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MEMORANDUM

DATE: November 20, 2015

TO: Dean Goodwin

FROM: Steven J. Sandler, Department Head

RE: Strategic Planning for Undergraduate Curriculum and Student Experience

Introduction

Microbiology is a diverse field comprising many aspects of multiple disciplines. These include virology, bacteriology, parasitology, infection & immunology, host-microbe interactions, ecology, environmental science, physiology, genetics, evolution, and bioinformatics. While the microbial aspects of these disciplines are often stressed in Microbiology, it is often their relationship to human and animal health, biotechnology, and the environment as well as basic eukaryotic and prokaryotic biology that is the focus of our research. Providing students with the right balance of these is constantly being revisited and re-adjusted.

The Department of Microbiology recognizes the diversity of our students, their different backgrounds, their interests, and their future goals. We want our students to graduate within four years and then be equipped to "hit the ground running" in graduate school, medical school, government positions, or the labor force. We want our students to graduate confident in their Microbiology education and training.

The field of microbiology has grown for the past two decades due to technological improvements and new discoveries. Examples include emerging infectious diseases around the globe (SARS, MERS, Ebola, Bird Flu), new medical treatments (virotherapy), biotechnology (biofuels, industrial precursors), climate change, and the search for life beyond Earth. The visibility of microbiology in society and its value to industry and medicine have risen such that high school students are now noticing microbial science as a field of study at increasing levels. The number of Microbiology majors has risen steadily over the past five years to ~200 with room to grow if the conditions are right. 15% of first-year students choose Microbiology as their major, 35% choose it during their second year, and the remainder either choose it later or are transfer

students from other institutions. The majority of our graduates go into biotechnology, medicine, graduate school, and public policy.

For most of our majors, microbiology is a hands-on laboratory or field experience. Our students getting experience with cutting-edge techniques is paramount for our training. Therefore, laboratory classes are extremely important and are the focus of our action plan described herein. While most of our students are on a "laboratory trajectory", we also recognize that a few students are seeking a different trajectory that will take them into public policy, journalism, and community health. We try to provide these students with some educational options.

Graduate Teaching Assistants (TAs) are highly utilized in our undergraduate lab classes and the importance of their role in teaching cannot be over-emphasized. Hands-on training and the passing of "know how" to undergraduate students cannot be achieved exclusively from lectures or textbooks and requires teachers experienced in microbiology. A major limitation in our teaching curriculum for laboratory classes in general is adequate lab space, laboratory equipment for the students to use, and sufficient numbers of Graduate Teaching Assistants.

Description of Curriculum

The first year at UMass for a Microbiology major is designed to strengthen their knowledge in Biology (BIO 152, 153), Chemistry (CHEM 111, 112) Math (MATH 127,128), and general education. These classes provide the foundation to understand the multi-disciplinary principles of microbiology and are essentially the same as those taken by nearly all other life science majors. As a result, Microbiology is part of the college-wide effort to create a unified two-year life science curriculum.

Second-year students continue their training in Organic Chemistry (CHEM 261, 262) and Organic Chemistry Lab (CHEM 269). Microbiology majors take their first Microbiology classes in the fall of their second year. These classes include an Introduction to Microbiology called MICROBIO 310 (soon to be renamed MICROBIO 285) and an Introduction to Microbiology Lab called MICROBIO 312 (soon to be renamed to MICROBIO 286). MICROBIO 310 is a large class of 170-220 students and is taught every semester. The majority of the students enrolled in it are from other departments. It is a quick-paced overview of microbiology where many Microbiology majors identify their area of specialization. The MICROBIO 312 lab is much smaller (25-30 students) and contains mostly Microbiology majors. Class bottlenecks generally do not form in our curriculum since multiple sections of this class are taught every semester. However, if the numbers of majors continues to grow, we will be limited by space, equipment, and TA's.

Third-year Microbiology majors take required classes in Infectious Disease and Defense (MICROBIO 320), Microbial Genetics (MICROBIO 330), and Physics (PHYS 131, 132). These Microbiology lecture classes each contain 60-80 students. Many Microbiology students also apply to do Independent Study (MICROBIO 396) in the labs of our faculty during this year. Space in faculty labs is limited, but the experience is extremely valuable for our top students as they get more hands-on experience, apply the knowledge that they acquired in classes, and build their resumes. Most faculty have 3-5 undergraduates in their lab. The third year is also a transition period from learning more

classical microbiological techniques (Gram staining, microscopy, plate streaking, bacterial identification) to more molecular-based techniques (PCR, cloning, data analysis). Many students make this transition during their Independent Study in the labs of our faculty. Those who cannot have the option of taking a Molecular Biology Lab course (MICROBIO 385). This is a relatively small class of 18-24 students. Molecular biology and tissue culture techniques are taught, which is extremely important for those students who see their trajectory going into biotechnology. A Biotechnology Certificate is available to students who choose this option. Improving this "molecular transition period" is the main theme of our Action Plan.

In their fourth year, Microbiology majors take Microbial Physiology and Diversity (MICROBIO 480, ~60 students per class), Integrative Experience classes (MICROBIO 494, 26 students per class per semester), and two laboratory classes (limited to 24 students). For these two laboratory classes, our majors choose from Immunology (MICROBIO 542), Pathogenic Bacteriology (MICROBIO 552), Environmental Biotechnology (MICROBIO 562), and Micro 565 Molecular Genetics (MICROBIO 565). Each of these is offered once every four semesters. Students in their third and fourth years can also choose from a variety of electives including Virology (MICROBIO 570), Microbial Ecology and Evolution (MICROBIO 440), and Parasitology (MICROBIO 590S) among others. These classes have less than 30 students. Students at large and Commonwealth Honors College students can also do an Honors thesis or a Capstone project.

Analysis of Curriculum

Our analysis of our curriculum is that there currently are no bottlenecks in the availability of required classes that would cause students to be delayed in graduation. We estimate that >75% of our majors graduate within four years. Those who do not are often held back because they transferred into the major with insufficient background classes or fail classes that must be repeated.

We also carefully examined our website and believe that all of the information needed by students to plan their classes is available and easily accessible. While advising will be the topic of next spring's Strategic Planning, we believe the students are advised often and in a timely manner to be able to plan their schedules to give them the fullest experience possible.

After much discussion, the faculty concluded that there was one area of the curriculum that could be improved at this time. This area is the "molecular biology transition period" mentioned previously. The faculty think that when students reach their fourth year and take the two final required lab classes that the students generally fall into two groups: those who are well prepared and those who are not. The well-prepared students are often those who have conducted Independent Study in a research lab or have taken some mid-level molecular biology lab class like MICROBIO 385. The remainder are generally students who have only taken MICROBIO 312 and opted out of the junior level molecular biology lab class. These latter students are often unprepared to take full advantage of the higher level lab classes. As a result, the instructors of the 500-level lab classes have to take time to cover basic protocols that should have been covered previously. Besides techniques, some students also lack the basic ability to analyze data.

The instructors would rather focus on the special attributes of that area in a thematic way, in applying the techniques, rather than going over them briefly due to time constraints.

The faculty also concluded that we are at the brink of an "enrollment cliff". This is a situation where the number of majors is just exceeding our capacity in the classroom lecture style course and more importantly in our laboratory courses. Our action will also make suggestions to deal with these issues.

Diversity and Internationalization

As stated above, Microbiology is by its very nature interdisciplinary. Thus diversity in our faculty and student populations is very important, is no stranger to us, and as opportunities arise, we strive to increase diversity. Microbiology is international. It makes little difference where the Science is done, as it gets published online in journals that span the globe. We make this new knowledge available to our students. For students that participate in research in our laboratories, we encourage them to go to meetings nationally and internationally to present their work as there is opportunity and funding.

Action Plan –No Additional Resources

We have several ideas on how to improve our curriculum. First, we will re-examine the learning goals of our Molecular Biology Lab course (MICROBIO 385). The lab currently teaches both molecular biology techniques and tissue culture techniques. Both are important and are "value-added" skills when applying for jobs in biotechnology. However, we need to increase the number and depth of skills the students are taught and the time they get to practice them. To solve this problem, we have started a dialog with the Department of Veterinary and Animal Sciences (VASCI) who were thinking of creating a similar lab class. The idea would be to create two third-year lab classes, one in each department, that would be offered in different semesters: one would focus on tissue culture techniques; the other, molecular techniques. Each course would emphasize different aspects of data analysis. Majors in either department would then have the choice of taking one or both courses. These courses would not require additional instructors or TAs. This would provide the students with more relevant lab skills along with the necessary practice and application of those skills before taking more advanced classes that tend to be more about applying skills in certain areas.

Another idea that arose regarding our curriculum is that we could teach two new summer classes. One would be a molecular biology lab, similar to MICROBIO 385, and the other would be a lecture or online class on Introduction to Microbiology (MICROBIO 310). We have designed a syllabus for the lab class (called MICROBIO 490) that is currently under review within the Faculty Senate. Dr. Jeffrey Kane, a Lecturer who teaches our Advanced Molecular Biology (AMB) Master of Science Program during the academic year, is slated to teach the lab class in the summer. The syllabus for MICROBIO 310 is also already established. We would need to further define whether this class would be in the classroom or online and an instructor would have to be identified. These classes are designed to be revenue generating, paying for the instructors themselves, and could be available by the summer of 2017.

In consultation with Heath Hatch, the Director of Program Development in the College of Natural Resources, it became apparent that we could push back our "enrollment cliff" by increasing our use of online resources consisting of pre-recorded lectures. Initially, we could create a series of online lectures by using the automatic recording system available in most lecture halls. In subsequent semesters, we could refine the lectures with other methods recording and editing, adding to the quantity and quality of the resources. Such resources could be used by students during the normal academic year and could be further used for summer session online classes. Giving students the option to take classes in the summer will reduce their stress during the semester and decrease class size during the academic year.

Finally, we discussed that we could do more in career preparation. One way we could improve is to help students who are not doing Independent Study in faculty labs on campus to obtain internships with biotechnology companies. To some degree, this is already being done at college level for life sciences. We would coordinate our efforts with Rick Robar. We would also like to explore using reagents or technologies from biotechnology companies in our laboratory classes. The companies would then have access to our experienced students as interns.

Action Plan – With Additional Resources

Improving the unified molecular biology laboratory skill set of our majors would require all of them to take our molecular biology lab course. However, this introduces a number of problems. If we keep the course as a single class of 24 students and offer it only once a year as it is currently done, then we will have created a graduation bottleneck for our students. To remove this bottleneck with our current number of majors, we would need to make the course available for 24-30 students every semester. This means that we would need an additional instructor, at least one additional TA, and more teaching lab space and lab equipment.