

**Report of the External Review Committee
for the College of Biological Sciences, University of Minnesota**

The College of Biological Sciences at University of Minnesota admirably aspires to create “the best undergraduate biology program in the country.” Substantial progress toward this goal has been accomplished, as documented by the College’s excellent self-study and program evaluation. Three members of the CBS External Review Committee (Bruce Alberts, Ken Burtis, and Bill Wood, Chair) visited the campus on April 25–27, toured the CBS facilities, and met with ten different groups of CBS faculty, students, and staff. Below is the Committee’s report on the current strengths of the program and opportunities for further improvements that will help to accomplish the program’s goals.

Strengths:

- **The Nature of Life Course**

This appears to be an outstanding several-day orientation program, which could be a national model for students entering an undergraduate science major. Students commented on the value of the NOL course in forging lasting relationships, and indicated that the experience provided them with a new view of their roles as students and of university-level research.
- **The “Foundations” Courses (BIOL 2002-2004)**

Using research-based teaching approaches and exploiting state-of-the art classroom technology, these classes (Concept Labs) and the accompanying inquiry-based open laboratory courses offer incoming students an excellent introduction to the practice of science as well as the foundations of modern life science, from molecular biology to ecology. They immediately establish that college-level learning requires active engagement with topics in depth, and that education involves much more than the memorization of information.
- **The quality of the students, faculty, and departmental leadership**

The Committee was impressed with the students we met: their enthusiasm, level of engagement, and academic aspirations. Several faculty, younger ones in particular, impressed us with their dedication to improving the undergraduate program. The Dean and Associate Dean appear to be providing energetic and enlightened leadership toward the College’s goals.
- **The University’s investment in SCALE-UP classroom facilities**

The Committee applauds the university for its foresight in preparing for what is emerging as the undergraduate pedagogy of the future. To our knowledge, Minnesota’s level of investment in ten new student-centered classrooms designed for in-class active learning is unique among large research universities. The Committee (whose members are extremely envious of these facilities!) predicts that they will contribute in a substantial way to the College’s goal of national pre-eminence in undergraduate biology education.

Opportunities for improvement:

- **Extension of the highly successful pedagogical transformation of the introductory level “Foundations” courses (2002-2004) to the upper division courses in the program.**

We were struck by the data on the bottom of page 138 of the 2010 Self Study. Here freshman rate their overall undergraduate experience more highly than the average of such ratings by freshman at other research universities; but in contrast, the situation is reversed for seniors. These data, as well as comments from students and faculty during our visit, suggest that there is room for improvement in some of the upper level core courses in the College. These courses could benefit from some of the new pedagogies developed nationally and employed in the “Foundations” courses, as well as from the 10 new “active learning classrooms” that will become available next fall. Incentives and support (see third bullet) should be provided to faculty teaching upper level courses who are willing to transform them to more student-centered formats. This process is more likely to succeed if it is developed with full collaboration of the faculty participants, rather than directed by a few individuals with educational expertise, and it may be best achievable by team teaching as suggested below.

- **Improved cooperation with the College of Science and Engineering (CSE, formerly IT) so as to:**
 - introduce more biologically relevant material into CSE service courses in math, physics, chemistry;**
 - increase enrollment capacity for “service” courses to allow growth of the CBS major;**
 - encourage more interdisciplinary team teaching.**

The structure of the University -- in which the biological sciences are located in a separate college from chemistry, physics, mathematics, and engineering – provides both opportunities and challenges. The opportunities arise from the clear focus of the excellent leadership and faculty of the College of Biological Sciences on becoming the best biology program in the nation. However, for the following reasons, this can only be accomplished if efforts are made to strengthen and incentivize cooperation between CBS and CSE. Major challenges are attributable to two realities that will only become more troublesome with time:

1) A background in the fundamentals of mathematics, chemistry and physics is essential for all of modern biology. For true educational excellence, a great deal of coordination will constantly be needed to insure that what is taught in mathematics, physics, and chemistry optimally meets the needs of students entering biological fields. For example, we learned that a major reason for CBS students avoiding the physics course for life sciences was that it was associated with one additional credit hour (for no particular reason the students could discern), and was therefore perceived as “more work.” The need for greater coordination was also apparent with respect to incorporating meaningful biological examples into the physics curriculum. Although there was substantial satisfaction with the chemistry curriculum among students and faculty, it was noted that the capacity of CSE to teach required prerequisite courses in chemistry is the limiting factor for the number of students who can be accepted each year

into CBS. They see no way to correct this problem, and we learned that the Education Policy Committees for the two colleges never meet; this situation should be addressed.

2) The great complexity of biological systems means that new approaches are needed to attack biological problems. In response, departments of physics, applied math, and engineering are becoming increasingly involved in biology. For example, about 40 percent of the engineering faculty at MIT is now engaged in biological research efforts, and the new field of “systems biology” is expanding on many campuses. Courses in systems biology and biophysics should be made prominently available to students in the College of Biological Sciences. Moreover, an increasing number of courses should be jointly taught by faculty in the two colleges. Several students praised the “Computing in Biology” course offered by Dr. Myers in CSE as an outstanding example of a course spanning engineering and biology.

We were told repeatedly in several groups that the formula (budget model) currently used to allocate university resources based on student credit hours creates a major barrier to such collaborations, as each college endeavors to retain as much of the curriculum for their students as possible inside the unit, leading to unnecessary redundancy in courses on similar topics (see below) and barriers to sharing responsibilities for interdisciplinary courses. If unchecked, this tendency will cause even more problems in the future, as biologically oriented research becomes increasingly prominent in the chemistry and engineering departments. We strongly recommend that a separate advisory committee to the Provost be established to bring solutions to this problem, which have been developed at other universities, to the attention of the relevant Deans and other University leadership, and that explicit steps be taken by the relevant Deans to create the desired synergies.

- **Retention and integration of Teaching-Professor track faculty into CBS**

The non-tenure-track faculty in the Teaching Professor group are crucial to the CBS program in several regards. First, several of them appear to be superb teachers who contribute substantially to the success of the “Foundations” courses (2002-2004). Second, several are highly qualified educators, who are attracting grant support and publishing educational research papers on scholarship of teaching in respected education journals. Third, several are providing, or are willing to provide, pedagogical expertise and assistance to tenure track faculty who teach upper division courses and are interested in transforming them. Team teaching with these faculty may be the most effective way to bring upper division teaching approaches into line with the pedagogy of the “Foundations” courses.

Unfortunately, the Teaching Professors are disadvantaged by perceived lack of appreciation and recognition as well as tenuous job security. To increase the probability of retaining this valuable group, the Committee suggests three possible steps that could be taken:

1) Their current 1-year appointments should be replaced with 3-year rolling appointments to provide an additional small measure of job security.

2) Consideration should be given to forming a Department of Biology Education within CBS, to be staffed in part by some of these faculty. Such a department would seem highly appropriate as part of a College of Biological Sciences. As a side benefit,

this department could take responsibility for the Biology major, which currently has no departmental home or departmental oversight.

3) The possibility of tenure-track appointments should be considered in the future for selected members of this group who have achieved distinction through their scholarly accomplishments in education and successful competition for extramural grant support.

- **Inclusion of the Physiology major in CBS**

The Committee recommends that the Physiology major be moved into the College of Biological Sciences. The separation of this cohort of students from their natural peers in the other basic biology majors seems disadvantageous, and the absence of the “Foundations” course series from the requirements for this major is equally perplexing.

Students reported to the Committee that avoiding the “Foundations” course, which was considered challenging, was one reason students chose to matriculate in Physiology. We recognize that moving the major would create obstacles for a subset of incoming students who are unsuccessful in gaining admission to the College of Biological Sciences. These students could be accommodated in the CLA Biology, Society and Environment major, but inter-college efforts should be made to create a maximally efficient system for transfer to CBS of those whose coursework performance after admission to CLA meets necessary criteria.

Co-localization of Physiology with the other CBS majors would maximize opportunities for interactions between students with similar professional and career interests, as well as creating economies of scale in providing basic biology students with curricular options. A requirement for the “Foundations” course, as for all other CBS majors, could lead to an appropriate increase in the rigor of the Physiology major. The necessity of offering this major as a B.A. rather than a B.S. was not made apparent to the Committee, but should not be an obstacle to relocation of the major.

- **Removal of redundancies in molecular biology instruction within and between colleges**

The Committee notes with concern the fragmentation of the upper division core curricular offerings in molecular biology into multiple departments and colleges. In an era of limited resources, this situation leads to unnecessary redundancy in instruction within CBS courses (students mentioned learning the “central dogma” up to three times in fulfilling the requirements for their major). Between CBS, CLA, and CSE, it also creates additional workload while diminishing the opportunities for students from different disciplines to recognize the unifying principles that underlie modern biology. Faculty perceived that the primary reason for overlapping courses was the competition for resources associated with student credit hours. The Committee reiterates its recommendation above that the relevant Deans, with the support of the Provost, negotiate a mechanism for strategic distribution of resources that would incentivize the faculty in CBS, CSE and CLA to work collaboratively rather than competitively in designing molecular biology (and other) courses that serve all students.

- **Expansion of independent research opportunities for students**

The “Foundations” second-year laboratory course (BIOL 2004) serves as an excellent introduction to laboratory research for most CBS majors, but is not a sufficient

research experience for many of them. We heard from several constituencies (including faculty, students, and student services) about the substantial value that independent research in a faculty laboratory can add to the undergraduate experience. We also heard that a limiting factor for students seeking this experience is information on availability of faculty labs that will take students. Between all the schools and colleges in the university, there is a large number of diverse biology-related research labs, likely enough, if students were aware of them, to accommodate all interested students in CBS. We recommend establishment of an online directory of all such labs that would help all students who wish a research experience to find one, and that even more be done to incentivize students to work in faculty laboratories starting as juniors.

- **Other suggestions**

Women and minority scientists are under-represented on the CBS faculty, and this imbalance should be actively addressed in future hiring. Given that the majority of CBS students are women, it is particularly important to have successful female faculty who can serve as good role models.

There are some concerns about the integration of transfer students from outside the university who join the CBS program after two years at another institution. We heard and would support suggestions that the Careers course currently required of these students should be made optional, and that it should be supplemented with an orientation course that would include at least some elements of the NOL course for incoming first-year students.

We heard evidence that some aspects of the introductory laboratory component of the “Foundations” course (BIOL 2002) may be too prescriptive, like the high school science labs students have already had, and that they do not prepare students as well as they could for the subsequent open, inquiry-based BIOL 2004 lab course, in which many students initially feel lost when they are asked to assume the roles of semi-independent researchers with minimal guidance. Some “uncooking” of the BIOL 2002 lab course to help bridge this gap would be desirable. Also in the area of laboratory courses, it would be desirable to reinstate the recently discontinued upper division genetics lab.

To help address the acute national need for more qualified K-12 teachers, it would be desirable to negotiate with the School of Education a streamlined program that would allow CBS students interested in teaching careers to graduate with both a biology degree and a teaching credential, preferably in four years. We realize that in Minnesota, where there is apparently a surplus of life sciences teachers, this recommendation may be more important for CSE students than those in CBS. However, it seems likely that more active counseling of the many students who enter as premeds, but discover by sophomore year that they are unlikely to have the grades needed for medical school entry, could encourage these science-able students to prepare themselves well for a variety of careers within four years, including meeting real science teaching needs in middle or high school.

Although our focus was on the undergraduate program in CBS, the Committee noted that there was no pedagogy course on the teaching and learning of biology offered to graduate students, many of whom will end up in careers that include classroom teaching. We believe that “the best biology program in the country” should offer such a course.

Finally, we suggest that the CBS faculty consider reformulating the various majors curricula as sets of specific learning objectives, corresponding to the syllabi of required core courses, and develop assessments that can be used to gauge how well these objectives are being met (for successful examples of such a process, see the Wieman et al. article referenced below). Within each course, these assessments could be administered as pre- and post-tests to measure student learning gains. At the department level, such an assessment could be given as an exit exam at graduation to gauge knowledge gained in the course of the major. The process of formulating learning objectives would highlight for remediation the redundancies mentioned above, and would perhaps also identify gaps that should be filled in the curriculum. The accompanying assessments could provide at least semi-quantitative measures of success in educating students that departments, as their programs go forward, could strive to improve on -- as they should in the country’s best undergraduate biology program!



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Reference: Wieman, C., et al. (2010) Transformation of Science Education at Large Research Universities: a Case Study in Progress. *Change*, Mar.-Apr. issue. (www.changemag.org)