

Biochemistry and Molecular Biology Strategic Planning Phase III, Part 1

BMB within the discipline of biochemistry, CNS and UMass

As of January 2015, the Department of Biochemistry and Molecular Biology (BMB) will have 23 faculty members, of which 14 are tenure system (TT), comprised of 2 Distinguished Professors, 7 Professors (5 of whom are elected Fellows to disciplinary societies), 2 Associate Professors, and 3 Assistant Professors who were reappointed through their Tenure Decision Year this past academic year. Of the 14 TT faculty members, 43% are women and 36% are minority (four are Asian and one is Hispanic). BMB has three Research Professors and six non-TT faculty members comprised of one Clinical Professor and Director of the Institute of Applied Life Sciences (IALS), one senior lecturer, two lecturers (one PEF-funded), and two Extension Associate Professors; one is the director of the Core Mass Spectrometry Facility and the other is an IALS-related hire who will liaise with the UMassMed Small Molecule Screening Facility.

BMB faculty are highly research active, with over \$3M in research expenditures in FY 2014 obtained from federal funding agencies to support approximately sixty grant-funded postdocs, graduate students, undergraduate research assistants, research technicians and administrative assistants in BMB faculty research programs. All BMB faculty members are engaged in publication of peer reviewed journal articles (the standard in our discipline) or nationally disseminated textbooks and teaching resources, with national and international visibility through their participation in conferences, editorial boards and grant review panels.

Academic Analytics data from Fall 2012 (release date 4/21/14) indicates that BMB compares very favorably to peer institutions within a field of 206 departments of Biochemistry and Molecular Biology and among 25 public, very high research institutions. Most do not have a medical school, with the exception of University of Connecticut, Pennsylvania State and Stony Brook University. In faculty numbers BMB is 80% of the field median of 24 (as of 2012), while BMB awards per faculty are 5 times the field median, BMB faculty with grants are 1.7 times the field median, grants per BMB faculty are 1.8 times the field median, grant dollars per BMB faculty are 2.2 times the field median and citations per BMB faculty are 1.7 times the field median. Articles per faculty and BMB faculty with articles are on par with the field median. Overall, by quantitative measures of productivity, BMB faculty members demonstrate excellent productivity within a crowded field. BMB does not have an independent PhD program, having co-founded the MCB graduate program with Biology over 25 years ago. The four interdisciplinary life science graduate programs within CNS are undergoing a review this academic year. It is worth noting that individual life science departments within CNS, including BMB, have generally compared more favorably to peer, discipline/department-specific PhD granting programs than has MCB in comparison with other MCB programs/departments. With 14 TT faculty and 6 senior faculty members either slated to retire within 3-5 years (4 of them) or having retired since 5/2014 (2 of them), BMB has carefully considered how best to renew our faculty numbers in order to continue our trajectory of highly visible research activity at the forefront of our discipline.

The research programs of BMB faculty focus on cellular biochemistry including protein trafficking and folding, protein degradation, structure/function of proteins, particularly membrane proteins, organelle biogenesis, gene expression and regulation, signal transduction, and host-microbe interactions. BMB faculty research programs are internally complimentary and externally synergistic. As such, BMB faculty members actively collaborate extensively within the department and with faculty in CNS departments (currently Chemistry, Veterinary and Animal Sciences, Stockbridge School of Agriculture) and the College of Engineering (Chemical Engineering, Electrical and Computer Engineering). With the fortuitous recent hire of an Extension Associate Professor who is a medicinal chemist, departmental and campus connections to UMassMed will be enhanced in the near future.

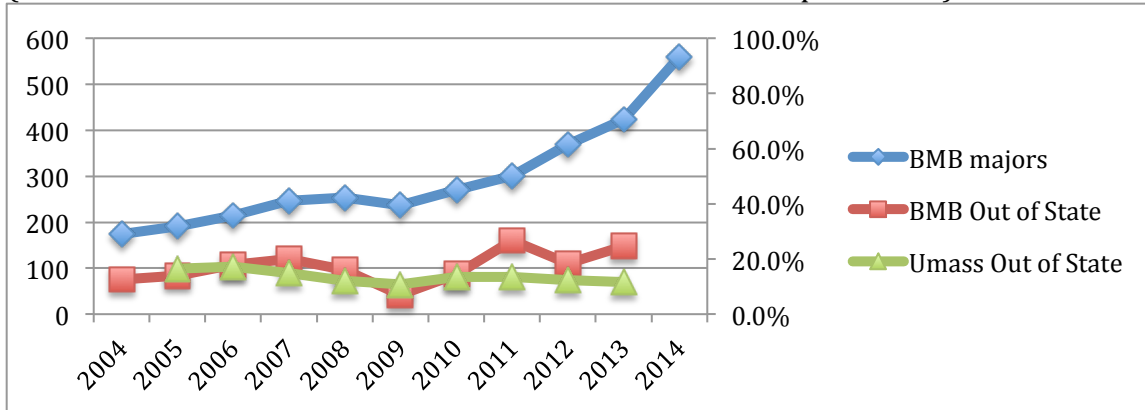
Because of the interdisciplinary nature of biochemistry and molecular biology and the highly collaborative culture of the department, the cluster model for TT-faculty hiring and population of the LSL has enhanced the research programs within BMB. BMB faculty members represent a very active core of the IALS Models 2 Medicine (M2M) Center and provide strength and a critical mass to research with plant systems, including providing leadership on a new initiative in translational plant biology research with enormous potential applications in human health, food security and sustainable sources of fuel and “green” biotechnology. We intend for future TT faculty hires to compliment and enhance campus research initiatives such as translational research and neuroscience. With these goals in mind, BMB aims to build upon the departmental and campus strength in structural biology, computational biology and synthetic biology.

The availability of state of the art instrumentation for experimental life science research has never been better on this campus. The recent \$95M investment into translational life science research positions BMB and life science departments on this campus to be very attractive to new hires with regard to availability of state of the art instrumentation. BMB currently has assigned, good quality laboratory space available on the 11th and 12th floors of the Lederle Graduate Research Tower (LGRT), which is in very close proximity to structural biologists in both BMB and the chemistry department (12th, 7th and 8th floors respectively). An x-ray diffractometer and NMR facilities are both in the basement of LGRT and a biophysical characterization core facility in the Life Science Laboratories (LSL) can be reasonably accessed once fit out is complete. The availability of the Mass Green High Performance Computing Center (MGHPCC) is another attractive resource that will facilitate campus efforts to hire in the area of computational biology. Synthetic biology is emerging field that is essentially molecular biology approached from an engineering perspective. As such, this area of research is relevant to BMB because of our inherent focus on the discipline of molecular biology and in keeping with our current collaborations with colleagues in engineering, our participation in the campus Institute for Cellular Engineering and campus initiatives in translational research. Two very recent senior faculty retirees and four of the faculty members who are likely to retire within the next three to five years did or do not currently have “wet” labs, and even hires in the area of computational biology may need some laboratory space, so renovations to space in LGRT will be paramount to attracting the best faculty candidates in the near term.

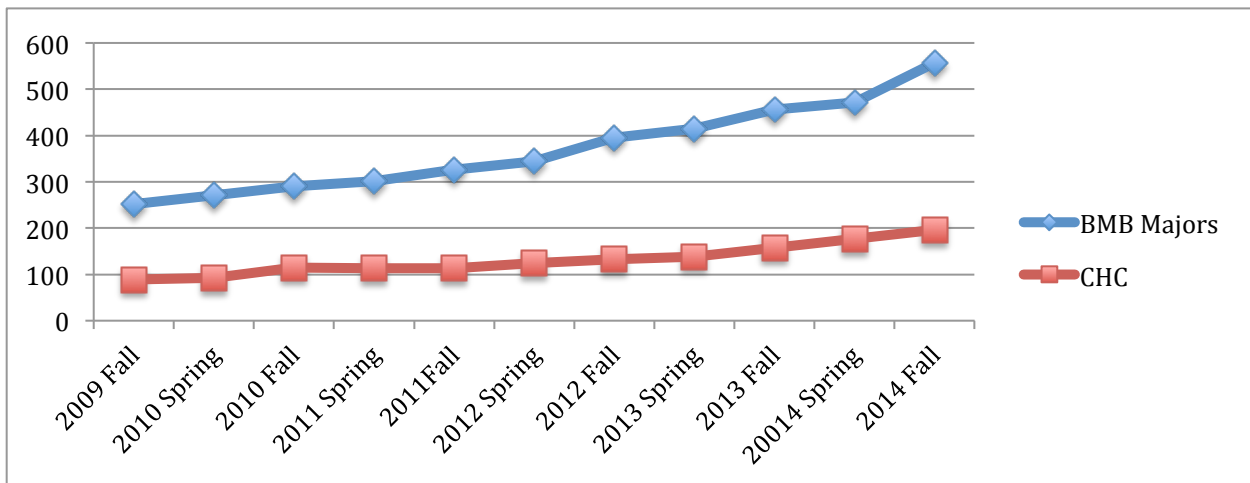
Destination of Choice: Undergraduate Education “They just keep coming”

Program Attractiveness and Competitiveness. *To what extent and in what ways does your department contribute to the “destination” goal, and to the campus’s overall attractiveness vis-à-vis competitor institutions?*

While we participate in open house events for prospective undergraduate students and accommodate visiting families with tours of our lab facilities and meetings with advising staff, BMB does not have any input into admissions decisions and we don’t actively recruit students to campus. CNS enrollments have been on the rise and BMB is no exception. The number of BMB majors has doubled in the past five years, and the number of BMB majors who are from out of state is slightly higher than for the campus as a whole (see below), no doubt because biochemistry is viewed as a major that will prepare graduates well for medical school, graduate school or jobs in the biotech industry. Senior exit surveys for the past ten years indicate that on average, 45% of our majors go on to graduate programs (more than 1 standard deviation above the mean for all departments).



The BMB curriculum is challenging yet leaves time for students to engage in authentic research during the academic year or to take a semester abroad. BMB Commonwealth Honors College students who pursue departmental honors (most of them) conduct senior thesis research. On average over the last five years, about 30% of our majors are CHC members and 24% are involved in independent study research in any given semester. We have a much harder time tracking our majors’ participation in off campus internships since



these activities are often not credit-based, so we only find out about them anecdotally. BMB faculty members are committed to including undergraduates in our research programs and have continued to do so as the numbers of BMB majors have increased. This is a challenge for us—we have approximately 15 faculty members who are available to mentor undergraduates in their laboratories and 550+ undergraduates, so a student to faculty ratio of about 36:1. We are working to either develop authentic research projects that are scalable to groups of students—there are national models for this that we could adopt, and we can develop computational projects that don't require laboratory access. These activities still require resources in the form of laboratory space, instruments and faculty mentorship.

Overall Program Effectiveness. *How well is your department meeting the overall needs and expectations of your majors for a high-quality educational experience?* **Student Engagement.** *The campus plan emphasizes active and engaged learning, and strong advising and teaching relationships demonstrated to promote student success. How well is your department incorporating these goals across its undergraduate experience?*

BMB majors do not have classes with BMB faculty until their second year (the first year is taken up with Intro Bio, Chem, Calculus and Eng Writing/GenEd). We try to build community amongst our majors and BMB faculty within the first year by holding a Meet and Greet ice cream social at the beginning of the fall semester and we assign each BMB major a faculty advisor as soon as they join the major. BMB majors are required to check in with an advisor once per semester (to have a registration hold lifted) and we support the very active RSO, the Biochemistry Club, which draws in BMB majors early on. The first year retention rates and four and six year graduation rates for BMB are on par with percentages campus-wide and in CNS overall. We are not surprised by the 1st year retention rates. We observed quite a bit of coming and going on the part of undergraduates in the first three years. We make a concerted effort to track student performance in required courses and challenge those of our major who seem to be struggling in their first and second year courses to think hard about their future in BMB. We consider student success to include our majors who transfer out of BMB and into a major that is better suited to their interests and aptitudes. Students have quite a bit of latitude in their choice of majors, minors, secondary majors, etc., and we accept students into the major as sophomores and juniors. We work very intentionally with these transfer students to develop a plan for timely graduation. The BMB major is specifically designed to require 14-16 credits per semester to stay on track for graduation in 4 years. Our sense is that the vast majority of our majors are able to complete their degree in four years. Thus the four-year and six-year graduation rates don't make as much sense to us based upon our knowledge of our class cohorts and the number of students who transfer into the major as opposed to leave it.

	1 st Yr Retention	4Yr BMB	4Yr Any	6 yr BMB	6 yr Any
Campus	67%	28%	58%	31%	49%
CNS	65%	28%	55%	32%	45%
BMB	69%	32%	57%	34%	37%

We are preparing to submit an application to our disciplinary society, the American Society of Biochemistry and Molecular Biology (ASBMB) for accreditation. This will require us to be more explicit and deliberate about articulating learning objectives for our courses, which should give our majors a better sense of the skills they have developed within BMB. Through the ASBMB Accreditation application process, we will be able to achieve a greater degree of coherence within the BMB curriculum with the intentional choice of learning outcomes for the major that are reflected in a coherent pathway through the core courses of the major.

Effective Use of Resources. *Promoting quality and effectiveness across all the domains identified above relies on the effective deployment of resources. Given the many competing demands on resources, and especially on faculty time and talent, how effectively do you use your instructional resources?*

While the two BMB faculty members who are no longer active principal investigators contribute substantially to the department's teaching mission, the vast majority of classroom instruction in BMB is delivered by research-active TT faculty. This includes core graduate courses in two interdisciplinary graduate programs as well as courses required by BMB majors and non-majors. Our three lecturers are responsible for four BMB laboratory courses (two required for BMB majors, one for non-majors and one interdisciplinary lab for majors that is co-taught with Chem Eng faculty) that are small enrollment sections with a high number of contact hours. As of 2015 we will have a new PEF-funded lecturer who will focus on the large enrollment non-majors biochemistry course.

Over the past ten years, on average 66% of our undergraduate instructional activity is directed towards non-majors: We offer one GenEd course, Biochem 100 "My DNA" is a popular course, now taught in a TBL format, in which students learn about the impact of the human genome sequencing project to their lives and society at large) and one semester biochemistry lecture and lab courses for non-majors. The 2015 Medical College Admission Test (MCAT) will incorporate more questions that test knowledge of biochemical principles, and medical schools are now recommending/requiring 1 semester (at least) of biochemistry. At the same time, medical schools adopting an integrated curriculum are de-emphasizing biochemistry taught by medical school biochemistry departments. Thus, we anticipate continued interest in our biochemistry courses from non-majors. In Spring of 2015 we will convert two large enrollment biochemistry courses (for majors, > 170 and non-majors > 200) to a team based learning format in order to develop teamwork skills for our students, to create a more student active learning environment and to create a smaller class feel to these large enrollment upper level courses.

In BMB, 80% of undergraduate instruction and 100% of graduate instruction is provided by TT faculty. Unfortunately, the majority of BIOCHEM courses taught by TT faculty have enrollments > 100. Our smallest class sections are sophomore level introductory biochemistry lab course (48 students per section) and the two-course junior year writing series (1 seminar style course and 1 lab course) each with 25 or 48 student sections. We have been transitioning our courses to blended, flipped, TBL formats over the past several

years and are offering sections of large enrollment courses each semester instead of only one semester. Instructional support levels have remained the same while our enrollments have increased. This creates a challenge for faculty—to provide high quality instruction to a growing number of students while maintaining productivity in their research programs. Where appropriate, namely in lower division or non-majors courses, we have utilized carefully vetted BMB undergraduate teaching assistants for lab courses and some lecture courses, and we would like to participate with the Center for Integration of Research Teaching and Learning and the Center for Teaching and Faculty Development to develop training for undergraduate TAs, graduate students and interested postdocs that includes best practices and professional development opportunities. We are participating in the Education Advisory Board Student Success Collaborative to track student progress within our major and are considering developing a continuation policy based upon performance in first year courses as well as a mechanism to intervene with students who struggle in our major well in advance of the “three-peat” rule serving as a de facto continuation policy.

Diversity, inclusion and access. *How well does your department do in attracting the interest of students in under-represented groups and sustaining it all the way to graduation?*

As of this semester, 87 of our 522 BMB majors (16.7%) are students in under-represented minority (URM) groups, which accounts for the 3rd highest percentage (11%) of URM students in the 26 programs in CNS (including pre-professional interest, majors and tracks). Roughly one third of BMB majors are 1st generation or low income. We do not have retention and time to degree data specific to BMB URM, low income or first generation college students.

Opportunities for Strategic Investment:

Student and faculty diversity and success are intertwined and not mutually exclusive. A diverse, interdisciplinary and highly research active faculty are in the best position to foster the success of a diverse student population. Continued faculty hires in the areas of structural, computational and synthetic biology will keep the department on a trajectory of research productivity that not only benefits the Commonwealth and beyond with regard to translational outcomes, but will allow us to prepare the next generation of scientists, policy makers, teachers and entrepreneurs in biochemistry. Critical to the success of our majors is a sense of community and connection with faculty and advising staff. A physical space for the BMB community to gather for socializing, advising, scientific interactions (seminars, poster sessions, project meetings) and professional development (career networking and recruiting) would go a long way to fostering this sense of community. We have literally outgrown all of the gathering spaces that are currently available to us. Renovation of space in LGRT for a departmental home along with lab space for new hires is a priority.

Our ability to provide hands on opportunities in experimental biochemistry is limited by space and instructional resources. We have excellent teaching laboratory space, but currently no means to recoup the costs of reagents and supplies, or equipment maintenance, repair, replacement or upgrading and instructional support. If we were able to develop open source or very inexpensive texts for our courses, we would be in a position

to charge lab fees without adding to the cost of undergraduate education. Two large scale projects worth pursuing are the development of open access (or nominal fee) textbooks for a) first year life sciences curriculum and b) the BMB curriculum for majors—from sophomore through graduate level courses (integrated with classroom and laboratory instruction). This would allow CNS/BMB to justify lab fees (instead of paying \$200 for a text book and no lab fees, students pay \$20 for open access and \$180 in lab fees...).

Resource considerations: substantial (faculty release time, summer stipends, support to CESD for infrastructure and development). One step toward the goal of lowering the cost of education for our majors might be to reduce the number of different textbooks that we require within the BMB curriculum. One way that this might be accomplished could be to select jointly a reference text in biochemistry and molecular biology that could be used for multiple courses, with each instructor filling in any gaps with material that could be posted on the class site.

Staff support is critical to student and faculty success. As we move to a more decentralized budgeting system and federal and state support of research remains at a low ebb, we need to be able to think strategically about staff support for faculty and students and hire accordingly, including being able to hire at a level and pay rate that attracts and retains talented individuals.

Recommendations for improving the undergraduate experience in BMB/CNS

Senior exit surveys for the past five years indicate many students are positive to enthusiastic about their experience as BMB majors; however, these surveys also reveal areas for improvement. The following suggestions were the most frequent of the negative responses:

- More advanced electives
- Better teaching
- More research opportunities
- More career advice/better advising

Additional external considerations impacting BMB strategic planning on the undergrad experience include

American Society of Biochemistry and Molecular Biology Accreditation Standards (new program as of 2013)

Medical School (and other allied health professional programs) requirement for 1 semester of biochemistry (Vet Schools prefer two semesters)

More Advanced Electives

- 1) Expand Biochem/Chem 657 “Drug Design” to include undergraduate BMB/Chem majors who have completed Biochem 523 or Chem 423. This course has some background lectures, discussion of primary literature associated with drug design, multiple writing assignments and numerous guest speakers from pharma, often a field trip to a biotech company is arranged.

Resource considerations: this course has no TA assigned to help with the writing assignments, so increasing enrollments will impact the instructor's ability to provide timely and substantive feedback on writing assignments.

- 2) New course: 300-level "Quantitative Biology" (there is interest from BMB faculty in developing such a course)

Resource considerations: all required courses for BMB majors (except jnr yr writing and two required lab courses have enrollments of over 100). A top priority is to make these courses smaller and more student-active.

- 3) New course sequence: A collaboration with iCons to develop iCons 3 and 4 (for the biomedical track) in which students in iCons 3 adapt/develop a cell-based assay for high throughput screening of natural products, small molecules, plant cell culture extracts, work through separations, lead compound identification/optimization, scale up, in iCons 4 students work through tech to market/entrepreneurship

Resource considerations: large number of contact hours—need part time lecturer to develop iCons 3 and 4—potential for this to be a teaching postdoc (along the lines of the Darwin Fellow) with possible sponsorship from industry partner, new instrumentation, need partnership with ISOM Entrepreneurship Center for iCons 4

Better Teaching

Smaller classes are better received by our majors

BMB majors take three small enrollment courses taught by BMB faculty 1) Biochem 276, a sophomore level introductory biochemistry laboratory, 2) Biochem 526, a junior-level laboratory course, and 3) Biochem 491H, the second part of our Junior Year Writing requirement. These small enrollment courses (25-48) are generally well received.

Biochem 276 has substantial writing assignments. We have assessed the out-of-class workload for this course and have submitted a proposal to increase this course from 2 to 3 credits.

Biochem 526 contains part I of the Junior Year Writing requirement. In recent years this course has not been available to juniors—because of increasing enrollments we have been giving priority to seniors so that they can graduate on time (4 years!). Spring of 2015 we will offer an additional section in order to allow juniors to start taking this course again.

Part two of the Junior Year Writing course is covered in Biochem 491H, which again is restricted to seniors.

Large enrollment upper division courses are less well received by our majors

The five required lecture courses taught by BMB faculty (Biochem 275, 394RI, 471, 523 and 524) have enrollments ranging from one section of 80 to 99-230 per section. Student responses to instruction of these courses is more variable than for the three lower enrollment courses listed above. We have discussed including more and earlier exposure to the primary research literature in BMB courses but are struggling with scale. The IE course (394RI, for juniors) includes a section on reading journal articles. The two required

laboratory courses (48 students per section) incorporate writing in the style of a journal article, but do not incorporate much reading/discussing of the primary literature. Biochem 491H requires reading primary literature, but this part of the course is usually taken by seniors.

Biochem 471 is now a TBL course, one 80 student section of Biochem 275 is flipped with a central theme of genes associated with muscular dystrophy (including references to the primary literature) and we are considering how to scale the group work in this section to the 230 student section, Biochem 523 is undergoing conversion to a TBL format (by fall 2015), which could include reading of the primary literature, and Biochem 524 will be revised (possibly flipped) for spring of 2016. Thus, by Spring of 2016 all of the courses taught by BMB faculty that are required for our majors should be either small enrollment or larger enrollment but employing team based and or student active methods.

Resource considerations: TBL and flipped courses are time-intensive for faculty to develop, teach, and provide meaningful assessment for. Instructional support is critical for these types of courses. These courses also provide excellent opportunities for senior undergrads, graduate students and postdocs to co-teach with faculty instructors. BMB is interested in developing a course or credit module for teaching assistants that covers best practices and includes mentorship around teaching. While TBL and flipped courses go a long way to developing teamwork skills and provide opportunities for student engagement, it remains the case that very few BMB courses have small enrollments. We are also running out of days of the week and hours of the day to provide timely access to the two required lab courses (we also offer a biochemistry lab for non-majors and an advanced bioprocessing lab with Chem Eng, which is mostly taken by Chem Eng majors). Per student costs for reagents and supplies for these four lab courses range from \$50-\$150 per student.

More research opportunities

- 1) We intend to develop a BMB CHC Capstone Experience: "Independent Study in Structure-Based Drug Design." BMB does not currently have an honors capstone course (BMB majors in CHC complete a senior thesis to qualify for Departmental Honors). The recent addition to our faculty of an expert in high throughput screening and structure-based drug design, we plan to develop a computer based independent study project using the Schrodinger software suite for structure based drug design to increase opportunities for authentic research experiences for undergrads that don't require a "wet" lab. Resource considerations: a single license for Shrodinger software is \$7500 per year. Grad students, postdocs and PIs would be interested in training on this software for research purposes; currently no model exists in life science programs for course or training fees involving software licenses or graduate level training/courses.
- 2) CNS: 1st yr life science curriculum must include authentic research. This is being done nationally and was the subject of the HHMI proposal submitted Oct 2013. Chemistry, Physics and Biology labs for life science majors could be re-organized to allow authentic research.

Resource considerations: need new instrumentation for intro labs (1400 students per year for each of the three departments)

More Career Advice/Better Advising

1) Career Advice: BMB has included career panels in our Integrative Experience course for the past two years and students are also required to develop a personal statement. BMB provides substantial support to the BMB Club (faculty sponsorship and financial support) in their organization of career networking events. We have yet to formalize career prep/networking in our curriculum but may do this in conjunction with pursuing ASBMB accreditation.

2) Better Advising: BMB faculty serve as advisors for a portion of a class year for all four years of the BMB curriculum, and we place an advising hold on our majors each semester to insure that they meet with their advisor. With increasing interest in the major, we have gone from two faculty advisors per class year (20 advisees) to four advisors per class year with 30-50 advisees. This is creating a significant bottleneck for faculty advisors in the two weeks prior to registration each semester, and the quality of the advising relationship is in jeopardy. We are re-organizing our staff, peer advisors, and Chief Undergraduate Advisor (CUA) positions to ensure that our majors get accurate advising and meaningful one-on-one mentoring from faculty advisors.

Resource considerations: While we are participating in the EAB Student Success collaboration, it remains to be seen as to whether this software will be useful in monitoring our students' progress. Initial queries reported out students with GPAs of 3.97 who were categorized as "moderate risk". We will work with the EAB folks to iron out these sorts of glitches; however, we may resort to outsourcing (through CESD) the creation of a custom Drupal-based database with SPIRE feeds in order to get accurate and timely information about our majors' academic progress. SPIRE queries are inadequate for this purpose, and exporting data from SPIRE into our in-house ACCESS database is cumbersome and time-intensive.

3) Currently beyond departmental control, but definitely worth college level advocacy, is the disconnect between undergraduate advising and course scheduling with regard to SPIRE capabilities. Course scheduling as a process is not collaborative between the Registrar and departments (Scheduling Reps), and inadequate software (SPIRE) and lack of opportunities for meaningful input from SchedReps in the course scheduling process is a major bottleneck for departmental productivity and a source of enormous dissatisfaction to undergraduates. Often the undergraduates don't distinguish between the department and the administration, so departments are the targets of student frustration about availability of required classes. Departments are required to propose course sections (number and enrollment capacity) a full year ahead of time, yet we don't have any input into the admissions process and are informed in April of the first year admissions results. This leaves CNS departments scrambling to staff required courses. We need to be more intentional about admissions going forward so that we can provide high quality interactions between faculty and students.

4) Currently only the instructor of record can view course grade rosters during the semester. The CUA and academic advisors don't have the ability to monitor/track student progress or identify at risk students until grades are posted at the end of the semester,

which is often too late. The ability of the departmental CUA and college advising staff to “peer in” to Moodle grade rosters during a given semester could result in meaningful interventions being directed toward at risk students earlier in the semester.

5) Campus TBL space is essentially already filled, and only courses that can bring room occupancy up to near capacity are being allowed into these spaces. It would be great to have a departmental TBL space (or even better, a few CNS-specific TBL spaces) that could be used for BMB/CNS TBL classes.