152 provide some insight on this because the students could speak more generally about merits and deficiencies of introductory biology. A number of complaints for 151-152 (14% of total written responses) dealt with the labs. The full comments, separated by the courses in which the surveys were conducted are attached. In contrast to this, 6% of the comments praised the labs. A review of the written comments will provide a glimpse into what various students found satisfactory versus unsatisfactory in the 151-152 labs. Because Biocore scored so well on the lab preparation (2.5), one cannot completely make the argument that introductory labs are incapable of garnering praise or being viewed as valuable by students.

The most favorable statistic for 151-152 was the amount of semesters students continued to spend doing research in labs following a 152 mentored research experience. In this case, if students took 152 mentored research, they averaged an additional 2 semester conducting research. This compared to 1.5 semesters for students taking Biocore. If students in 151-152 did not conduct mentored research, the average amount of research conducted was only 0.65 semesters and this was the identical number for students taking zoology 101/102. **Thus, not only does 152 put a large number of students into research labs, but it also increases the likelihood they will continue doing research.**

Specifically for 151-152, we evaluated preparation for different upper level courses. Using the same 1-3 scale used above with 3 being highest, preparation for animal physiology was seen as the best (2.21) followed by genetics (2.13), ecology (2.04), plant physiology (2.0), biochemistry (1.93), and evolution (1.90). Interestingly, when broken down by the course students were sitting in when giving the overall grade (0-4.0 scale), students in the human physiology course gave 151-152 the highest grade (3.25), followed by evolution (3.20), genetics (3.17), plant physiology (3.16), and biochemistry (3.05).

We also examined whether the major of the student affected perception of 151-152. The highest score was given (1-4 scale with 4 the highest) by pharmacy majors (3.28), followed by biology (3.14), genetics (3.13), other (3.12), and zoology (3.05).

When distinguishing between those students who only took 152 and those who took both semesters, the overall evaluation was higher (3.22 out of 4.0) than for those students taking both semesters (3.10). In contrast, when asked about the specific preparation of the intro course for the specific upper level course in which the survey was taken, students who only took 152 only gave a poorer review (1-3 scale with 3 highest) (1.79) compared to students who took both semesters (2.06). The simplest explanation for this the 152 only students could only think about what training they received from 152 whereas as students taking both semesters could reflect back on both courses to evaluate how well they were prepared for a specific course. Likewise, in response to how well prepared they were to a specific upper level lab, students taking just 152 versus both semesters gave scores lower scores of 1.5 versus 1.9, respectively. Again, decreased exposure to lab material in 151 could account for the perception of decreased lab preparation for upper level courses.

The responses from the instructors (attached) provided a broad spectrum of perspectives. The views of how well prepared students are ranged from good to poor. It was indicated that the more upper level courses a student takes prior to the upper level course in question, the better the student performs. As indicated above, students felt better about their intro biology courses if they had more than one semester of upper level courses under their belts. When asked about student preparations for specific topics, e.g., Mendelian genetics, enzyme kinetics, the instructors regularly rated student preparation between a B and F grade. As also indicated above, a shortcoming of surveying instructors is that they do not usually know the intro biology course their specific students took, so comments are general to all intro courses.

One common theme in the response is that a number of instructors felt more math, quantification and analysis should be taught in introductory biology courses. The sentiment was that students should feel comfortable using math in biology and learn the importance of math to biological analysis.

The instructor response was 25 and the specific comments to each line of inquiry is provided in the Excel file that can be found at the supplemental data website.

V. Consideration of Alternative Course Formats

(Subcommittee: Donna Fernandez, Bob Jeanne, John Kirsch, Brian Manske, Tony Stretton)

Botany/Zoology 151-152 was designed to provide a comprehensive introduction to biology, primarily for the many biological sciences majors on this campus. The structure and format of the course at its inception were appropriate for the philosophy, goals and objectives of the course. As the course grew in recent years, a need to revise and articulate the learning goals of the course was perceived. The faculty and staff began the process of revising the learning goals during the 2003-04 academic year. The updated goals document is presented as an appendix at the online supplemental data site. Given the updated student learning goals, it is reasonable to ask if the course structure and format is still appropriate and still effectively serving student learning. This section gives a preliminary view of alternative course formats.

The committee considered a number of areas, but narrowed its focus on components that should apply across the course and changes that would not infringe unduly upon the academic freedom of individual instructors. The components addressed in this section are:

- A. Lecture – content and structure
- B. Lecture – assessment
- C. Lab – purpose and structure
- D. Discussion – purpose and structure
- E. Coordinator roles
- F. Course evaluation and improvement

Each component includes and discusses to some degree:

1. A summary of our current format
2. Objectives, strengths and/or issues of the current format
3. Alternative formats with advantages and disadvantages

The following is not intended to be a comprehensive list of all alternatives, but rather some examples that address issues in our course and that concerned our committee. The issues are primarily anecdotal, reflecting the views of some but not all faculty and staff involved in this course. Further, any stated advantages or disadvantages to current or alternative formats, also may not reflect the opinion of everyone in the course.

A. Lecture – content and structure

Course content & coverage

Current format:

- 151 - cells, genetics & evolution/diversity (some variability where animal diversity is taught)
- 152 - plant physiology, animal physiology, ecology

The coverage among the several sections is not identical. However, this is a much-discussed issue among faculty, and there is organized communication among faculty members in the different sections so that they can compare their individual coverage with that of the others teaching the same unit. It is important that some variation be allowed, both to allow for experimentation, and to allow each faculty member to teach in a way that allows expression of his or her personal style and individual creativity. Individual choice is a strong positive incentive that attracts and keeps faculty in the course. On the other hand there is a responsibility to cover a certain amount of material in common between the sections, and there is an ongoing (and healthy) tension between these opposing forces.

There is a choice between comprehensiveness (an introduction to all of biology) vs. emphasis on basic topics & those to which the students are unlikely to be exposed in other courses. The course favors comprehensiveness, although time constraints prevent it from being complete – for example, behavior and development are not adequately covered. The vast majority of ‘biology’ majors will not be exposed to these disciplines in later courses, so they may deserve coverage in the introductory course. On the other hand, less time spent on genetics may be acceptable because virtually all majors are required to take Genetics 466. What courses students take after 151-152 should be one of the factors in the decision about which topics to emphasize.

The bottom line is: biology is big. Unanimity about content will never be reached, but perhaps that is no bad thing, as the very diversity of instructors reflects the comprehensiveness of the science.

Redistribution of topics within 151-152?

Advantage(s): Some of the units are more conceptual and might tie in together better. The first semester could outline the overarching concepts that shape our current understanding of biology (ecology, evolution, genetics, diversity). The second semester could look at the details on a system level (cells, prokaryotes, plants, animals).

Disadvantage(s): Some units may require more integration in the first semester of the example, making it more difficult to separate for individual faculty to teach. As with the current format, some units require concepts from other units; usually these are simple and one could just expect students to learn on their own and not cover it in lecture.

Lectures: should they be replaced? No!

A good lecture organized into a story line that makes sense and is true, is an indispensable teaching tool. A good lecturer communicates at multiple levels, using words and images to engage the student’s mind and emotions, and conveys much more than information - he/she also conveys validity and authenticity, and gives allusions to other spheres, both academic and in life, that help the student analyze, synthesize, and remember. As with a Shakespeare play, there is no substitute for the performance; reading the text is important and discussing the text is important, but “the play’s the thing” for interpretation and complete understanding. Different people learn in different ways, so it is important to present the material in multiple formats - lectures, written notes, the chance to discuss with faculty in office hours, in-class discussion session, or other informal settings, the illustrations in the text and other visual aids (e.g. from web).

One thing we do in a lecture is to convey the utter reality of our intellectual satisfaction, and the rewards we feel in our career choice. Consciously or unconsciously, we portray that being a scientist is pretty neat. The most important thing a teacher can do is to convey enthusiasm and a passion for the topic. We try to bring to our teaching the passion, joy, and intensity that we feel for science in our own research. It goes without saying that we find the subject matter that we teach intensely interesting; the concepts are fascinating, and the experiments on which they are based are the essence of science.

There is often a discussion about the relative merits of teaching “concepts” versus “facts”. In biology this is a hollow issue. Biology is not like mathematics - we cannot derive it from first principles. True, there are some unifying concepts and we must emphasize them, but there are enormous gaps in our current understanding, and much of this has to do with evolution having determined the way things are. The solutions are particular. Too bad we don't have enough time for much comparative biology, because the reality of biology is diversity.

Should a section be taught by fewer faculty members?

Current format:

- 2 semesters - 3 units/semester; typically 1 faculty member/unit. Each faculty member gives 14 or 15 lectures (each 50 min).
- 5 lecture sections/semester. 29 - 31 faculty members are involved (some faculty teach more than one unit and some teach every other year).

Advantage(s) of fewer faculty: Faculty recruitment is an issue. As the course grows, more and more are needed and it is difficult to ensure continuity or consistency across the course. Optimally a single lecture would create the best continuity.

Disadvantage(s): If only 2 faculty members taught each lecture section, it may be more difficult to split the material into 2 units; discussions of this among the faculty have supported division into thirds. Would the course suffer as a result? Would hiring a generalist be required in order to reduce the faculty involvement to one person? The importance of time (5 weeks vs. 8 weeks) as an incentive to engage faculty in a service course should be recognized.

Class size

Current format: Currently limited to 220 students per section.

Comments: Sections of up to 330 or 440 students have been tried previously. The near-universal reaction to larger lecture groups among instructors is negative. Part of this is due to the perceived disconnection with the students. However, the sample size for this particular experiment was far too small; class-to-class variation in liveliness or presence of just a few students (or TAs or coordinators) willing to speak out may obscure the true effects of class size. It is often said that in principle, once a lecture section becomes larger than 100 or so students it might as well go to 500, and that little personal interaction is possible beyond a class size of 30. But is the difference between 220 and 440 significant, and if it is, is it large enough to completely rule out the larger class size? Is there also an effect of lecture hall configuration (are long narrow rooms like 107 Psych really worse than wide amphitheatres like 145 Birge?)

Advantages of larger class size:

Easier to fill lecturer slots; requires fewer faculty; coordinator duties can be split up differently and perhaps more efficiently.

Disadvantages: Less interactive? Demands on instructor time go up in terms of answering e-mails, running honors discussions, etc. This could also be a strain on some labs to many students doing it at the same time; however, this often occurs anyway.

Time allocated: Should we use power lectures or add a semester?

Current format: 3-50 minute sessions/week for 2 semesters.

Advantage(s): If lectures were 75 min long on Monday and Wednesday, all discussions could be Wednesday through Friday. This would put discussions right after lecture, which would eliminate issues with exams (typically no discussion for final or overloading discussions before the exam) and not have discussion overlapping new lectures. Pre-discussion activities would need to go out before the lectures are given that week; students would go into lecture understanding what they should know.

Disadvantage(s): Students would not have the weekend to prepare any activities for discussion. Student attention span is limited, and many find it difficult to stay mentally engaged this long. Fewer topics may be covered by professors who like to feature 1 main topic per lecture.

Question: Would this allow more lab sections to be scheduled or fewer?

The conclusion is that two semesters are just about right. Extending the course to three semesters or two years would cut significantly into the number of upper level courses that the students can subsequently take. Two semesters of Introductory Biology leaves flexibility to select advanced courses in their areas of interest.

Teaching and Faculty expertise

In introductory teaching, how important is it that faculty have expertise in the area in which they teach? In principle, anyone trained in biology could teach any section of the course, but they would bring approximately the same level of expertise that they would bring to introductory chemistry or physics, i.e. they probably have not kept up with recent developments in the field since they themselves were undergraduates. We think that it is good that faculty teach only a small fraction of what they know – students do not want their professors to be ignorant. They also want their professors to convey a broad view of the field, to make connections across disciplines, to link them to the current state of the field, and to make connections with their lives. Persuading a pre-med of the value of ecological thinking takes some skill, and is probably best not left to amateurs. **We strongly support the present practice of faculty members teaching within their own areas of expertise.**

B. Lecture – assessment

Objectives

Assessment has two aims: (1) to provide the student and instructor with a measure of the learning gains made by students via the lecture component of the course, and (2) to provide the instructor the data on which to base students' grades for the course.

Current format

The primary assessment tool in the lecture portion of the course is the use of three 90-minute examinations. The last of these, nominally the “final exam,” is typically non-comprehensive. Because of the large number of students in each section, exams are machine-graded (Scantron). Therefore, the questions are either multiple choice or a mix of multiple choice and true/false. Prior to most exams, instructors conduct review sessions, attendance optional. In some sections, students are allowed to bring to the exam a card of a specified size on which they can write anything of use to them while taking the exam. In most cases, sixty percent of the course grade depends on lecture exams.

Issues

A drawback of this form of assessment is that multiple choice and true/false questions may not test a student’s ability to synthesize information, to reveal their thinking about larger issues, and to write well-reasoned, logical narratives showing that they understand conceptual issues in biology. A second concern is the evidence that many (most?) students in the course focus heavily on ‘what they need to know’ for the exams; some seem more concerned about drawing a precise division between what material in the text and lecture will be on the exam and what they can effectively ignore than they are about the learning itself. Third, many students appear to put off reviewing the lecture material until just before the exams, rather than treating the entire semester as a learning journey. It encourages an “all eggs in one basket” approach to learning.

One of the concerns repeatedly raised by instructors in the course is that students fail to make connections between topics. A change that would help deal with this issue would be to institute a comprehensive final examination, which also may improve student long term retention of material.

Alternatives

With class sizes of 2-300 students, essay exams are not a viable alternative, given staffing limitations in the course. On the other hand, there are other ways to deal with some of the issues described above, not as alternatives to lecture exams, but as supplements, and some of these are being tried by some of the faculty in the course. One is to supplement the exams with frequent quizzes; some sections already do this by giving weekly short quizzes during the discussion meeting. Modern technology makes it possible to administer these on-line and grade them automatically. Quizzes could be used to encourage students to read the text and learn the material in digestible, chapter-sized units, rather than in 6-week chunks. Frequent short quizzes would also help the instructor uncover student misconceptions in time to deal with them.

A second form of assessment is in-class active engagement. Classroom communication technology (CCT) provides some advantages over the traditional method of asking questions of students and soliciting discussion, especially in large lectures. One technique is to put “clickers” into the hands of students, who use these to respond anonymously to in-class questions raised by the instructor. Carefully crafted questions can inform the instructor whether students understand a concept that is being covered at that moment in lecture. Clicker input gives instantaneous, quantified output, and results are stored in files that can be

saved for later analysis, or used as a component of the lecture grade. Combined with “peer instruction”—having students discuss their answers with their neighbors—CCT can be a useful learning tool as well as an assessment technique.

Improvements

The lecture exam format has evolved over the years to the point where it is probably an immutable fixture of the course. However, experimenting with various in-class assessment techniques as supplemental means of improving assessment and learning is certainly an option, and it is no doubt possible to design controlled studies of the effectiveness of different varieties of implementation.

C. Lab – purpose and structure

Current format

- Most labs are process oriented and inquiry-based (exceptions below); most labs are modular lasting 3 weeks. Goals include professional skill development.
 - 151 – 2 demonstration labs
 - 152 – 1 demonstration lab; IP project (Comm B course) students do library or mentored research
- Students perform and are assessed in groups most of the time
- Size of class – 20-22 students
- Time allocated – 1-3 hr sessions/week

Strengths – The premise of inquiry and problem solving is excellent, both in modeling the application of biology and for improving long-term retention; use of teamwork is good for diverse students. The mentored research seems to be the greatest strength.

Issues – There is some disagreement over the ideal focus of the lab activities, probably because each has its own issues.

- The process of science is emphasized in the lab, and this creates the following issues for some students. Some students feel lost; the emphasis on process becomes repetitive over 2 semesters; the modular nature of the labs results in coverage of only a few topics being covered; the process model is oversimplified. It is evident that students have a strong grasp of the overall process, but do not develop strong skills in the individual components (eg. developing hypotheses and data analysis). From the perspective of the staff, the inquiry-based nature makes it difficult to connect the lab directly to lecture. The slim pool of possible lab exercises leaves faculty/coordinators little flexibility when picking lab the exercises most suitable for learning objectives for a particular semester.
- Another focus of the lab are the professional skills of teamwork, critical thinking, peer review and communication. While many probably agree these skills are important, the only skill taught and assessed well is written communication. Students practice the other skills and improvement is notable but without assessment, improvement cannot be plotted and used to reinforce good performance. Better matching of goals, objectives and assessment may be the

answer. An overwhelming focus in this area raises concerns about what students learn as individuals; most assessment is writing and is done as group work.

- A third focus is on demonstration or illustration of principles and information presented in lecture, including how such discoveries are generated. A big issue here may be that labs need to parallel lecture very closely; this sounds good in theory, but is it practical in an introductory course? We've had little success making great connections overall. Also, there are too many lecture topics to even come close to covering them in lab. Finally, studies have shown that students don't learn a lot from demonstration labs, this is probably because many students take the "get it done quickly and get home" approach, which happens because there is less thinking and collaboration involved. This could be coupled with inquiry-based labs to improve the rigor and quality, and would also give students more background/direction to design a good experiment; however, this could possibly overwhelm students right away. Might some of these be suited for use in discussion?

Alternatives

- 1) Alternative: Lab review/innovation – we need a mechanism for new labs and more faculty input. ADVANTAGE(S): Strengthen connection to lecture; improve lab quality. DISADVANTAGE(S): If we take this to the extreme, there are too many faculty – how many lab exercise choices would we need to make everyone happy?
- 2) Alternative: More individual work – ADVANTAGE(S): Allows for more individual responsibility so that they aren't just brought up by the group. Maybe just individual opportunities to practice and be assessed would work also. DISADVANTAGE(S): More potential grading for TAs
- 3) Alternative: Longer lab project(s) – ADVANTAGE(S): Students would understand that research requires attention to detail and that scientific knowledge is based on the accumulation of data; not one experiment can necessarily answer a question. DISADVANTAGE(S): Labs would need to be interwoven instead of modular, but this would be more realistic.
- 4) Alternative: More content – ADVANTAGE(S): Students can integrate more knowledge; they have more tools to think scientifically. This can reinforce concepts they learn in lecture. DISADVANTAGE(S): Requires more knowledge from TAs and reworking of some labs.
- 5) Alternative: Make separate course – ADVANTAGE(S): Removes student complaints regarding the connection between lecture and lab; connection is no longer an issue. Allows for a single coordinator to manage a semester of lab for better efficiency, which has the potential make it a stronger unit as an individual package. TAs could also specialize, which can definitely improve their workload. The idea of lab coordinators and lab TAs was tried before; the only reason it was discontinued was because it weakened the lecture/lab connection. Unit order in lecture won't affect lab. Concurrent enrollment with lecture, lab and discussion is a huge pain for students and coordinators – having separate enrollment would ease this and allow for more labs to run in the same space per week. DISADVANTAGE(S): Begs the question, do we need lab? - Lecture grades would drop and more students would fail. How do we get students to take both or is it a majors decision?

- 6) Alternative: Bio152 lab is only IP – ADVANTAGE(S): Cut down on work load, students do much more work currently in 152 than 151. Without lab modules, the coordinator/TAs could focus on the communication skills required for the paper & presentation. The coordinator may have time to run a mentor training program (the HHMI study demonstrated that students with trained mentors had a more satisfying experience); this doesn't involve training the lab PI, only the grad student, tech or post doc the student is directly working with. DISADVANTAGE(S): Students get less lab experience.
- 7) Alternative: Bio151 as IP prep – In some ways it is now, but could be redesigned with that in mind. Students could be given choices on mentored research and their curriculum could possibly be tailored to their research track. We could teach more common techniques that mentors wish students would have coming into their lab – survey past mentors. ADVANTAGE(S): Students could identify mentors earlier in 151. Would strengthen the package with the next alternative. Many of the current labs could remain, but be spun differently with added tools. Mentors would have better prepared students that would more likely finish experiments within 152. DISADVANTAGE(S): How much customizing to individual students is feasible? Would this defeat some of our current goals on professional skills?
- 8) Alternative: All Bio152 IP is Mentored – This would require more alternatives into service learning, education and possibly other areas. Very few students will work in labs, but most will apply biology to future careers. There would be no library. ADVANTAGE(S): Greater student satisfaction; better experience. Students have more exposure to other career options. Students may be more interested in the work of others at the poster session. Lab sessions could be shorter (1 credit) and only focus on communication skills. Library projects aren't very well defined as is; TAs struggle as much as students and very few library IPs are very good. Great boost to the program by having 1000 mentored students a year. Could collaborate with diverse departments on campus; e.g., engineering, law, business, veterinary, pharmacy, med school, etc. Different student clubs/organizations may be useful in recruiting mentors. DISADVANTAGE(S): All individual work would mean more papers; could add writing fellows to the TA pool as a solution, or maybe use peer teaching.
- 9) Alternative: 18 students – ADVANTAGES: Decrease group sizes to 3; currently with 4, one is always left out – especially in the writing/assessment. DISADVANTAGES: Need more labs to make up the students (~2).
- 10) Alternative: 2-2 hr sessions/week – ADVANTAGE(S): Allows for potentially better experiments because of increased sessions. The shorter session period keeps students busier and more engaged; TAs too for that matter. DISADVANTAGE(S): Possible scheduling issues.

D. Discussion – purpose and structure

Current format

- Highly variable
- Discussion questions common (some review lecture material, others apply lecture material to problems)

- Occasionally quizzes and a few case studies have been tried. We have the tutorials also, but they are not really useful for class use; they are better for individual studying.
- Size of class – 20-22 students
- Time allocated – 1-75 minute session/week

Strengths – Some lecturers have a specific plan, which helps with quality and consistency across the lectures in that sequence. They can be useful for reviewing concepts students didn't understand in lecture. Modeling helps students with diverse learning styles or background. If problem solving is used in discussion and on exams, students have the chance to practice.

Issues – Some lecturers don't have a specific plan, which hurts quality and consistency across the lectures; this also increases TA workload. As lecture review, the discussion period can be too long. Also as review, why is it mandatory that brightest students go? Is this always correlated with the exam – meaning, if the exam is about application of lecture material, shouldn't discussion be giving them the chance to practice application?

Alternatives – Again this may be an issue of what is the focus of discussion? Should discussion clarify, amplify, enrich? Should this be lecture specific and course independent, which it is now?

1. Alternative: Combine with lab period – ADVANTAGE(S): Use lab period for more than one purpose to keep students engaged. See also lab alternatives – this may make better use of 2 lab sessions per week. Students could do investigative cases – combination of lab and discussion.
2. Alternative: Standard format across the course – The format can vary across sections and options are few. We currently provide tools that help students with diverse learning styles like modeling for hands-on learners, but could also provide demo-type lab setups. There could be problem solving or case studies. At the minimum we need more alternatives for materials to use.
3. Alternative: Dual format – Different discussions for different students. Many current activities are designed for students with less background not the higher achievers. ADVANTAGE(S): Address greater student diversity in learning. DISADVANTAGE(S): Finding a stable/predictable format. Creating categories of students may create an unintentional hierarchy.
4. Alternative: Case studies – This has been tried before in one semester. ADVANTAGE(S): Could overlap with lab. Breaks passivity and engages students. DISADVANTAGE(S): This is time consuming and would need to replace lecture review in many discussions.
5. Alternative: Optional discussion – ADVANTAGE(S): The bright students that don't need review to do well on the exams don't have to go. Saves time and resources. DISADVANTAGE(S): This time could be used for additional learning and not just review. Do we even need discussion then?

E. Coordinator roles

Current format

- 1 coordinator per 220 student lecture
- Each is responsible for administration, training TAs, preparing lab and discussion meetings, developing teaching activities, occasionally teaching, reviewing IP papers

Strengths – with the current course format in which an entire lecture has one set of TAs and the same lab/discussion exercises, having one coordinator in charge of that lecture ensures consistency within that lecture. Students, faculty and TAs benefit from the continuity and a clearly identifiable “point person.”

Issues – As the course grows, the number of additional coordinators is becoming the same issue as with faculty numbers – lack of consistency across the course. Many believe the coordinators are overworked, and their efforts are often time-inefficient and redundant. This leaves little room for proper evaluation and innovation.

Alternative: Coordinator specialization – ADVANTAGE(S): Currently a coordinator’s role should require excellent skills in management, organization, leadership, creativity, synthesis/analysis/evaluation, communication and sometimes teaching. Current coordinators have different strengths, passions and desires for growth – having roles suited to this will cut down on unreasonable overtime, allow coordinators to teach, create greater job satisfaction, improve TA performance, provide mechanisms for course growth and improve student learning. DISADVANTAGE(S): Continuity and consistency within a section could suffer (as was noted following the model used with the 400-student lecture, with one coordinator handling lab and the other handling discussion). Balancing roles would be an issue, but if coordinators were more motivated with their more narrowly defined role, this would correct itself. Types of roles could include, but are not limited to:

- Lab coordinator (151 & 152)
- IP coordinator (student setup, poster presentation)
- IP mentor trainer
- Lecture/discussion coordinator (includes student administration, exams, grades)
- Instructional material and curriculum development & implementation
- TA training and professional development
- Course staff director (lead coordinator)
- Science education specialist (monitor literature, invite speakers, write grants, curriculum consultant)
- Resource base manager
- Web management

Possible coordinator arrangement

A. Lab coordinator

- Directs 151-2 modular labs
- Directs weekly TA training
- Works with faculty committee on lab development

B. IP coordinator

- Directs IP program and poster session
- Guides student mentor setup
- Offers mentor training program
- Directs weekly TA training

C. Lecture & discussion coordinators (2 – for 151 and 152)

- Administration – students, exams, grades, web management
- Directs weekly TA training
- Works with faculty on objectives and assessment
- Designs & implements learning activities for lecture and discussion

D. Course Director & instructional specialist

- Manages coordinators and lab manager
- Works with faculty co-chairs on all course issues and as a liaison to ICBE;
- Networks with Delta/CIRTL, Science House, HHMI, the Teaching Academy, etc.
- Biology education research – curriculum consultant for lecture, lab and discussion
- TA professional development and coordinates semester TA training
- Oversees course budget
- Directs grant writing
- Resource base manager

F. **Course evaluation and improvement**

Goal: To provide vehicles for obtaining feedback about course and personnel effectiveness; and to provide an administrative structure for recognizing and rewarding stellar performance and innovation, generating ideas, and implementing change.

Evaluation

Current format: At the end of each semester, the students are asked to fill out extensive questionnaires on the effectiveness of faculty, coordinators, and TAs. They are also asked to evaluate various components of the course, including the lab exercises. The TAs are evaluated at the end of each semester by the coordinators that they worked under. The coordinators are evaluated yearly by a committee consisting of the lead coordinator, Zoology academic program manager, and the course co-chairs; and comments are solicited from the TAs and, on occasion, the faculty of their section. Student evaluations of faculty are returned to individual departments, if requested, where they are presumably used in pre-tenure evaluations and merit exercises.

Issues: While it is important to invite student feedback, the current evaluation forms are long and complex. They require a considerable investment of student time. Faculty are often required to use their departmental forms, which vary in format, and this adds to the complexity. Students are not necessarily educated consumers: for example, they are asked to evaluate coordinators, although they may have had little or no personal contact with that person; and they are asked to comment on how various aspects of the course contributed to their “learning”. This requires a certain degree of maturity and reflection.

Alternatives: 1) Different format for evaluation forms- shorter and more concise, with more directed, specific questions. These could be administered as each part of the course or each lab exercise is completed to reduce the burden at the end of the semester. 2) Switch to more active forms of student feedback, particularly for lab and discussion. For example, we could ask students to work in groups to make recommendations for one particular lab exercise per semester. We could probably even get volunteers for this if they thought their comments were going to be incorporated into future revisions. We might also set up a system of peer advocacy: for example, one person from each lab section could be identified who would be willing to meet weekly and bring questions/concerns/comments from students in their section to the faculty and/or staff (as appropriate). 3) Convene focus groups: ask students in upper level courses to state what they thought was effective and what was not.

Improvements

Current format: The semi-annual retreats and informal discussions at the Fluno Center play an important role in facilitating exchanges between faculty about effective practices. Staff meetings presumably play a similar role in allowing coordinators to exchange ideas; however, time for planning is extremely limited during the academic year. It is essential that coordinators have time during the summer for more creative endeavors and for planning and implementing improvements.

Issues: Although we would like faculty and staff to be conducting controlled experiments aimed at improving student learning (new lecture formats, new lab exercises, revisions of lab manual), at present, there is no formal mechanism for assessing and implementing changes.

Alternatives: Provide an administrative structure for assessment and for facilitating change. Perhaps faculty and staff in the course could be assigned to an assessment/steering committee on a rotating basis. This committee would be charged with reading evaluations, identifying pedagogical issues, and suggesting areas where creative energies might be focused effectively. This would be particularly beneficial if it could take place before the summer so that staff and faculty have time for developing materials and ideas before the fall semester starts.

VI. Summary—where are we and where do we go from here?

Strengths

Introductory Biology 151-152 at UW-Madison has several features that we consider to be notable strengths. Although it is an introductory science course, the lectures are taught by leading scientists who are experts in the area they are teaching. Students frequently comment on the noticeable enthusiasm the professors have for their science, and they have opportunities, early in their academic program, to connect with faculty whose interests overlap with their own. The emphasis on and opportunity for research through Introductory Biology is unique and notable among peer institutions. This offers students one of the key advantages that should derive from studying at a leading research institution; as a course, we are proud of our track record in engaging introductory students in research.

Our teaching laboratories are modern and function well. Faculty involvement and commitment to this course—seriously considering course content, philosophy, pedagogy and structure—are truly commendable. As shown by comparisons with similar courses on and off campus, Introductory Biology 151-152 is cost-effective.

Vision

Introductory Biology seeks to increase our effectiveness at providing students an outstanding—intellectually rigorous and engaging—introduction to modern biology. We want to do the best job possible at meeting our stated course goals. In concert with this, we want to prepare students well for their more advanced courses. We also want to provide adequate access to this course for all students wishing to enroll by their sophomore year. Administratively, we envision a culture of commitment, collaboration and innovation among course staff and faculty.

Challenges—course content and structure

Fundamental to the challenges we see regarding course content and structure is the balance between diversity and integration. An ongoing challenge, and the subject of numerous course meetings, is how to achieve an optimal balance of consistency among different sections of the course while retaining flexibility in content, pace, and emphasis for the faculty teaching a given section. Similarly, we have struggled with mechanisms for integrating topic areas more effectively throughout the two-semester sequence. Another recurrent issue is how to integrate the laboratory and lecture components of the course most effectively (or whether to consider them semi-independent). The relative weighting in laboratories of process (the methods of scientific inference) and content (mastering current techniques or knowledge) is a subject of ongoing discussion. We welcome suggestions on these issues as part of the review process.

Challenges—course administration

The recruitment of faculty to a service course at a research university remains a challenge; we would like even greater faculty involvement in Introductory Biology from departments across campus, and institutional mechanisms for achieving this. The administrative units responsible for decision making for this course remain unclear at times. Space needs are critical, there is an urgent need for much improved preparation and work space for course staff. The operating budget is insufficient for equipment maintenance and replacement, and this should be addressed. The TA workload associated with the course is high; we remain concerned about the TA workload interfering with graduate student progress toward degree. We again welcome

suggestions on these issues as part of the review.

VII. Appendices

All appendices may be retrieved from this website:

http://www.botany.wisc.edu/spalding/151-152/supplemental_data.htm