I. Title: Proposal for a Master of Science Program in Biotechnology

II. Goals and Justification of the Proposed Program

We are proposing a Master (M.S.) degree program in Biotechnology based in the Thomas H. Gosnell School of Life Sciences (GSOLS) that currently houses Bachelor of Science (B.S.) programs in Biotechnology and Molecular Bioscience, Biology, Bioinformatics, and Environmental Science in the College of Science at RIT. We envision this new program will exist as a stand-alone, two-year M.S. program with an accelerated "4+1" B.S./M.S. option for existing Biotechnology B.S. students who show unusual promise and interest in graduate work in Biotechnology. Biotechnology is the exploitation of biological processes for medical, industrial and other purposes. The field encompasses many subcategories pertaining to disciplines and subject areas such as; health, industry, agriculture, environmental remediation, green energy, government, academia, law, business, ethics, etc… The goals of an M.S. program in Biotechnology are to: (1) increase the availability of graduates trained to pursue employment in industry, government and academia and/or to continue to pursue graduate work in a Ph.D., MBA, medical or law degree among others, (2) to provide practical training for the enhancement of products, practices, and living systems through biotechnological research and discovery, and (3) to enhance RIT's mission to apply the principles of science through discovery.

Justification of the M.S. Program is evidenced by the national need by employers and Ph.D. programs for graduates with high-level biotechnology skills. Our M.S. graduates will have acquired the skills and expertise to enable them to flourish in the very competitive translational science environment. Biotechnology is a rapidly expanding cutting-edge scientific discipline producing new discoveries and often life-saving products at a rapid pace. The biotechnology industry includes a merger of science and business and demands a multi-disciplinary workforce skilled in basic-research, product development, regulatory affairs and commercialization. The forecasted growth in the biotechnology industry, including biopharmaceuticals, biopesticides, bio-seeds, biofuel and bioenzymes, has been determined to be 10.2 % compound annual growth rate from 2005 to 2016 – future (1).

The application of molecular and cellular biology research to human health sciences dominates the US biotechnology market followed by agricultural and industrial applications. The biotechnology industry in the US is comprised of large multinational corporations, small entrepreneurial firms, various public and private research entities, dedicated biotechnology investment companies, bioinformatics companies and academia. The US biotechnology industry revenues have increased in the recent years to over 75 billion US dollars. A graduate program in Biotechnology will position RIT to continue to be a leader in biotechnology workforce training and enhance scientific discovery. A successful M.S. program will also enhance the research and scholarly activity at RIT given the collaborative nature of the disciplines aligned with the B.S. in Biotechnology and Molecular Bioscience program. This new program will enhance collaboration between RIT, private industry and government through faculty development and collaboration among several RIT units (programs and colleges). The program will launch from and expand upon RIT's longstanding and *signature* B.S. program in Biotechnology and Molecular Bioscience.

III. Description of the new program

The program is expected to be a four-semester (2 academic year) program emphasizing experimental and computational biological research that will cumulate in a written research thesis with oversight from a thesis advisor and a graduate committee comprised of two or three additional faculty members (internal and or external to RIT). Graduation from the program will also require the successful completion of a block of theoretical/practical courses designed to supplement the wet-laboratory aspect of the thesis research. This curriculum and research project work can be accelerated for exceptional internal B.S. students who apply for and are accepted for admission into the M.S. program in their third year of undergraduate study. These students would begin a combination of B.S. and M.S. work in their fourth academic year and complete the programs in their fifth year. This accelerated plan can accommodate a 5 year completion for both the B.S. and M.S. degrees (a 4 + 1 option). An alternative professional M.S. in Biotechnology (non-research thesis option) will be offered and can be completed by the successful completion of only course work. The coursework in the program will include a suite of graduate-level biotechnology courses in the areas of molecular biology, microbiology, tissue culture, and genomics, proteomics and bioinformatics. Advanced, molecular biology graduate courses will include areas of plant biotechnology, microbial and viral genetics, genetic engineering, virology, gene regulation and cancer biology. A wide array of advanced microbiology courses will include the areas of bacterial-host interactions, industrial and commercial microbiology, food microbiology, environmental microbiology, bioremediation, bioenergy production, and microbial genetics. A suite of advanced cell culture courses will include the areas of advanced tissue culture and hybridoma technique, advanced immunology, and synthetic biology. The genomics, proteomics and bioinformatics training will be covered through available courses in advanced proteomics including molecular modeling and algorithm design, graduate bioinformatics training in both analytical and algorithm development, training in next-generation sequencing (NGS) techniques, and analysis of whole-genome and meta-genome (big) data sets.

The Life Science graduate faculty envision a 30 credit hours requirement to include at least 15 hours (5 courses) in graduate-level wet bench training to enhance the experimental skill sets of program students. Formal research project work will account for at least 12 and up to 15 credit hours necessary for the design, implementation, and conclusion of faculty-mentored research projects that culminate in the defense of a final research thesis project. These research projects will be fundamentally experimental (hypothesis driven) and involve the students in the entire process of experimental design, implementation, data analysis, and publication. The thesis option will be carried out under the mentoring of GSOLS biotechnology faculty who will advise and guide ambitious students through the process of acquiring the skills necessary at each of the levels of successful scientific experimentation and dissemination of results.

The process of scientific research is an ideal setting through which students learn the best practices of the scientific method including necessary imaginative critical thinking skills, successful experimental design, proper lab technique and work flow, plus organizational and communication skills through dissemination of their work. A non-thesis or professional option for entering students who are already in the biotechnology workforce will be possible through the substitution of research project credit hours with alternative coursework. This coursework would be designed to develop complementary skills in areas such as business, finance,

marketing, and ethics beneficial for those at a stage in their professional careers for whom movement and promotion within existing corporate organizations is desirable and beneficial.

IV. Fit with RIT Academic Portfolio

The Master (M.S.) degree program in Biotechnology supports the RIT Mission Statement and is aligned with the Strategic Plan of RIT, COS and GSOLS in that it emphasizes hands-on discovery research with respect to innovative technologies and approaches. Our program will: 1) train students, particularly women and AALANA, through dynamic experimental and theoretical research to become STEM graduates and career scientists; 2) train M.S.-level students in original research in Biotechnology in addition to other synergistic fields; and 3) create collaborations with regional, national and international research laboratories in academia, government and industry.

It should be noted that of the STEM disciplines, Life Sciences and Biotechnology in particular have the most successful history of attracting, training and retaining women in science careers. Our current GSOLS faculty is composed of 50% women as are our current enrolled students in Life Science programs including our Biotechnology BS program. There will continue to be a growing importance of STEM scientists in solving complex global challenges with backgrounds in the Life, Health and Environmental Sciences. The critical importance of increasing the number of women participating in these science careers will be assisted by a graduate program in the field of Biotechnology at RIT. We are confident that an MS program in Biotechnology will continue and in fact advance the positive trajectory for more women in science set at RIT by the BS in Biotechnology and other Life Science programs that have been so successful in training young women for advanced science careers.

V. Synergy with Other Programs

The M.S. degree program in Biotechnology will complement the existing graduate programs in the Thomas H. Gosnell School of Life Sciences (Bioinformatics and Environmental Science) by providing students with a third option in pursuing a M.S.-level training. In addition, the program will be aligned and will dovetail into our existing undergraduate programs in biotechnology and molecular biosciences, biology, and bioinformatics. This program is designed to expose students to the breadth of knowledge and training in the scientific and practical aspects of biotechnology that is synergistic with the Biotechnology and Molecular Bioscience Bachelors of Science Program.

VI. Administrative Structure for the New Program

The oversight and facilitation of the M.S. in Science degree program in Biotechnology will be the responsibility of a faculty director who will work in collaboration with the GSOLS School Head and a steering and admission committee comprised of faculty in the GSOLS that are aligned with the M.S. program.

Acceptance into the program should indicate a strong interest in biotechnology and related research as well as student qualification based on academic transcripts, letters of recommendation, interviews and other criteria. The admission committee will screen applicant

submissions and supporting documents to assure that minimum standards are maintained. These standards include but are not limited to; ensuring that the student is qualified to carry out the objectives and goals of the proposed project, qualifications of the student and faculty match to support for mentoring and training of the student.

Tenured and or tenure-track faculty members from the School of Life Sciences will be able to join the program and mentor students enrolled in the M.S. program by submitting their interests and mentoring plan to the M.S. of Science in Biotechnology steering committee. The submission will be reviewed by the committee to make sure the mentoring and training activities proposed are aligned with the program goals and objectives.

VII. Enrollment Management Expectations and Sustainability

RIT Enrollment Services estimate a sustainable steady-state of 8-12 new students per year after an initial first year enrollment of seven new student. We envision at least 5 of these new students each year will be internal admissions that are graduates from our B.S. degree program in Biotechnology and Molecular Bioscience. Exact enrollment each year will be dependent on the availability of suitable MS program advisors for both thesis and non-thesis options.

It should be noted and emphasized that the acceptance of students is highly dependent upon the program budget and number of faculty aligned with the program. As new faculty, including incremental and retirement hires come on board in the Thomas H. Gosnell School of Life Sciences that are aligned with the program, we anticipate that the student acceptance rate could increase beyond the 10 per year estimated in the model

Enrollment Services has also confirmed that though opportunities in the field are growing, the external market for applicants is competitive since other programs exist at several institutions including Northeastern, NYU Polytechnic, SUNY Buffalo, Worcester Polytechnic Institute, and Rensselaer Polytechnic Institute. This reality will require that aggressive marketing and competitive funding models be in place for students including a 30% tuition discount rate.

VIII. Impact on Resources

We anticipate that new courses will be an integral and a necessity to facilitate this program. As such; two new full time equivalent (FTE) faculty tenure-track lines will be necessary to support the program depending on realized enrollment increases. Current enrollment estimates of 8-12 entering students per year require the addition of at least two additional faculty. New faculty will be provided resources of at least $80K ($40K overhead recovery + $40K incremental) for their first 3 years of employment to facilitate the startup of their research program. During this time they must be capable of establishing an extramurally funded research program. They must also teach graduate level courses to support the program in addition to providing mentoring and training opportunities for students in their research and scholarship area of expertise. In addition, we envision that a staff assistant will be necessary to help coordinate and facilitate the Student financial support

Graduate Assistantships (GA), Graduate Teaching Assistantships (GTA) will be made available for students in the thesis-based MS degree program only. The goal of providing M.S. in Biotechnology candidates with this opportunity is to both facilitate a high academic standard in the upper division Biotechnology undergraduate courses and enhance synergism between the B.S. and M.S. programs. Generally, students receiving a Graduate Teaching Assistantship teach 2 labs during a semester. Duties include lab preparation instruction, and administering and grading lab problem sets, quizzes, practical tests, or other assignments. Consistent with institute guidelines (and NSF guidelines), graduate teaching assistants (GTA) are assigned to teach lower- and upper-division laboratory courses, while graduate assistants (GA) are assigned supplementary duties by a faculty lab instructor.

Since this is a new program, we also anticipate that marketing materials will be needed to advertise the program for recruitment such as a devoted website for the program, electronic and printed brochures and outreach.

IX. Conclusions

In summary, The Thomas H. Gosnell School of Life Sciences has proposed a M.S. program in Biotechnology. This program enhances on one of RIT's *signature* undergraduate programs with the overarching goal to prepare graduates to meet the growing demand of the biotechnology industry. The proposed M.S. in Science degree program in Biotechnology will capitalize on the forecasted trend in growth of the Biotechnology industry. The biotechnology market in the US has witnessed a rapid expansion in recent years driven by increased biotechnology applications in various sectors such as health, medical, energy, food, agriculture, and environmental sciences. RIT will be positioned to provide the highly skilled workforce that can leverage the technological advances in the life sciences that biotechnology represents with an M.S. program in Biotechnology.

Reference

1 The US Biotechnology Market Outlook to 2016 - Future Growth Led by Surging Biotech Application in Agriculture, Health and Industrial Sector. ID: 2330143 November 2012 Region: United States 111 Pages Ken Research Private.

Master of Science in Biotechnology
SUMMARY REPORT

Fiscal Year	2018	2019	2020	2021	2022	Total
Avg Enrollment: Students (FT + PT)	7	17	19	19	19	82
Part-time Faculty expense	$ -	$ -	$ -	$ -	$ -	$ -
Full-time faculty expense	$ 123,079.99	$ 251,083.18	$ 256,104.85	$ 261,226.94	$ 266,451.48	$ 1,157,946.45
Total Expenses	$ 181,690.34	$ 376,747.17	$ 395,800.20	$ 401,949.91	$ 405,905.80	$ 1,762,093.42
Revenue (Net of Aid)	$ 168,895.43	$ 359,269.53	$ 420,435.25	$ 420,435.25	$ 420,435.25	$ 1,789,470.71
CONTRIBUTION MARGIN Surplus/(Deficit)	$ (12,794.91)	$ (17,477.64)	$ 24,635.05	$ 18,485.34	$ 14,529.45	**$ 27,377.29**

Note : This sheet is password protected to maintain the formulas.