

Academic Business Plan, Biochemistry and Chemical Biology Graduate Program Proposal, 3/16/2020

Overview

The proposed Biochemistry and Chemical Biology (BCCB) graduate program will prepare students for careers at the interface between the chemical and biological sciences. As a highly interdisciplinary program, it will provide opportunities for education in the molecular aspects of life, for example how biomolecules operate, fold, interact, and direct cellular function. Students will integrate cutting edge laboratory research with classroom work to generate new knowledge about biochemical and chemical biology mechanisms and pathways, and the implications of these mechanisms for human disease. Graduates from the program will work as educators and researchers in academia, pharmaceutical and biotech industry, as well as in the public sector. The program will add to the existing BU graduate programs in Chemistry and Biological Sciences, providing a more specialized degree at the interface between these disciplines. It will allow for more focused recruiting of top graduate students with interest in this research area. Research volume at the interface between Chemistry and Biology is growing at Binghamton University. The proposed new BCCB program will fill the current gap in graduate education in the Biochemistry and Chemical Biology fields.

Context

There is strong and currently unmet need for advanced Biochemistry and Chemical Biology degrees. A graduate degree in this interdisciplinary area provides the basis for a wide variety of careers in industry and academia. The need for graduate education in Biochemistry and Chemical Biology at BU has been recognized in the past. The Chemistry Department at Binghamton University, for example, has in their strategic plan called for an expansion in the Biological Chemistry/Biochemistry discipline, which is now recognized by the American Chemical Society (ACS) as the fifth sub-discipline of Chemistry. This includes cluster hiring by the Chemistry department of faculty members with Biochemistry and Chemical Biology research interests. The Chemistry Department has long offered a Biological Chemistry track for Ph.D. students, with specialized cumulative exams. The proposed degree will formalize this program and thereby enhance visibility and recruitment of top tier graduate applicants who seek training in this emerging area of research.

The life sciences field in general continues to be a strong contributor to the US economy (<http://www.us.jll.com/united-states/en-us/Research/JLL-US-Life-Sciences-Outlook-2017.pdf?e89ae5d2-1063-4ad2-b303-bac0a93f4f1f>). Wages for R&D employees in the life sciences have grown by more than 50% over the past decade, in the background of relatively stagnant wages in the overall US economy. These statistics indicate strong demand in the industry for a qualified workforce, most of them at the Masters and Ph.D. level. In the Northeast, NY City (number 2), Westchester county (number 6), and the Long Island area (number 8) are among the top 10 of areas nationwide, in which new life science clusters were developed with over 2 million square feet of lab space in the NY City area alone. Since many of our undergraduate students are from these areas, advanced degrees, as offered in this proposal, may be very attractive for them to stay at Binghamton University for combined or accelerated programs. The proposed graduate degrees in Biochemistry and Chemical Biology will serve these needs not only in the state, but nationwide.

STEM occupations continue to grow at an above average rate, with a growth rate of 10.5% in 2015. (<https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/home.htm>). 24,690 of these new positions were in the life sciences. The projected growth rate for life scientists is 6.7% for 2014-2024 for projected job openings of 116,000. It is expected

that this above average growth will continue to provide opportunities for graduates with life science degrees, especially at the Master and Ph.D. level.

The proposed BCCB program will be administered under the umbrella of the Chemistry Department in close collaboration with other departments on the BU campus, most importantly Biological Sciences. It is expected to continue existing, or increase future participation of a diverse population of faculty and graduate students in these departments. The Chemistry Department already offers a Biological Chemistry track for graduate students, however, these students graduate with a Chemistry degree. The proposed BCCB program will expand on this Biological Chemistry track, offering a more specialized and applicable degree, while utilizing infrastructure that already exists and is used for the Biological Chemistry Track. For example, the courses that are required for the new program are already in place, and are listed in the application for the new degree program. In addition, Chemistry and Biological Sciences Departments have a combined number of 17 faculty members who will contribute to the BCCB program. These faculty members perform research at the interface between the chemical and biological sciences and are particularly-well qualified to train students in the Biochemistry field. 12 of these laboratories are currently funded by the NIH and/or NSF, providing excellent research opportunities for BCCB graduate students.

Diversity

In terms of diversity of the faculty body, the program will be striving to maintain or increase future participation of a diverse population of faculty in the Biological Sciences and Chemistry departments. For example, the faculty body in the Chemistry Department consists of members from eight different nationalities, both male and female, and of three different ethnicities. While female faculty members represent only 22.3% of the faculty body, strides are being made to address this gender imbalance. Three of the four female faculty members in the Chemistry Department were hired within the last five years, all of them will contribute to the proposed program. The Biological Sciences Department is also highly diverse. Out of the total of 29 faculty members 42% are female, from four countries and three ethnicities.

The existing graduate student body in both Chemistry and Biological Sciences graduate programs is also highly diverse, with traditionally about 45-55% of students being international. The domestic student pool includes minority students, both African American and Hispanic, several of whom are supported by the Clifford D. Clark diversity fellowship for graduate students. It is planned that the new Biochemistry and Chemical Biology graduate program will continue this tradition of both Chemistry and Biology programs of inclusion of a diverse set of students and faculty members.

Of special note is the Wandiga-Hull fellowship program, which was established between the Chemistry Departments of Binghamton University and the University of Nairobi in Kenya, Africa. Through this fellowship, our existing graduate program is committed to accept at least one of the top three Chemistry graduates from the University of Nairobi into the program each year. Currently, the program has nine students from Kenya, including five Wandiga-Hull fellows. The proposed Biochemistry and Chemical Biology graduate program plans to draw students from this Kenyan pool of applicants, having established direct contacts through former students (now faculty members) with the University of Nairobi, Kenyatta University, and Dedan Kimathi University of Technology.

Benefits

In August of 2017, Binghamton University released the latest strategic plan, "The Roadmap to Premier" (<https://www.binghamton.edu/president/road-map/>). The roadmap includes four university initiatives (UIs), two of which are centered around the health sciences, *Developing a College of Nursing and Health Sciences*, and creating a *Health Sciences Core Facilities Support combined with the Brain and Body Imaging Center*. Both of those initiatives would directly be impacted by the proposed graduate programs

in Biochemistry and Chemical Biology, which would generate collaborative opportunities with the planned college of health science, as well as provide users to add to the critical mass of students and faculty who benefit from the health sciences core. It is expected that graduate students who are admitted through the proposed Biochemistry and Chemical Biology graduate program, in synergy with the core facilities, will strengthen the research programs of the affiliated faculty, resulting in an increased ability to compete for federal and other funding sources.

Second, the proposed graduate program will directly benefit the existing Trans-disciplinary Area of Excellence (TAE) in Health Science. The Biochemistry and Chemical Biology graduate program will by nature be crossing disciplines, ranging from Biology to the Physical Sciences and Bioengineering, thus creating new opportunities for collaboration in Health Sciences not only within Harpur College, but also with the Watson School of Engineering, and the new Pharmacy School.

Third, a third part of the roadmap focuses on a Data Science Initiative. As research at the interface between biology and chemistry becomes more quantitative, collection and evaluation of large data sets will be more common in the future. In fact, several members of the Chemistry and Biological Sciences Departments, all potential members of the proposed Biochemistry and Chemical Biology program, work on analysis of large data sets for example in genetics, or use computational tools for studying biochemical processes. Availability of computational resources will be increasingly critical in these fields. The Biochemistry and Chemical Biology graduate program would add an additional incentive for the university to expand in the data science field, making investigators more competitive in their ability to tackle large data science projects and increasing likelihood of attaining funding.

Fourth, the proposed program would provide valuable new training opportunities for students interested in the interface of the chemical and biological sciences, an area that is recognized for high potential of training students by the National Institutes of Health (NIH) through several training grants <https://www.nigms.nih.gov/training/instpredoc/pages/predocdesc-chemistry.aspx>.

Cost

The Chemistry and Biological Science departments have existing faculty qualified to run in this proposed program (see faculty table, section 4).

Following to its strategic plan, the Chemistry Department has hired eight faculty members at the interface between Chemistry and Biology over the past 10 years. These faculty members perform research in the area of the proposed program and could accept graduate students from the program into their laboratory. Seven of these faculty members are currently funded by the NIH and/or NSF. They have resources to support independent research by Master's/Ph.D. track students who are expected to enroll in the program. The expertise of these faculty members covers a broad range, from structural biology to nucleic acid chemistry, giving graduate students exposure to a large number of opportunities in Biochemistry and Chemical Biology research. All of these faculty members have published in journals that are relevant to the proposed program. One area of expertise currently missing is imaging/microscopy/fluorescence, as indicated by the external reviewers. This area of expertise will be covered by the new hire proposed for year one of the program, see "*Expenses Table*" below. This new faculty will be also instrumental in teaching the two new proposed graduate courses, Advanced Biochemistry and Techniques in Biochemistry.

Other expertise that is not covered by faculty members in the Chemistry Department can be supplemented by potential affiliated members of the program from other departments. The Biological Sciences Department has strengths in environmental genetics (EvoS program), microbial communities (biofilm group), mitochondrial genetics, and diabetes research, as potential contributors to the proposed graduate program. In addition, contributions from other schools at BU are expected (School of Pharmacy, Watson

School of Engineering).

The Biochemistry and Chemical Biology program will share existing resources with the existing Chemistry and Biological Sciences graduate programs. For example, students who are currently on the Biological Chemistry track in the Chemistry program are expected to enter BU in the future through the new Biochemistry and Chemical Biology program. Thus, TA lines that are currently utilized for the Chemistry graduate students on the Biological Chemistry track can be utilized to fund graduate students in the new program. Therefore, no resources for new TA lines are requested.

Both, Chemistry and Biological Sciences Departments had recent success in attracting federal funding. 12 out of the 17 faculty members are currently funded by the NIH and/or NSF. Therefore, it is expected that a substantial number of students in the Biochemistry and Chemical Biology program will be funded by external grants on research assistantships.

Administrative support for the Chemistry graduate program is currently provided by three administrative assistants. At the start of the new program, it is planned to utilize the administrative structure of the Chemistry Department for administrative support. Specifically, Anne Hull (Instructional Support Specialist in Chemistry) will provide the necessary administrative support for the program. While no new resources for an Administrative Assistant are requested at this time, it is possible that a part-time Administrative Assistant may be required in the future, depending on the rate of growth of the program.

Operating Plan

We project that the new graduate program will begin in the Fall of 2020. The target for admissions in the first year is 2-3 Ph.D. track students and 4-5 Masters students. At a constant admissions rate, we expect to have 18-27 students in the program at year five, about half of those will be on the Ph.D. track. Traditionally, many of the domestic students in the existing chemistry graduate program are in state. We expect this trend to continue in the admissions to the new program. 40% of the incoming students are expected to be international.

These numbers are based on our experience with current chemistry graduate students, who specialize in the existing biological chemistry track of the program. It is expected that most of these biological chemistry track students (who graduate with a degree in chemistry) will enter through the proposed Biochemistry and Chemical Biology program in the future. If enrollments are not achieved, the program will grow more slowly than predicted. This is not a problem because faculty members with research in Biochemistry and Chemical Biology can still recruit research students through the existing biology and chemistry graduate programs, as is current practice.

Year	Anticipated Headcount Enrollment			Estimated FTE
	Full-time	Part-time	Total	
1	6	0	6	6
2	12	0	12	12
3	18	0	18	18
4	22	0	22	22
5	24	0	24	24

The program will be administered by a Program Director, who will oversee day to day operations of the program in cooperation with a graduate program committee (GPC). It is planned that the GPC duties are initially integrated with the Chemistry GPC, however, as the number of students increases, a separate

GPC may be established for the new program. The GPC will oversee issues such as student's progress to degree, approval of credit from outside graduate courses, graduate students awards etc.

Admissions will be handled through the Slate admissions system of the graduate school, to which prospective students submit their application materials. Required application materials consist of the application form, transcripts, GRE scores, English language credentials, three letters of recommendation, a personal statement and a resume. While the GPA cutoff is 3.0, consistent with graduate school regulations, we expect the average applicant to have a GPA of 3.4-3.5, based on our experience with applications to the current biological chemistry track. The quantitative GRE scores may be of particular importance, with accepted students in the 50% and above range. For international applicants, we expect documentation of TOEFL (>90) or IELTS scores (> band seven).

The proposed program will be under the umbrella of the Chemistry department. Therefore, admissions will be initially administered by the existing Graduate Admissions Committee (GAC) of the Chemistry graduate program. Because the interdepartmental nature of the program, with faculty members contributing from other departments, the GAC will collaborate closely with admissions committees from other departments, most importantly Biological Sciences. The GAC will review applications and make admissions decisions in communication with department chairs, as well as with consideration of the funding situation with respect to anticipated numbers of RA and TA lines. The committee will also uphold admission standards and strive for diversity in the pool of admitted students. Recruiting will be achieved in collaboration with the Chemistry graduate program, which has a recruiting committee. Activities include recruiting tables at conferences, sending current students to their Alma Maters to give presentations, the visiting speakers program with four-year colleges, and an undergraduate colloquium. The program will also coordinate with efforts of the graduate school to recruiting, including recruitment fairs dedicated to minority applicants, visiting colleges where minority students attend in large numbers, and my advertising the affordability of the Binghamton area in terms of cost of living.

The program will be assessed on an annual basis, the first assessment being three years after the start of the program, which is planned for Fall 2019. The Chemistry Department has developed a detailed assessment plan for the Chemistry graduate program. The assessment plan for the new program will be built on this existing plan, with modifications targeted toward the new program. The program director will be responsible for generating the assessment reports. The reports will be based on data collection through a variety of data mining pathways, including results from coursework, exams, research, and output from scholarship. The assessment report will be based on the major program goals, as described in section 2.3:

- 1) Broad Knowledge
- 2) In-Depth Knowledge in Focused Area
- 3) Original Research Project
- 4) Professional Skills

The SLOs derived from these goals, which will be assessed in the report, are also described in detail in section 2.3, so they will not be repeated here.

The following tools will be used to generate data for assessment:

- Performance in core 4-credit courses (6 for Ph.D. and M.A., 4 for M.S.)
- Performance in placement exams
- Results from literature review exam.
- Results from preliminary oral examinations in several categories.
- Performance in the graduate seminar class
- Results from research proposal
- Number of publications/presentations
- Thesis defense
- Teaching assistant evaluations

- Safety exams upon joining the program and at the beginning of each semester
Action plans will be generated if the results from the assessment report do not meet expectations.

The course offerings for the Biochemistry and Chemical Biology graduate program are listed below. Students will have a choice to take four 4-credit courses from the list below. Courses 5 and 6, filling the 24 credit full course requirements, are two capstone courses, Advanced Biochemistry and Techniques in Biochemistry and Chemical Biology. These are new courses. These courses should align with the research direction the student chooses, and are usually recommended and approved by the graduate program chair and/or the research adviser. Only four courses are requirements. These courses are the Advance Biochemistry course (course number TBD), Techniques in Biochemistry and Chemical Biology (course number TBD), the Colloquium (CHEM 593), which has to be taken for two semesters with one credit each, and the Graduate Seminar (CHEM 592) for two credits, usually taken in the spring semester of the first year. The courses do not have pre-requisites. However, weak students, as identified by placement exams, will be required to take remedial courses to make up for deficiencies.

Course Title	Credits	Course Title	Credits
BIOL 502, BIOCHEMISTRY: METABOLIC ASPECTS	4	BIOL 521, IMMUNOLOGY	4
CHEM 534, BIO-ORGANIC CHEMISTRY	4	CHEM 583D, CHEMISTRY IN DRUG DISCOVERY	4
BCHM 507, ADVANCED BIOCHEMISTRY, <u>REQUIRED</u>,	4	BIOL 558, BIOSTATISTICS	4
BCHM 508, METHODS IN BIOCHEM. CHEM. BIOL., <u>REQUIRED</u>, NUMBERING TBD	4	BIOL 523, CANCER BIOLOGY	4
CHEM 583L, CHEMICAL BIOLOGY	4	CHEM 585C, COMPUTATIONAL CHEMISTRY	4
CHEM 583M, ENZYMES: STRUCTURE AND MECHANISM	4	CHEM 543, MOLECULAR PHOTOCHEMISTRY	4
CHEM 583P, PROTEIN BIOCHEMISTRY	4	CHEM 593, FRONTIERS IN CHEM. AND BIOCHEM., <u>REQUIRED</u>	1
CHEM 583S, FLUORESCENCE	4	CHEM 592, GRADUATE SEMINAR, <u>REQUIRED</u>	2
CHEM 586S, NMR SPECTROSCOPY	4	BIOL 503, MOLECULAR BIOLOGY LABORATORY	4
CHEM 585K, CHEMICAL KINETICS AND THE LIFE	4	BIOL 504, BIOCHEMISTRY LABORATORY	4
BIOL 505, GENOMICS AND PROTEOMICS	4	CHEM 584B, BIO-INORGANIC CHEMISTRY (NEW COURSE)	4
BIOL 501, MOLECULAR GENETICS	4	CHEM 542, PHYSICAL INORGANIC CHEMISTRY	4
BIOL 513, CELL AND MOLECULAR BIOLOGY I	4	CHEM582C, CHEMISTRY AND THE ENVIRONMENT	4
BIOL 514, CELL AND MOLECULAR BIOLOGY II	4		

CHEM532, ORGANIC SYNTHESIS	4		
CHEM583C, MODERN CATALYTIC REACTIONS	4		
Total required credits: 40			
Independent study (research) courses and thesis research, for example CHEM597-699 are not listed here.			

Financial Plan

Expenses (in dollars)
Only new expenses are listed

Program Expense Categories	Before Start	Academic Year 1:	Academic Year 2:	Academic Year 3:	Academic Year 4:	Academic Year 5:	
(a) <i>Personnel (including faculty and all others)</i>	0	80,000	81,600	83,232	84,897	86,595	
(b) <i>Library</i>	0	0	0	0	0	0	
(c) <i>Equipment</i>	0	2,000	2,040	2,081	2,122	2,165	
(d) <i>Laboratories</i>	0	0	0	0	0	0	
(e) <i>Supplies</i>	0	0	0	0	0	0	
(f) <i>Capital Expenses</i>	0	0	0	0	0	0	
(g) <i>Other (Specify): Merit based stipend for MS student</i>	0	0	0	10,000 +11,310 tuition	10,000 +11,310 tuition	10,460 +11,536 tuition	
(g) <i>Other (Specify): Recruiting expenses</i>	6,000	6,000	4,000	3,000	3,060	3,121	
(g) <i>Other (Specify): Seminar series</i>	0	3,000	3,060	3,121	3,184	3,247	
(h) Sum of Rows Above	6,000	91,000	90,700	112,744	114,573	117,124	
Anticipated Revenue							
(a) <i>Master's students* domestic</i>	0	11,310 (1)	23,072 (2)	35,301 (3)	36,006 (3)	49,968 (4)	
(b) <i>Master's students international</i>	0	25,384 (1)	51,782 (2)	52,820 (2)	80,814 (3)	82,428 (3)	
(c) Sum of Rows Above	0	36,694	74,854	88,121	116,820	132,396	

*: All tuition estimates are based on Fall 2019 tuition rates, adjusted annually for 2% inflation. The numbers in the second row reflect anticipated student numbers.

Budget Justification

The values specified in the above table are costs that are incurred in addition to those of the current Chemistry graduate program.

- a) Personnel: If growth of the proposed graduate program proceeds as expected, we anticipate the need for a new faculty hire starting in year 1 of the program. The rationale for the new hire is to offer additional teaching resources for the two new proposed specialized graduate level classes (new

Advanced Biochemistry course, and new Methods in Biochemistry and Chemical Biology), as well as to offer research opportunity to be able to absorb the number of graduate students coming into the program. This will be especially important if the growth in the MS part of the program is higher than expected. The new faculty hire should be in the research area of imaging-/microscopy/fluorescence, as suggested by reviewer 1. Binghamton University currently does not have strength in this research area, despite its growing importance in life science research.

- b) Library: No need for new library resources are anticipated.
- c) Equipment: Equipment for the program is currently available as part of the core facilities in the Smart Energy Building, as well as shared resources in the TAE Health Sciences facility, and the ADL. Specialized equipment will be available in the laboratories of the faculty members who contribute to the program. This equipment is acquired through external funding. Therefore, no funds for acquiring equipment are requested, but a small annual budget (\$2,000) is requested for maintenance of equipment.
- d) Laboratories: Ample laboratory space is currently present in the Smart Energy Building, as well as the Science III Building. The Smart Energy Building has space for expansion to accommodate at least three additional faculty members and their laboratories. Therefore, laboratory space is not needed.
- e) Supplies: Office supplies for administrative purposes will be shared with the Chemistry graduate program.
- f) Capital Expenses: No capital expenses are necessary.
- g) Other: It is expected that the MS track will be a substantial part of the new graduate program, with the Stipend for possible admission of up to 5 MS students per year. In order to attract top students to this track, MS student we request funds for one merit-based "thesis semester" MS stipend, plus tuition. We are planning to use this stipend as a tool to enhance the quality of MS theses, an award to recognize the best students, and as a recruiting tool. This stipend will be merit based and available for one MS student per semester. Each MS student can only receive this stipend for a maximum of one year. Therefore, not all MS students will receive this stipend. The rationale behind this stipend is that it will facilitate acceptance of MS offers by the best students. Second, it will give faculty members incentive to accept MS students into their laboratories. Overall, we anticipate that such a stipend could greatly enhance the MS track of the program, in both quality and quantity.
- g) Other, Recruiting: We request \$6,000 for advertising the new program before its start. In year 2, this budget will be reduced to \$4,000 per year in the second year, and \$3,000 per year in the third year and thereafter. It will be critical for the new program to be able to advertise, in order to quickly build up a substantial applicant pool.
- g) Other, Seminar: A seminar series will be important for students to be informed on the cutting edge research by other Seminar research groups outside of Binghamton University. A budget of \$3,000 is requested for this seminar series, which will be partly integrated with the Chemistry colloquium. However, additional budget will allow invitation of speakers nationwide, which is currently a limitation for the Chemistry colloquium because of budgetary issues.

Design

The proposal of a Biochemistry and Chemical Biology graduate program originates from a long-standing effort at Binghamton University to expand the existing undergraduate Biochemistry program to graduate education. This effort started in 2013 by the establishment of a Biochemistry task force by Provost Nieman, chaired by Dr. Christof Grewer from the Chemistry Department. The program was designed by a group of faculty members from Chemistry, including department chair Dr. Eriks Rozners, in close collaboration with the faculty from the Biological Sciences Department, in particular current chair Dr. Karin Sauer.

Both, Departments of Chemistry and Biological Sciences have continued to expand in numbers of faculty members with research expertise at the interface of the chemical and biological sciences. For example, following its strategic plan, the Chemistry Department has hired eight faculty members at the interface between Chemistry and Biology over the past 10 years. These faculty members perform research in the area of the proposed program and could accept graduate students from the program into their laboratory. Nine of these faculty members are currently funded by the NIH and/or NSF, and one is holding PRF funding (see faculty table, section 4). The Department of Biological Sciences has likewise hired three faculty members at the interface between Chemistry and Biology in the last 7 years. Three Biological Sciences faculty members are currently funded by the NIH/NSF (see faculty table, section 4). They have resources to support independent research by Masters/Ph.D. track students who are expected to enroll in the program. The expertise of these faculty members covers a broad range, from structural biology to nucleic acid chemistry, giving graduate students exposure to a large number of opportunities in Biochemistry and Chemical Biology research. All of these faculty members have published in journals that are relevant to the proposed program.

Expertise that is not covered by faculty members in the Chemistry Department can be supplemented by potential affiliated members of the program from other departments. The Biological Sciences Department has strengths in environmental genetics (EvoS program), microbial communities (biofilm group), mitochondrial genetics, and diabetes research, as potential contributors to the proposed graduate program (see faculty table, section 4). In addition, contributions from other schools at BU are expected (School of Pharmacy, Watson School of Engineering).

The outline of the proposed program received input from many of those faculty members. Details of the program were extensively discussed in the graduate program committee (GPC) and the graduate admissions committee (GAC) of the Chemistry Department (all discussions archived in meeting minutes), as well as the faculty meetings of both, Chemistry and Biological Sciences. All Chemistry and Biological Sciences subcommittees and faculty have voted on the program proposal and have approved it.

Binghamton faculty performing research in the Biochemistry/Chemical Biology area have a strong history of collaboration with external partners, including collaboratively-funded projects. Students in the program will strongly benefit from these collaborations, including those with international partners. Faculty members contributing to the proposal have discussed the planned program with these collaborators, as well as visiting speakers in the Chemistry Department colloquium series. In addition, input was sought from the external reviewers who conducted the last departmental review.