UNIVERSITY FACULTY SENATE

Resolution

Whereas present and future research in life sciences will benefit from a multidisciplinary approach, including biology, chemistry, mathematics and physics, and

Whereas current undergraduate biology education does not adequately prepare students for a multidisciplinary research environment, specially in quantitative aspects of the discipline, and

Whereas the Department of Mathematical Sciences and the Department of Biological Sciences have collaborated enthusiastically in designing this program, and

Whereas the program is having significant impact in furthering knowledge in biological and life sciences, and

Whereas this program does not require major additional resources in order to run successfully, be it therefore

Whereas the Quantitative Biology program, in its first five provisional years, has graduated exceptional students that meet the original program objectives.

Whereas the Quantitative Biology programs continues to attract top-notch students interested in becoming leaders in biomedical research.

Resolved that the BS major in Quantitative Biology be granted permanent status in the College of Arts and Sciences.

UNIVERSITY FACULTY SENATE FORMS

Academic Program Approval

This form is a routing document for the approval of new and revised academic programs. Proposing department should complete this form. For more information, call the Faculty Senate Office at 831-2921.

Submitted by: _Louis Rossi_____phone number__831-1880_____

Department: _Mathematical Sciences_____email address_rossi@math.udel.edu

Date: _4 October 2012_____

Action: **Request for permanent status _____**
(Example: add major/minor/concentration, delete major/minor/concentration, revise major/minor/concentration, academic unit name change, request for permanent status, policy change, etc.)

Effective term__13F_____
(use format 04F, 05W)

Current degree__BS_____
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed change leads to the degree of: __BS_____
(Example: BA, BACH, BACJ, HBA, EDD, MA, MBA, etc.)

Proposed name:__BS in Quantitative Biology_____
Proposed new name for revised or new major / minor / concentration / academic unit (if applicable)

Revising or Deleting:

Undergraduate major / Concentration:_BS Quantitative Biology_____
(Example: Applied Music – Instrumental degree BMAS)

Undergraduate minor:_____
(Example: African Studies, Business Administration, English, Leadership, etc.)

Graduate Program Policy statement change:_____
(**Must attach** your Graduate Program Policy Statement)

Graduate Program of Study:_____
(Example: Animal Science: MS Animal Science: PHD Economics: MA Economics: PHD)

Graduate minor / concentration:_____

Note: all graduate studies proposals must include an electronic copy of the Graduate Program Policy Document, highlighting the changes made to the original policy document.

List new courses required for the new or revised curriculum. How do they support the overall program objectives of the major/minor/concentrations)?
(Be aware that approval of the curriculum is dependent upon these courses successfully passing through the Course Challenge list. If there are no new courses enter "None")
None.

Explain, when appropriate, how this new/revised curriculum supports the 10 goals of undergraduate education: http://www.ugs.udel.edu/gened/

Identify other units affected by the proposed changes:
(Attach permission from the affected units. If no other unit is affected, enter "None")

Departments of Biological Sciences, Chemistry and Biochemistry, and Chemical and Biochemical Engineering.

Describe the rationale for the proposed program change(s):
(Explain your reasons for creating, revising, or deleting the curriculum or program.)

The Bachelor of Science in Quantitative Biology (QBio) is an innovative, interdisciplinary program that has earned UD a reputation as a leader in the education of the next generation of biomedical scientists. Faculty from Mathematics, Chemistry and Biochemistry and Chemical Engineering worked together to create this program in response to the call for programs like these in the report "Bio 2012". Among other things, this report noted that leaders in biomedical science were coming from undergraduate programs other than biology. Instead, leaders in biomedical sciences were coming from more quantitative fields such as mathematic, physics and engineering. The report called for the infusion of more quantitative material into the biology curriculum and the creation of new degree programs such as our Qbio program. This creation of our Qbio program was a key part of one successful HHMI grant and has played an important role in subsequent HHMI grants. The Q Bio program is one of the most rigorous programs on campus requiring an extraordinary 36 courses in disciplinary clusters including mathematics, biology, chemistry, physics and computer science. It is also unusual, being one of a very small number of undergraduate programs in quantitative biology, and also being administered by the Department of Mathematical Sciences.

The Qbio program has been and will continue to be a success at UD. Since its inception in 2007, the Qbio program has graduated 10 students. Of these, 7 are enrolled in PhD programs in biomedical engineering, bioinformatics, genetics, biophysics or applied mathematics at impressive institutions like Cornell University, Carnegie Mellon University and The Ohio State University. Among the remainder of the graduates, one is in medical school, one is a wilderness fellow for the US Fish and Wildlife Service and one is a programmer/analyst at Stinger Ghaffarian Technologies studying the climate. The number of students entering the program as freshmen has been between 4 and 5, and we typically one or two biology majors change into the Qbio program during their freshman year. More detailed assessments of the program are provided in the attached self-study.

Program Requirements:
(Show the new or revised curriculum as it should appear in the Course Catalog. If this is a revision, be sure to indicate the changes being made to the current curriculum and **include a side-by-side comparison** of the credit distribution before and after the proposed change.)

See attached.

ROUTING AND AUTHORIZATION: (Please do not remove supporting documentation.)

Department Chairperson _____Date_____

Dean of College_____Date_____

Chairperson, College Curriculum Committee_____Date_____

Chairperson, Senate Com. on UG or GR Studies_____Date_____

Chairperson, Senate Coordinating Com._____Date_____

Secretary, Faculty Senate_____Date_____

Date of Senate Resolution_____Date to be Effective_____

Registrar _____Program Code_____Date_____

Vice Provost for Academic Affairs & International Programs_____Date_____

Provost _____Date_____

Board of Trustee Notification_____Date_____

Revised 02/09/2009 /khs

Proposal for the Permanent Status of
the BS QUANTITATIVE BIOLOGY MAJOR
in the College of Arts and Sciences

Prepared by Professor Louis F Rossi
Undergraduate Director for the Department of Mathematical Sciences

Introduction and history (1-a).

The Bachelor of Science in Quantitative Biology (QBio) is an innovative, interdisciplinary program that has earned UD a reputation as a leader in the education of the next generation of biomedical scientists. Faculty from Mathematics, Chemistry and Biochemistry and Chemical Engineering worked together to create this program in response to the call for programs like these in the report "Bio 2012". Among other things, this report noted that leaders in biomedical science were coming from undergraduate programs other than biology. Instead, leaders in biomedical sciences were coming from more quantitative fields such as mathematic, physics and engineering. The report called for the infusion of more quantitative material into the biology curriculum and the creation of new degree programs such as our QBio program. This creation of our Qbio program was a key part of one successful HHMI grant and has played an important role in subsequent HHMI grants. The QBio program is one of the most rigorous programs on campus requiring an extraordinary 36 courses in disciplinary clusters including mathematics, biology, chemistry, physics and computer science. It is also unusual, being one of a very small number of undergraduate programs in quantitative biology, and also being administered by the Department of Mathematical Sciences.

Program compatibility (1-b).

The QBio program is compatible with existing programs in Biology and Mathematics. The program was created by faculty from both programs and has considerable support in both departments. The program is aligned with UD's Path to Prominance. In particular, this program advances our commitment to a Diverse and Stimulating Undergraduate Environment. Indeed, the QBio program is one of the most rigorous majors on campus and attracts high caliber students.

General education (1-c).

The QBio degree advances the following General Education goals.

1. Attain effective skills in (a) oral and (b) written communication, (c) quantitative reasoning, and (d) the use of information technology.

   Our curriculum is one of the strongest on campus in mathematics and physical sciences.

2. Learn to think critically to solve problems.

   Our curriculum features two integrative seminars plus a capstone course

featuring individual and group problem solving.

Curricular requirements (1-d).

The Qbio program meets all University, College and Department requirements for a Bachelor of Science degree. See original proposal and current catalog listing.

Assessments (1-e).

Our program is what it produces. The purpose of our program was to develop the next generation biomedical researchers. Are we producing top-flight students who are pursuing advanced studies in life-sciences research?

Since its inception in the Fall of 2007, the QBio program has graduated 10 students. Of these, 7 are enrolled in PhD programs in biomedical engineering, bioinformatics, genetics, biophysics or applied mathematics at impressive institutions like Cornell University, Carnegie Mellon University and The Ohio State University. Among the remainder of the graduates, one is in medical school, one is a wilderness fellow for the US Fish and Wildlife Service and one is a programmer/analyst at Stinger Ghaffarian Technologies studying the climate. We expect to graduate 8 majors this year. The number of students entering the program as freshmen has been between 4 and 5, and typically one or two biology majors change into the QBio program during their freshman year.

Advisement (1-f).

All students receive curricular advising and mentoring through faculty in Mathematics or Biological Sciences.

Accreditation (1-g).

There is no accrediting agency for Mathematics. However, the program was created and sustained with the help of two major Howard Hughes Medical Institute grants, so there is at least one external body that believes this program is very important.

Changes to degree requirements (1-h).

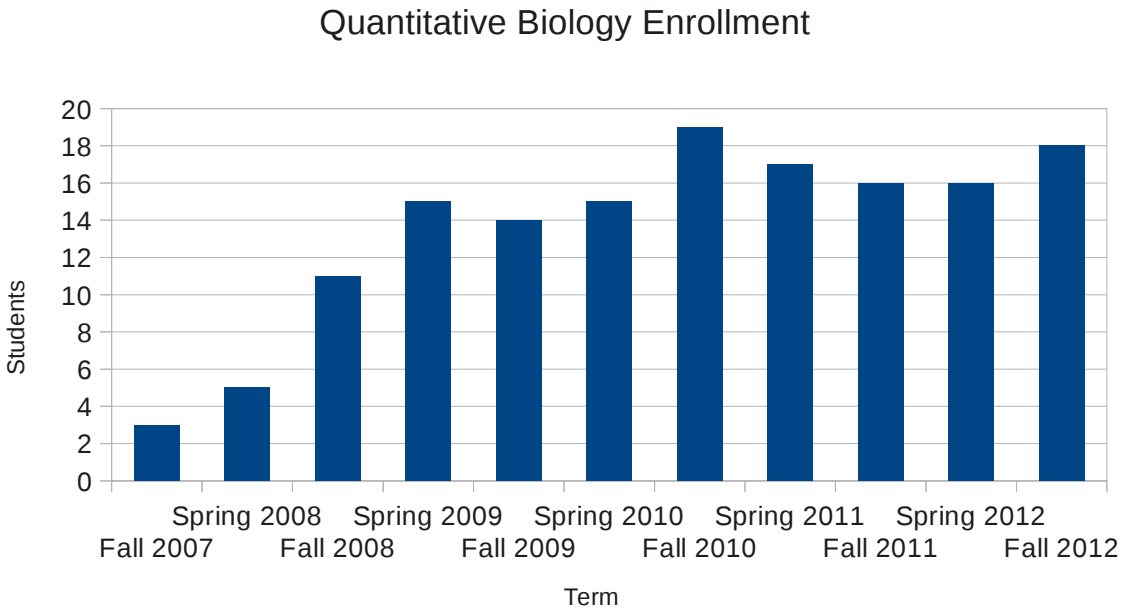
Concurrent with this proposal, we are requesting a minor revision to the Quantitative Biology program. We are proposing one minor adjustment in degree requirements. Rather than requiring CISC 106, CISC 108 or CISC 181, we are merely requiring CISC 106. This is a response to changes in CISC prerequisite requirements and course descriptions. In consultation with CISC faculty, we have concluded that the right course for QBio majors to learn programming structures is CISC 106.

General description of recruiting procedures (1-i).

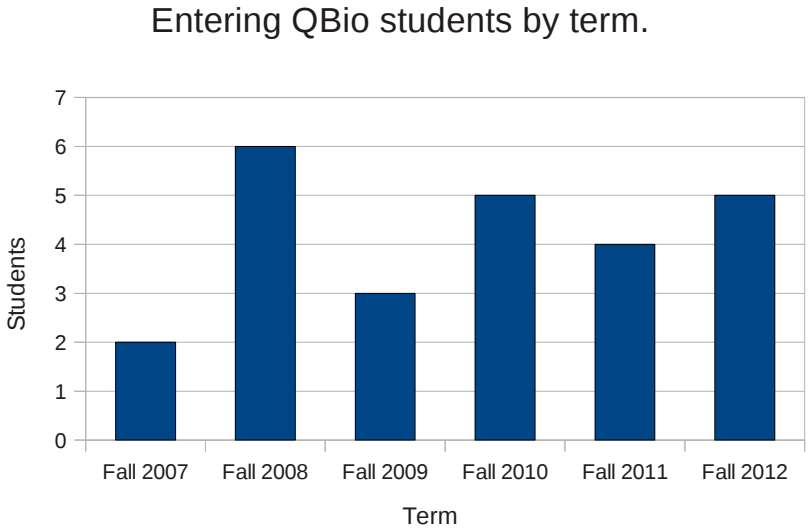
Students are recruited into the QBio program via Blue and Gold Saturdays, Discovery Days, Major Finder video outreach and advisement of existing students in Mathematics and Biology who might find this major interesting.

Application and enrollment history (2-a).

There is no enrollment limit for the major in Quantitative Biology, and due to its rigor, we expect it to remain an elite program at UD. The admissions criteria is the same as for any other degree in mathematics. Nonetheless, the program is sufficiently flexible to allow students to transfer into the program from related programs, such as Biology or Chemical Engineering, provided they are capable of completing the degree. Enrollments have grown during the provisional period.



Despite the challenges of recruiting students into a new and challenging program, the Qbio program has been and will continue to be a success at UD.



Annotated evidence of placement (2-b).

For an overview of our results, please see the Assessments Section (1-e). The individual student outcomes are listed below.

Name	GrdSem	
Gigantino, Matthew	2113	PhD Biomedical Engg. Ohio State.
Johnson, Zariel	2113	PhD candidate Thomas Jefferson Univ.
Liu, Alicia Joyce	2125	Doctor of Philosophy (Ph.D.), Genetics, Genomics, and Bioinformatics at University of Conn
McCabe, Meghan M	2103	PhD Chem Engg. Univ. New Mexico
Pippins, Kelly A	2103	Wilderness Fellow with US Fish and Wildlife Service National Wildlife Refuge System
Rackley, Ann L	2123	Programmer/Analyst at Stinger Ghaffarian Technologies (SGT)
Sheehan, Robert	2113	CMU Computational Biology.
Sloofman, Laura G	2103	PhD candidate Biophysics. Institute for Genomic Biology - Urbana, IL - University of Illinois
Toupo, Danielle Flora	2113	PhD candidate Applied Math, Cornell University
Ucciferro, Peter M	2098	Medical school

Additional factors (items 2-8).

As noted in the introduction, the Quantitative Biology program is one of the few of its type in the country. It thrives on the cooperation of faculty from several departments including Mathematical Sciences, Biological Sciences and Chemistry & Biochemistry. It does not require additional resources beyond two one credit integrative seminars to run, and it produces top quality students.

Academic Year: 2012-2013 ▼

[17704]
2012-2013 UD Catalog -->
2012-2013 Undergraduate Programs -->
College of Arts and Sciences -->
Mathematical Sciences -->
BACHELOR OF SCIENCE: QUANTITATIVE BIOLOGY

DEGREE: BACHELOR OF SCIENCE
MAJOR: QUANTITATIVE BIOLOGY

The College of Arts and Sciences administers an interdisciplinary major program in Quantitative Biology leading to the Bachelor of Science degree. The major provides a strong background in mathematics, biology, chemistry and physics appropriate for students who wish to pursue a career or graduate studies in biomedical and life sciences.

CURRICULUM		CREDITS
UNIVERSITY REQUIREMENTS		
ENGL 110	Critical Reading and Writing (minimum grade C-)	3
First Year Experience (FYE)		**0-4**
University Breadth Requirement (minimum grade C-) Up to 3 credits from each of the University Breadth Requirement categories may be used to simultaneously satisfy the College of Arts and Sciences Breadth Requirements.		12
Discovery Learning Experience (DLE)		3
Multi-cultural Course		3
COLLEGE REQUIREMENTS		

Writing (minimum grade C-)	3

A second writing course involving significant writing experience including two papers with a combined minimum of 3,000 words to be submitted for extended faculty critique of both composition and content. This course must be taken after completion of 60 credit hours

BREADTH REQUIREMENTS (minimum grade C-)

Eighteen credits from Groups A, B and C with a minimum of six credits from each group. One of the courses should be in the area of Bioethics

Group A	6
Group B	6
Group C	6

MAJOR REQUIREMENTS

A grade of C- or better is required for major courses and related work.

Biology

BISC 207	Introduction to Biology I	4
BISC 208	Introduction to Biology II	4
Three of the following three-credit courses		9
BISC 302	General Ecology	
BISC 305	Cell Physiology	
BISC 306	General Physiology	
BISC 401	Molecular Biology of the Cell	
BISC 403	Genetic and Evolutionary Biology	
One of the following three-credit laboratory classes		3
BISC 312	General Ecology Laboratory	
BISC 315	Experimental Cell Biology	
BISC 316	Experimental Physiology	
BISC 411	Experimental Molecular Biology	
BISC 413	Advanced Genetics Laboratory	
BISC 484	Computer Based Genetics Laboratory	

Either **CISC 106** or **CISC 108** (for those with no previous equivalent experience),or **CISC 181**	3

Chemistry

One of the following options (A, B or C)		8-12
Option A		
CHEM 103	General Chemistry	4
CHEM 104	General Chemistry	4
Option B		
CHEM 111	General Chemistry	3
CHEM 112	General Chemistry	3
CHEM 119	Quantitative Chemistry I	3
CHEM 120	Quantitative Chemistry II	3
Option C		
CHEM 111	General Chemistry	3

CHEM 112	General Chemistry	3
CHEM 220	Quantitative Analysis	3
CHEM 221	Quantitative Laboratory	1
CHEM 321	Organic Chemistry	4
CHEM 322	Organic Chemistry	4
CHEM 527	Introductory Biochemistry	3

Mathematics

MATH 210	Discrete Mathematics I	3
MATH 241	Analytic Geometry and Calculus A	4
MATH 242	Analytic Geometry and Calculus B	4
MATH 243	Analytic Geometry and Calculus C	4
MATH 302	Ordinary Differential Equations	3
MATH 349	Elementary Linear Algebra	3
MATH 350	Probability Theory and Simulation Methods	3
MATH 426	Introduction to Numerical Analysis and Algorithmic Computation	3
MATH 450	Mathematical Statistics	3
MATH 460	Introduction to Systems Biology	3
MATH 535	Introduction to Partial Differential Equations	3

Physics

PHYS 207	Fundamentals of Physics I	4
PHYS 208	Fundamentals of Physics II	4

OTHER REQUIREMENTS

Two one-credit integrative seminars		2
MATH 260	Integrative Seminar	
Three integrative or technical electives, 6 credits of which should be integrative electives from a list maintained by the Department of Mathematical Sciences. In addition, undergraduate research is strongly recommended.		9

CREDITS TO TOTAL A MINIMUM OF **125**

Although every effort has been made to assure the accuracy of the information in the Catalog, students and others who use the Catalog should note that the policies, rules, regulations, requirements for graduation, course offerings, and other materials reproduced in the Catalog change from time-to-time and that these changes may alter the information contained in this Catalog. see ***Legal Statement***

UNIVERSITY OF DELAWARE

DEPARTMENT OF BIOLOGY
OFFICE OF THE CHAIR

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Randall L. Duncan, Ph.D.
Professor and Chairman
Department of Biological Sciences
118C Wolf Hall
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Fax No. (302) 831-1033
E-mail: rlduncan@udel.edu

October 3, 2012

Dr. Louis Rossi
Director of Undergraduate Studies
Department of Mathematical Sciences
University of Delaware
Newark, DE 19716

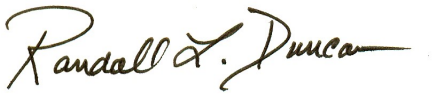
Dear Dr. Rossi,

This letter is to state my enthusiastic support of the application of the *Quantitative Biology* program for permanent status. As you know, I have always believed that the training of our student in the quantitation of biological studies is essential for our majors to succeed. I believe that this program is an excellent start to increasing our students' knowledge of biological quantitation. While this program has been small during the past five year probationary period with only 10 graduating from the program, I have been impressed with the quality of students coming out of this program. As you have mentioned, the most of these graduates from this program have gone on to graduate schools with one going into medical school. This is an impressive statistic that demonstrates the quality of students in the program. The move of *Quantitative Biology* to permanent status only helps to strengthen the Department of Biological Sciences.

Since this program is small, there is little impact on the Biology curriculum. Even with an increase in the number of students in this major, I do not expect that this program will significantly impact our course populations. We welcome the addition of these students in our curriculum as an example to our majors of the need for this type of studies for biologists.

In summary, I fully support the move of the *QBio* program to permanent status and look forward to our continued interaction with your department.

Best regards,



Professor and Chair

UNIVERSITY OF DELAWARE

DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY
OFFICE OF THE CHAIRMAN

102 Brown Laboratory
University of Delaware
Newark, Delaware 19716-2522
Ph: 302/831-1247
Fax: 302/831-6335

September 28, 2012

Louis Rossi
Professor and Undergraduate Director
Department of Mathematical Sciences
University of Delaware

Dear Prof. Rossi,

I am writing this letter in support of permanent status for the undergraduate Quantitative Biology major that is completing its five-year probationary period and is scheduled for review. The program was initiated by a Howard Hughes Medical Institute's Undergraduate Science Education Grant to the University and is considered to be a significant accomplishment of the HHMI program, which is housed in the Department of Chemistry and Biochemistry and directed by my colleague Prof. Hal White.

While the University of Delaware program is small, in part due to its demanding curriculum, the students who are Quantitative Biology majors are among the best students at the university and an unusually high percentage of them go on to prestigious graduate programs. Their preparation goes beyond mathematics and biology. Of particular interest to my department, it includes a solid grounding in chemistry and biochemistry as well.

Numerous recent national reports, policy statements, and emphasize the importance of mathematics to the future of biology and call attention to the woeful gap in the preparation of both mathematicians and biologists in biology and mathematics, respectively. The Quantitative Biology major established at the University of Delaware is unique in that it is administered from a department of mathematics, rather than a department of biology, a distinction that reveals enviable interdepartmental cooperation and foresight into the needs of future graduates. The future of STEM education lies in the implementation of interdisciplinary approaches, such as quantitative biology, that prepare students for the challenges they will encounter.

In summary, I strongly support permanent status for the Quantitative Biology Program. Furthermore, the chemistry and biochemistry department is pleased to continue serving its majors in our courses.

Sincerely,

Murray V. Johnston
Professor and Chair

Checklist for Curriculum Proposals

_X_. 1. Are all **signatures on the hard copy of the proposal?**

_X_. 2. Is the **effective date** correct?

_X_. 3. Is the **rationale** for the proposal consistent with the changes proposed?

_X_. 4. Does the proposed **number of credits** match the stated number?

_X_. 5. Have affected units been identified and contacted? Are required **support letters** attached?

N/A. 6. Is a **resolution** necessary? If so, is it attached?

(Necessary for: establishing a major; disestablishing a major; a name change to any program with permanent status; a name change to a department or college; a transfer or creation of any department; request for permanent status).

_X_. 7. Are all **courses (required or referenced)** in the UDSIS Inventory or in the approval process?

_X_. 8. Are all **university requirements** correctly specified?

_X_. A. Breadth requirements.

_X_. B. Multicultural requirement.

_X_. C. Writing requirement.

_X_. D. DLE requirement.

_X_. 9. Are all **college requirements** correctly specified?

_ _. 9. Is a **side-by-side comparison** provided?

Proposal for a BS in Quantitative Biology

G. Schleiniger

October 18, 2006

1 Description

The proposed major is a Bachelor of Science in Quantitative Biology to be offered jointly by the Departments of Mathematical Sciences and Biological Sciences. The program of studies is designed to develop and reinforce the connections between biology, chemistry and mathematics so as to better prepare students to a career that requires interdisciplinary and multidisciplinary work. Graduates will be expected to have acquired a solid foundation in biology, chemistry and mathematics, with an emphasis on preparation for a research career in biomedical and life sciences. The success of this new major will be measured by how well its students perform after graduation, as well as by the career paths they pursue.

The mathematics courses required for this major lie at the core of many applied mathematics areas that have very strong ties to biological and biomedical research. The ties between principles of physics, chemistry, biology and mathematics will be continually developed and reinforced through a sequence of integrative seminars to be taken during the sophomore and junior years, as well as integrative electives to be taken in the junior and senior years. A capstone course, *Introduction to Systems Biology*, will integrate and synthesize the knowledge acquired during the first three years; it will achieve this objective through an emphasis in mathematical modeling in systems biology, including hands-on experience via PBL modules and projects.

2 Rationale and demand

2.1 Institutional factors

The proposed new major is compatible with the academic priorities of the University in that it aims at providing high quality education in an area of national need and

potentially of great impact to the future of research in biomedical and life sciences. The principal outcome of this major should be graduates who will have skills bridging between traditional researchers in biology and those in other fields, notably in physics, chemistry and mathematics — a demand of future life sciences research, if full advantage is to be taken of the latest advances in measurement technologies, and the wealth of experimental *omics* data that is being generated.

This proposal is the result of discussions among UD faculty in Biological Sciences, Chemistry and Biochemistry, Chemical Engineering, and Mathematical Sciences. These discussions were motivated by a report of the National Research Council (NRC) of the National Academies: *BIO2010 — Transforming Undergraduate Education for Future Research Biologists*. The proposed curriculum follows recommendations contained in the BIO2010 Report. It was approved by the faculty in Mathematical Sciences, and endorsed by the Department of Biological Sciences. It also received enthusiastic support from other researchers (see support letters in the Appendices).

The new major can be started with minimal additional resources; it will utilize existent UD resources, thus maximizing the return of University investments in facilities and personnel, while providing current and future students an additional alternative to pursue first-class educational opportunities at the University of Delaware. As new faculty arrive on campus, and new courses are developed that may serve this new major, we will be looking to use those resources for further improvement of the program.

2.2 Student demand

It is anticipated that the initial number of new majors will be small, consisting mostly of current UD students who will change into the new major from biology, chemical engineering and mathematics. The number of majors should steadily increase as we proceed with efforts to inform our Admissions Office, high school counselors, and prospective students visiting our campus about the new BS in Quantitative Biology (BSQB). It is expected that mathematically talented students who might otherwise lose interest in studying the life sciences will be attracted to this new major. Conversely, students in life sciences who find they have mathematical ability beyond what is demanded by the traditional curriculum may also find the BSQB attractive.

After five years of existence, it is expected that the BSQB major will have about 10 to 15 freshmen, and about 5 graduating students. The goal is not necessarily to have a very large number of students in the major, but rather to have a good

number of talented students who are able to follow a very demanding curriculum, and who will be well prepared to pursue a research career. If we succeed with this goal, we will be already making a very important contribution to the education of a new breed of biomedical and life sciences researchers.

The following citations are indicative of a recognized demand for a program of studies of the type represented by the proposed BSQB. Note also Vol. 303 of *Science* (February 2004), a special issue on Mathematics and Biology.

How biologists design, perform and analyze experiments is changing swiftly. Biological concepts and models are becoming more quantitative, and biological research has become critically dependent on concepts and methods drawn from other scientific disciplines. The connections between the biological sciences and the physical sciences, mathematics, and computer science are rapidly becoming deeper and more extensive. (BIO2010, p. 1)

In contrast to biological research, undergraduate biology education has changed relatively little during the past two decades. The ways in which most future research biologists are educated are geared to the biology of the past, rather than to the biology of the present or future. Like research in the life sciences, undergraduate education must be transformed to prepare students effectively for the biology that lies ahead. Life sciences majors must acquire a much stronger foundation in the physical sciences (chemistry and physics) and mathematics than they now get. Connections between biology and the other disciplines need to be developed and reinforced so that interdisciplinary thinking and work become second nature. (BIO2010, pp. 1–2)

In the postgenomic era of research, multidisciplinary and interdisciplinary research will command center stage, requiring team approaches and the collaboration of many individuals from vastly different fields, ranging from computational mathematics to clinical science. (The Role of the Private Sector in Training the Next Generation of Biomedical Scientists, American Cancer Society et al., 2000).

2.3 Transferability

As indicated in Section 2.2, we expect an initial small number of students to transfer to the new major. Accommodations on a case-by-case basis will be made, whenever possible, so as to minimize the amount of extra course work needed by transferring students, without compromising the principal goals of the major.

2.4 Regional, state, and national factors

There are no comparable courses of study at the undergraduate level in the region. The University of Delaware will be one of the first schools in the US to address the need for this kind of undergraduate program. Many experts believe that this type of program will eventually be developed by other universities. On the other hand, several interdisciplinary graduate programs have been created in recent years: The Harvard Medical School, Department of Systems Biology (Ph.D. Program in Systems Biology), the University of Washington and the Fred Hutchinson Cancer Research Center, in collaboration with the Institute for Systems Biology (Molecular and Cellular Biology Graduate Program, and Biomolecular Structure and Design Graduate Program), the University of California, San Diego (Graduate Program in Systems Biology), the Department of Systems Biology and Translational Medicine, Texas A&M University (Interdisciplinary Graduate Program), the Center for the Study of Biological Complexity, Virginia Commonwealth University (Ph.D. Program in Integrative Life Sciences), the University of Texas Southwestern Medical Center (Integrative Biology Graduate Program), the The Lewis-Sigler Institute for Integrative Genomics, Princeton University (Graduate Program in Quantitative and Computational Biology), and Cornell, Rockefeller, Sloan-Kettering Cancer Center (Tri-Institutional Program in Computational Biology and Medicine).

2.5 Other strengths

The proposed course of study for the BSQB is unique, in that it will continually develop and reinforce the connections between the various disciplines that play a central role in modern biomedical and life sciences research. The presence on campus of faculty in several departments and institutes who conduct research in diverse areas of biological sciences is of particular value to the program, as the opportunities for undergraduate research across campus will be very attractive.

The willingness of researchers in industry to collaborate in making the new major a success (see letters of support) will be very helpful as we try to arrange internship opportunities for the students in the major. Researchers from industry, as well as from other departments on campus, will be invited as guest lecturers, and to help with the integrative seminars and student projects for the capstone course.

3 Enrollment, Admissions and Financial Aid

3.1 Enrollment

There is no enrollment limit for the BS in Quantitative Biology. The clientele for this program, at least for the first five years, is not expected to be much larger than for a typical BS in Mathematics.

3.2 Admission requirements

The admission criteria are the same as for the BS in Mathematics.

3.3 Student expenses

Student expenses should be commensurate with those incurred by a typical biology major.

4 Curriculum Specifics

The degree to be awarded is a bachelor of science. The curriculum requirements are consistent with University requirements for a baccalaureate degree, more specifically for a bachelor of science.

- **University Requirements**

  ENGL 110 Critical Reading and Writing (minimum grade C-) 3

  First Year Experience 0-4

  Discovery Learning Experience 3

  Three credits in an approved course or courses stressing multi-cultural, ethnic, and/or gender-related course content 3

- **College Requirements**

  Writing (minimum grade C-) 3
  Second writing course taken after completion of 60 credit hours.

- **Breadth Requirements**
  Eighteen credits from Groups A, B and C with a minimum of six credits from each group. One of the courses should be in the area of Bioethics.

Group A 6

Group B 6

Group C 6

- **Major Requirements**
  A grade of C- or better is required for major courses and related work.

Biology Section

BISC 207 Introduction to Biology I 4

BISC 208 Introduction to Biology II 4

Three of the following three-credit (CORE BIO) courses 9

BISC 302 General Ecology

BISC 305 Cell Physiology

BISC 306 General Physiology

BISC 401 Molecular Biology of the Cell

BISC 403 Genetic and Evolutionary Biology

One of the following two-credit (CORE BIO LAB) laboratory classes . . . 2

BISC 312 General Ecology Laboratory

BISC 315 Experimental Cell Biology

BISC 316 Experimental Physiology

BISC 411 Experimental Molecular Biology

BISC 413 Advanced Genetics Laboratory

Computer and Information Sciences Section

Either CISC 105 or CISC 106 (for those with no previous equivalent experience), or CISC 181 Introduction to Computer Science 3

Chemistry Section

One of the following options (A, B or C, 8 – 12 credits total)

Option A

CHEM 103 General Chemistry 4

CHEM 104 General Chemistry 4

Option B

CHEM 111 General Chemistry 3

CHEM 112 General Chemistry 3

CHEM 119 Quantitative Chemistry I 3
CHEM 120 Quantitative Chemistry II 3

Option C

CHEM 111 General Chemistry 3
CHEM 112 General Chemistry 3
CHEM 220 Quantitative Analysis 3
CHEM 221 Quantitative Laboratory 1
CHEM 321 Organic Chemistry 4
CHEM 322 Organic Chemistry 4
CHEM 527 Introductory Biochemistry 3

Mathematics Section

MATH 210 Discrete Mathematics I 3
MATH 241 Analytic Geometry and Calculus A 4
MATH 242 Analytic Geometry and Calculus B 4
MATH 243 Analytic Geometry and Calculus C 4
MATH 302 Ordinary Differential Equations 3
MATH 349 Elementary Linear Algebra 3
MATH 350 Probability Theory and Simulation Methods 3
MATH 426 Introduction to Numerical Analysis and Algorithmic Computation 3
MATH 450 Mathematical Statistics 3
MATH 535 Introduction to Partial Differential Equations 3
MATH 460 Introduction to Systems Biology 3

Physics Section

PHYS 207 Fundamentals of Physics I 4
PHYS 208 Fundamentals of Physics II 4

Other Requirements

Two one-credit integrative seminars 2
MATH 260 Integrative Seminar
Three integrative or technical electives, 6 credits of which should be integrative electives from a list maintained by the Department of Mathematical Sciences 9

Credits to total a minimum of 124

Sample Curriculum — BSQB

Freshman Year

BISC 207	Intro to Biology I	(4)	BISC 208	Intro to Biology II	(4)
CHEM 103	General Chemistry	(4)	CHEM 104	General Chemistry	(4)
ENGL 110	Crit Read/Write	(3)	MATH 210	Discrete Math I	(3)
MATH 241	Calculus A	(4)	MATH 242	Calculus B	(4)
First Year Experience		(1)			
Total		**16**	**Total**		**15**

Sophomore Year

CHEM 321	Organic Chemistry	(4)	CHEM 322	Organic Chemistry	(4)
CORE BIO		(3)	CORE BIO		(3)
MATH 243	Calculus C	(4)	CISC 181	Intro Comp Sci	(3)
MATH 349	Linear Algebra	(3)	MATH 302	Diff Equations	(3)
Breadth	Group C	(3)	MATH 260	Integrative Sem	(1)
Total		**17**	**Total**		**14**

Junior Year

CORE BIO		(3)	CHEM 527	Intro to Biochem	(3)
MATH 350	Probab & Simul	(3)	MATH 450	Math Stat	(3)
MATH 426	Num Computing	(3)	MATH 535	Intro to PDEs	(3)
PHYS 207	Physics I	(4)	PHYS 208	Physics II	(4)
Integrative Elective		(3)	MATH 260	Integrative Sem	(1)
			Breadth	Group A	(3)
Total		**16**	**Total**		**17**

Senior Year

CORE BIO LAB		(2)	Bioethics	Group A	(3)
MATH 460	Intro Sys Biology	(3)	Integrative Elective		(3)
Breadth	Group B	(3)	Breadth	Group B	(3)
Integrative Elective		(3)	Breadth	Group C	(3)
Research I		(3)	Research II		(3)
Total		**14**	**Total**		**15**

Total number of credits: 124

5 Resources Available

5.1 Learning resources

The resources needed by the proposed BSQB are the same as those needed by current majors in biological sciences, chemistry, chemical engineering and mathematics. Wet labs, computer labs, library resources, etc., all exist within the University, and there would be no adverse impact on those resources by the relatively small number of majors in the new program.

Current faculty, in addition to those who will be hired under ongoing searches, will properly teach and advise students in this major. The administration of this interdisciplinary major will be done primarily in the Department of Mathematical Sciences, with help from the Department of Biological Sciences in student advisement.

A Howard Hughes Medical Institute (HHMI) grant awarded to the University will fund collaboration among biology, chemistry, chemical engineering and mathematics faculty in the development of instructional modules to be used in the BSQB, as well as for teaching biological sciences majors.

6 Resources Required

The capstone course proposed with the BSQB should be team-taught by a mathematician and a researcher in systems biology, at least the first few times it is offered. This will require some workload adjustments within the departments involved, and this has been agreed on by those departments. Support to start this program will also come from a Howard Hughes Medical Institute grant.

7 Implementation and Evaluation

Some sections of MATH 241 will give preference to students in Biological Sciences and in the BSQB. The calculus material to be covered will be the same as for the other sections of 241, but with a strong emphasis on examples of applications to the life sciences. Those students who do not get AP credit for MATH 241, will be directed to take the special "bio" section of calculus.

Collaboration among some key faculty in Mathematical Sciences and in Biological Sciences will help include more quantitative analysis in introductory biology courses; this has already started in Fall 06, and will continue. By Fall 07, some changes

implemented in those courses will make them even more attractive to the incoming students to the BSQB major. Starting in Spring 08, material for the one-credit integrative seminars will have been developed, funded by the HHMI grant, and we will start offering those seminars. The capstone course is to be offered in the Fall of the senior year, thus preparing students for meaningful internships and undergraduate research during the following Winter Session.

The new major will be part of the assessment plan of the Department of Mathematical Sciences. We also plan to keep track of the movements into and out of the major, as well as of graduating seniors, in order to evaluate the effectiveness of the program in meeting its goals.

8 Appendices

Attached are a detailed description of the capstone course, letters of support from the Department of Biological Sciences, from the Department of Mathematical Sciences, from the Department of Chemistry and Biochemistry, from Dr. Prasad Dhurjati of Chemical Engineering, from Dr. Anastasia K. Christianson of Astra Zeneca, and from Dr. San Kiang of Bristol-Myers Squibb. Also included is a testimonial by Dr. Lauren A. O'Donnell, UD alumna, and other supporting documentation.