iology Core Curriculum

Biocore

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MEMO
TO: Dean Gary Sandefur and Elaine Klein (Asst. Dean, Academic Planning, Program Review and Assessment)

FROM: Janet Batzli (Biocore Assoc. Director)

RE: Biocore Program Goals & Assessment of Student Learning

Overview of the Program:

Biology Core Curriculum (Biocore) is an intercollege honor's biology program devoted entirely to undergraduate teaching and learning. Our mission is to provide a solid foundation in biology and actively engage students in the process of scientific discovery. Biocore's sequence of 7 courses (4 lecture and 3 lab) integrate and build on one another over four semesters. Our lecture courses are currently taught by faculty/staff from across campus; L&S (3), CALS (3), Med School (4) and ICBE (1). Two permanent Biocore academic staff teach three lab courses.

Biocore is not a major, and, therefore, does not confer degrees. Rather, Biocore is a sequence of courses that fulfills some or all of the undergraduate biology requirements for a variety of biological science majors, including many in CALS, L&S and Engineering (Appendix 1). Students who complete Biocore receive 16-18 honors credits towards their biology requirements.

Students generally enter Biocore as sophomores and stay together through four semesters as a cohort. Limited enrollment of up to 150 students each fall allows for the establishment of a supportive, strong learning community associated with Biocore courses, and additional opportunities for peer mentoring, independent research, and service learning projects (see Table 1 for enrollment figures). Unique elements of Biocore in addition to the learning community include an emphasis on integration of biological concepts at all levels of organization (from molecules to the biosphere), critical thinking and problem solving, scientific writing, and focus on the process and nature of science.

Summary of Program Learning Objectives:
The Curriculum
The Biocore sequence begins with an overview of ecology, transmission genetics, and evolution, in Biocore 301/302 (lecture/lab), moves into cell and molecular biology in Biocore 303/304 with emphasis on chemistry, biochemistry and bioenergetics, continues with animal and plant physiology in Biocore 323/324, where students apply physics, chemistry, and math to organismal biology, and culminates in a capstone experience in Biocore 333. In Biocore 333, students synthesize concepts and skills learned over the previous three semesters of lecture and lab and

apply what they have learned to studies of the primary literature using a cooperative learning pedagogical model (Burgess 2002). Laboratory courses focus on the process of science and challenge students to develop their own independent research projects, with topics drawn heavily from the lecture courses as well as their math, chemistry and physics experiences. Labs are taught by the same permanent academic staff through three semesters, providing continuity and high standards for continuous intellectual development of students. Labs are structured so that over three semesters students gradually gain skills and confidence in doing and communicating independent research in the language and conventions of the discipline. All laboratory courses stress making observations, finding relevant information from the primary literature, designing tests for hypotheses, drawing conclusions based on evidence, and writing reports in the form of scientific papers. The courses are writing intensive, and challenge students to analyze and think critically about scientific data.

Each Biocore course is led by a faculty course chair whose responsibilities include helping to establish the overall course learning goals with input from the entire the instructional team. Course chairs meet monthly to help build and maintain the integrative nature of our courses.

In 2004, Biocore faculty/staff met in course teams and then as a whole program during a mid-summer retreat to formulate a cohesive set of Program and Course Learning Goals for each of the lecture courses and the labs. The following is a list of **Program Goals** that has been revised several times as instructors become more used to articulating learning objectives and using them to guide course, curriculum, and program assessment/evaluation.

As a result of participating in Biocore, students should be able to:
1. Utilize experience, knowledge and creativity to solve complex biological problems.
2. Understand how we know what we know in biology through study of the nature of science, the primary scientific literature, and historical experiments.
3. Build a logical argument based on evidence, learn to think critically, be skeptical, look at evidence before believing, and understand that there is not always just one right answer to a question.
4. Use terminology accurately and effectively within appropriate conventions of the discipline.
5. Frame sophisticated biological questions, formulate testable hypotheses, design and carry out experiments, make logical conclusions based on evidence.
6. Analyze a problem using a systems approach ("systems thinking"), recognizing levels of biological organization, and emergent properties of the whole.
7. Express ideas clearly and logically in oral and written form.
8. Know how to find and evaluate information.
9. Work as a member of a productive, collaborative research team.
10. Identify how biological structure follows function, and recognize how this phenomenon results from the process of evolution.
11. Use practical tools and procedures to investigate biological problems
12. Recognize how biological entities sense and respond to their environment.
13. Appropriately apply concepts from chemistry, physics and mathematics to the study of biology

The Program Goals guide Course goals that, in turn, allow a context for development of individual lecture or unit learning objectives in a hierarchical fashion. As a capstone course, Biocore 333 course goals are similar (if not identical in some cases) to program goals. These goals challenge students to apply their accumulated knowledge and experience from the previous three semesters to solve complex problems and critique the primary scientific literature in specific research areas. (See a sample of Biocore 333 (Capstone Course) Course Goals and sample Unit Learning Objectives in Appendix 2.) We believe that this course provides the best summative assessment of the learning gains of our students. Therefore, we have targeted much of our assessment efforts in Biocore 333.

Student Achievement of Learning Goals
Direct Assessment
The Biocore assessment plan and methods rely heavily on embedded course assessment (problem sets, exams, written scientific papers and posters, and presentations), particularly team worksheets and exams in Biocore 333 (our capstone course) as direct measures of learning outcomes.

Table 1: Biocore student enrollments from 2003-2005

Course	Typical semester taken	2003	2004	2005
Biocore 301/302 (Ecology, Evolution, & Genetics)	Fall, sophomore year	153/139	121/109	107/97
Biocore 303/304 (Cell Biology)	Spring, sophomore year	155/143	144/117	124/115
Biocore 323/324 (Organismal Biology)	Fall, junior year	122/53	125/57	100/37
Biocore 333 (Capstone)	Spring, junior year	86	107	88

Table 2: Frequency Distribution of Grades Earned in Biocore 333

Year	A	AB	B	BC	C	D	F
2003	48	7	28	0	3	0	0
2004	16	6	68	0	16	0	1
2005	35	12	32	4	3	2	0

The majority of students over the last three years have achieved a B or better in Biocore 333, providing strong evidence that students are achieving course and program learning goals. As an honors course, with high achieving students, we are sometimes surprised that more students do not do even better in this course. Yet, we recognize that the topics covered in Biocore 333 over

the last three years have not represented the full range of concepts and scale of study in the biological sciences. As a result of faculty recruitment opportunities, Biocore 333 currently focuses on molecular to tissue-level study of human medically-related issues. Our intent in future years is to recruit faculty to represent a broader range of topics that would balance the current cell to tissue medical focus with a physiological/ecological/evolutionary perspective to better serve a broader student population.

Indirect Assessment

We also assess achievement of our program learning goals indirectly using student surveys and, most recently, focus groups. During the last week of Biocore 333, students fill out a Program Survey that asks them to reflect on their four semesters of Biocore. This survey includes a chance for them to rate how well they feel they have achieved Biocore's Program Goals and whether they would take Biocore if they had a chance to do it over again. Results from our Spring 2006 survey are shown in Table 3. The data indicate that most of our students feel that they have achieved program goals "well" or "very well".

Table 3: Results of program survey (Spring 2006) taken by Biocore 333 students who had completed all 4 semesters of Biocore. Intermediate categories of "somewhat well" and "fairly well" are reported in aggregate. N=67

Program Goals in 2006 As a result of participating in Biocore, students should be able to:	**Self Reported Achievement of Program Goals**		
	Not well at all	Somewhat - Fairly Well	Very Well
Utilize experience, knowledge and creativity to solve complex biological problems	1%	31%	67%
Understand how we know what we know in biology through study of the nature of science, the primary literature, and historical experiments	1%	23%	75%
Build logical argument based on evidence, learn to think critically, be skeptical, look at evidence before believing, and understand that there is not always just one right answer to a question	1%	28%	70%
Use terminology accurately and effectively within appropriate conventions of the discipline	1%	55%	43%
Frame sophisticated biological questions, formulate testable hypotheses, design and carry out experiments, make logical conclusions based on evidence	1%	27%	72%
Analyze a problem using a systems approach ("systems thinking"), recognizing levels of biological organization, and emergent properties of the whole	1%	34%	64%
Express ideas clearly and logically in oral and written form	1%	29%	69%
Know how to find and evaluate information	1%	38%	60%
Work as a member of a productive, collaborative research team	0%	28%	72%
Identify how biological structure follows function, and recognize how this phenomenon results from the process of evolution	3%	27%	70%
Use practical tools and procedures to investigate biological problems	1%	40%	58%
Recognize how biological entities sense and respond to their environment	1%	34%	64%
Utilize understanding from related science (e.g. physics, chemistry, and mathematics courses) in biology	0%	57%	43%

Although students generally feel that they are achieving the learning goals, we recognize two areas (terminology and utilizing related science in biology) where support, guidance and instruction could improve student's confidence. In Fall 2004, Biocore initiated a peer mentoring program where experienced Biocore students (juniors) and Biocore alumni (seniors) lead study groups of 5-6 first semester Biocore students. This is a voluntary program for new Biocore students, which we think will improve student confidence in many areas, including terminology and integration of science knowledge.

In addition, Biocore 333 lecturers and TAs consistently feel that students seem to have lower confidence associated with practical skills and knowledge of tools and procedures used in biology. To address this issue in 2006, instructors in Biocore 333 and 304 (Cell Biology Lab) teamed up with a small group of graduate teaching interns enrolled in a Wisconsin Program for Scientific Teaching course (lead by Jo Handelsman, http://scientificteaching.wisc.edu/) to develop lab and lecture instructional materials to improve students' understanding of cell and molecular biology techniques. We have learned a great deal about our students through this project and recognize this as a ripe area for improvement in the future. We look forward to analyzing the student learning assessment data that our teaching interns collected and using it to improve our courses.

An important question that we ask the outgoing Biocore cohort each year is whether they would choose to take Biocore if they had to do it all over again. Table 4 reports students' responses for the last three years.

Table 4: Results of Biocore program survey taken by 2004-2006 Biocore 333 students who had completed all 4 semesters of our program.

Relevant Survey Questions Outgoing Students	% Response		
Knowing what you know now, would you choose to take Biocore if you had to do it over again?	Yes	No	Don't Know
Spring 2004	72%	11%	17%
Spring 2005	62%	16%	22%
Spring 2006	81%	0%	19%
Why or Why Not? Representative Comments			
"Yes! Biocore has exposed me to so many amazing students, professors, TAs, and other staff. Also, I have made many friends that I would not have otherwise met. The professors really do care about us, and are dedicated. I know that I am a better scientist because of Biocore. I can actually write research proposals thanks to lab. Also, it feels good to really think about science with a critical eye. ….Biocore is strong because it makes us realize what we can really do!"			
"Yes & No. I've met some really great people and had some amazing profs. 304 and 324 were so great! But I feel my GPA took an un-needed hit and it won't be recognized in [Med and Grad school] applications."			
"No, I think it would have been useful to have taken other advanced bio classes and only a few intro courses."			

The major concern reiterated through program evaluations is that some students believe that they would have received better grades if they had taken an alternative intro biology sequence rather than Biocore (see comments in Table 4). While we have not done a systematic study to address this concern, Dr. Tom Sharkey (Director, ICBE) did an independent analysis of GPA comparisons between students who took Zoo/Bot 151-152 and those who took Biocore. (see on-line report at http://www.biology.wisc.edu/images/Grading_in_Bio_Courses.pdf). Dr. Sharkey's conclusions from this study indicate no grade penalty for taking Biocore.

Biocore Focus Group
In Spring 2005, eight students in the outgoing Biocore class volunteered to participate in a focus group led by Michelle Harris and Janet Batzli to discuss the following questions:

1. How do Biocore lecture courses compare to other university lecture courses (integration/continuity)?
2. Do you feel you lack preparation for any area of biological study?
3. How well has Biocore prepared you for upper level courses, research, jobs, graduate school, MCAT?

Discussion Summary:

Q1. Biocore provides a solid foundation in most areas. The lecture courses (except for 333) were similar to those in other courses, except for the style of exams. Exams were challenging. You had to think outside of a particular topic, to connect concepts learned in other units. In 333, you learn from other members of your team. Working in small groups, makes you recognize and learn to value the variation in perspectives and differences in how [one] might interpret the same thing.

Q2/Q3. Biocore is strong in biochemistry, cell and molecular biology but somewhat weak in genetics (particularly population genetics). Biocore does not cover developmental biology in any detail, and is missing microbiology (bacteriology) and immunology (except in discussion of use of immunology for molecular techniques). Biocore is strong in helping you develop critical thinking skills. Solving problems in lecture (integrated questions!) and lab gives you confidence to dive in and explore other areas in upper level courses. Preparing for exams in Biocore helped us learn how to approach difficult problems—this, in turn, helped in exam preparation in upper level courses. After Biocore 303 and 333, you will feel very well prepared for upper level biochemistry, physiology and cell and molecular biology courses. [Several students had just completed the MCAT]—Taking Biocore is good preparation for MCAT. [Other students were preparing for graduate school] – Research experience in Biocore labs is excellent preparation for independent research as an undergrad or in preparation for graduate research. It is unfortunate that Biocore labs are not worth more credits. [All students in this group planned to go on to Med or graduate school at the time of the interview].

Admittedly, this focus group discussion was flawed by having biased facilitators (Biocore staff who were very familiar with the students). In the future, we plan to recruit unbiased facilitators to conduct similar sessions. Nevertheless, this discussion confirmed our notion that we need to

improve the teaching of genetics in Biocore and provide opportunities to integrate genetics concepts in other areas of the curriculum.

What we have learned from past assessment
Future Plans/Next Steps:

In the past three years, there are several questions that have arisen repeatedly from discussions of our program goals and learning objectives.

1. How can instructors integrate our course curriculum to better reflect the interconnectedness of biology? How can instructors integrate genetics more fully to broaden and strengthen students understanding?

Even though we have made great efforts to help instructors communicate and coordinate with other instructors in different units of their own course and with instructors from other courses, we have received feedback from students indicating that they can not see how ecology, for example, has anything to do with cell biology, or how an understanding of evolution and genetics is central to the argument for using model organisms to explain basic biological phenomenon.

To make these interconnections visible and comprehensible to students, we encourage instructors to regularly include "integrative questions" into their problem set assignments and on exams. We will make pedagogy the main focus of our monthly course chairs meetings, where we will discuss and refine course goals and verify their alignment with our program goals. We will be asking course chairs and instructors to make more of an effort to align their specific unit or lecture learning objectives with course and program goals. In addition, we encourage course instructors to attend our beginning-of-semester teaching workshop, with the objective of working together and sharing ideas for use of common examples, finding common themes, and to get familiar with what and how their faculty colleagues are teaching.

2. Are we sufficiently preparing students for upper level courses and for post-baccalaureate work?

In Spring 2006, the Institute for Cross College Biology Education did a survey of students enrolled in upper division courses, asking them how well they felt they were prepared for the course given the introductory biology sequence they took (Biocore, Zoo101/Bot130, Zoo151-152). We have not received the summary of this survey yet, but believe that this could provide good feedback and initiative for work on particular areas of our curriculum that are weak. In addition, we would like to survey alumni who have taken Biocore – those who are 5 and 10 years out—and ask them about aspects of Biocore that helped them in their current work, or skills/concepts they wish they had mastered while in Biocore.

3. How can we help our students improve their capacity to analyze and interpret data [through an understanding of statistics and use of statistical reasoning]?

Although we feel we do a good job in helping students develop testable research questions and design experiments, we have been frustrated with students' lack of statistics training, and have struggled with how to improve students' capacity to analyze and interpret data in an authentic

way in lieu of statistics. We would like for our students to have some understanding of statistics prior to (or concurrently with) Biocore lab courses. Statistics is central to interpreting data and making sound conclusions based on scientific evidence. We recognize the difficulty in requiring that statistics be a prerequisite course for Biocore. Alternatively, we plan to develop a statistics manual and class statistics exercises with the help of graduate teaching interns (through the DELTA program) and two current Biocore students who are equally frustrated with the lack of statistics training in Biocore. This manual would be used by our students as they progress through the 3 lab courses.

We hope that this new initiative will not only improve students' work and ability to think critically about data in the laboratory, but will also extend their capacity to understand and appreciate limitations and logistics of experimental design, and their ability to critique scientific literature.

4. How do we efficiently and accurately assess students' learning and attitudes about their achievement of learning goals?
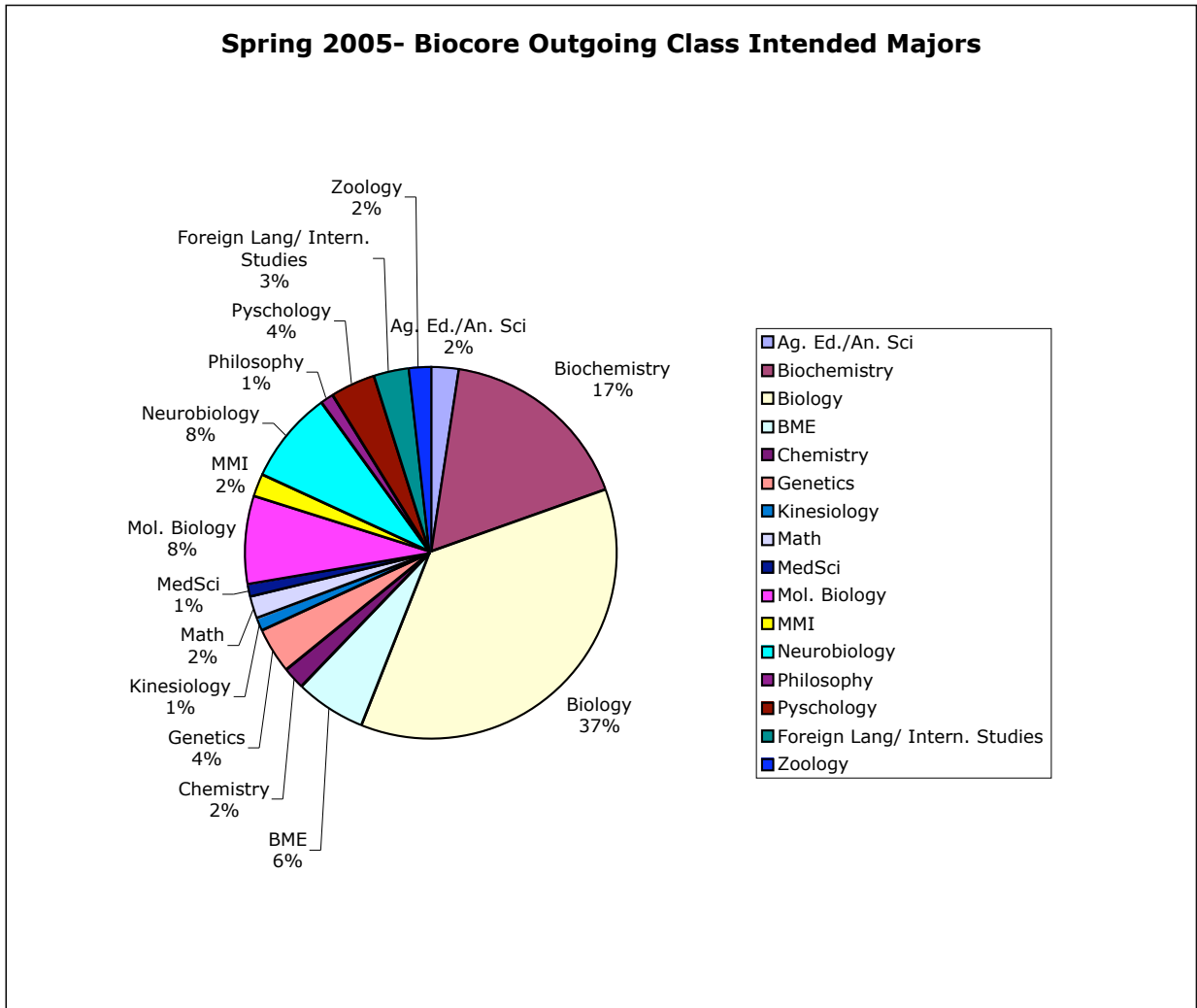
In spring 2006 we began using the WebSurvey@UW online survey tool to collect mid-semester and final course, TA, and program evaluation data from our 303 and 333 students. We are very encouraged by the WebSurvey tool because of its ability to proficiently collect, organize, and summarize relevant demographic and self-reported attitude data. We believe that this tool has great potential to improve our capacity to assess students' learning, as well as helping us keep track of alumni and long-term learning gains.

Literature cited:

Burgess, A. B. 2002. Cooperative Learning: Moving from theory to practice in a class of 80 students. Bioscene 28: 3-8.

Appendix 1. Intended majors of Biocore 333, Spring 2005 outgoing class. Nearly 20% of this student cohort plans to pursue a double major (each major counted independently in the figure below). N=88

Spring 2005- Biocore Outgoing Class Intended Majors

Zoology 2%
Foreign Lang/ Intern. Studies 3%
Pyschology 4%
Philosophy 1%
Neurobiology 8%
MMI 2%
Mol. Biology 8%
MedSci 1%
Math 2%
Kinesiology 1%
Genetics 4%
Chemistry 2%
BME 6%
Ag. Ed./An. Sci 2%
Biochemistry 17%
Biology 37%

Legend:
Ag. Ed./An. Sci
Biochemistry
Biology
BME
Chemistry
Genetics
Kinesiology
Math
MedSci
Mol. Biology
MMI
Neurobiology
Philosophy
Pyschology
Foreign Lang/ Intern. Studies
Zoology

Appendix 2. Biocore 333 Course Goals and sample of lecture learning objectives from Unit 3 (focused on the genetics of colon cancer susceptibility).

Biocore 333 Course Goals- as drafted 7/28/04
At the end of 333 students should be able to:
1. Draw on past experience, accumulated knowledge, and creativity to solve complex biological problems.
2. Build a logical argument based on evidence.
3. Use terminology accurately and appropriate conventions of the discipline in your approach to problems and to generate logical solutions.
4. Frame a sophisticated biological question and formulate a testable hypothesis to guide in answering that question.
5. Apply and connect concepts from previous Biocore courses in the context of problems presented in 333.
6. Utilize underlying knowledge of biology to describe how a whole system works from the molecular to the organismal level.
7. Build confidence to think as a biological scientist and be able to communicate your knowledge to others
8. Provide evidence of your capacity to work as a member of a productive, collaborative member of a group.
9. Understand there is not always just one right answer to a question.

Unit 3, Week 1, March 20-24, 2006
Hereditary Cancer Susceptibility: The Role of *APC* in Colon Cancer Susceptibility

Learning Objectives
By the end of this week, you should be able to:
• Define **hyperplasia, dysplasia, carcinoma *in situ***, and **invasive cancer**.
• Explain the general function of **tumor suppressor genes** and **oncogenes**.
• Explain the difference between **tumor initiation** and **tumor progression.**
• Describe the process of **mapping genes in human pedigrees**.
• Explain how a mutation in a tumor suppressor gene can lead to predisposition to cancer.
• Explain how cancer predisposition differs from a classical genetic disease such as cystic fibrosis.
• Describe the balance of cell proliferation and loss in the intestine.
• Explain the effects of **missense**, **nonsense**, **deletion**, **frameshift,** and **splice site** mutations on mRNA and proteins.