University of Georgia

New Program Proposal

Date:	March 17, 2006
Institution:	The University of Georgia
Department/Institute:	Institute of Bioinformatics
Names of Proposed Programs:	Bioinformatics
Degree:	M.S. (Master of Science)
Major:	Bioinformatics
CIP Code:	
Starting Date:	August, 2006

Signatures:

Department of Population Health

Biological and Agricultural Engineering

Chemistry

Genetics

Mathematics

Poultry Science

Plant Biology

Department Heads

Biochemistry &Molecular Biology

Cellular Biology

Computer Science

Marine Sciences

Microbiology

Physics and Astronomy

Statistics

Program Directors

Institute of Bioinformatics

Faculty of Engineering

College Deans

Agricultural & Environmental Sciences

Arts and Sciences

Veterinary Medicine

Dean of the Graduate School

MARCH 22, 2006

Vice-President for Research

Vice-President for Instruction

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1. Program Abstract:

This proposal seeks approval to establish the *Masters of Science in Bioinformatics* degree program at the University of Georgia; this interdisciplinary program will be administered by the Institute of Bioinformatics (or IOB). Its mission is to educate and prepare the next generation of leaders in research and innovation in the rapidly growing field of bioinformatics and to establish the University of Georgia as a national leader in this emerging interdisciplinary field. The students matriculating in this program will be educated effectively in lectures and laboratories, and mentored well in their research projects by faculty from multiple departments and disciplines, spanning the biological, computational, mathematical, engineering, and pharmacy faculties. Such a mission and purpose are consistent with those of the University of Georgia and its Graduate School.

Since the inception of the Human Genome Project in the mid 1980's, we have witnessed a revolution in life sciences, fueled by high-throughput biological data production, which is profoundly transforming biology from a qualitative science into a quantitative and informational science. Emerging from this revolution is a new discipline at the interface of biological, computational, mathematical, and physical sciences called *bioinformatics* or *computational biology*.

We describe bioinformatics as the use of advanced informational and computational technologies to facilitate the solution to problems of biological interest, frequently involving the great mass of DNA and protein sequence data being generated. Briefly, the generation of sequence and functional genomics data is outpacing analysis by traditional biological and biochemical "wet lab" methods; bioinformatics tools are used to generate hypotheses and predictions about these data. The need for "computational" biologists goes beyond the field of bioinformatics. High-throughput biological data production capabilities now permit scientists to tackle very complex biological problems at the systems level. The demand for biologists capable of handling the complexity of the biological systems and the enormity of the biological data is increasing rapidly. This transition in the field of biological sciences has not escaped the sharp minds of the undergraduate and graduate students at the University of Georgia and elsewhere. For the past few years, we have been regularly receiving inquiries about the possibility of obtaining an advanced degree in bioinformatics at UGA.

Recognizing the significance of this explosively expanding field, over 70 U.S. universities have established advanced degree programs in bioinformatics or computational biology (http://www.sloan.org/main.shtml) to meet the needs for training the next generation of biologists capable of using computational and mathematical techniques for solving complex biological problems. A number of universities in the Southeast region, including Georgia Institute of Technology, the University of Tennessee, North Carolina State University, and the University of North Carolina, have established degree programs in bioinformatics or computational biology.

The demand for bioinformatics instruction at the University of Georgia has led to the creation of over a dozen bioinformatics courses, currently being offered to both undergraduate and graduate students by numerous UGA departments, including Biochemistry and Molecular Biology, Plant Biology, Genetics, Microbiology, Animal Science, Computer Science and Statistics. These courses have attracted a large number of students. An announcement of a bioinformatics course (Summer 2005) attracted 65 students in just four days for a class that could accommodate only 30 of them. The University of Georgia is in a fortunate position of already employing greater than 30 faculty members whose research overlaps the field of bioinformatics; and new bioinformatics faculty members are continuingly being recruited. Many of these researchers are currently full or associate members of the Institute of Bioinformatics (http://www.bioinformatics.uga.edu/people.php). Recently, a bioinformatics certificate program was approved by the Board of Regents, which is administered by the Institute of Bioinformatics. We believe that the University of Georgia has all the key components for establishing and sustaining a highly successful M.S. degree program in bioinformatics. The Institute of Bioinformatics provides a natural home for this program.

A Program Development Committee of the IOB has defined the overall goals, structure and implementation details of the proposed degree programs. A subset of existing courses have been selected as core and elective courses for this new program and two-four new courses will be created and taught by new faculty recently hired in joint appointments with the IOB. A detailed plan for student recruitment and program administration has been developed.

Initial funding for the program will be provided jointly from the colleges involved, the graduate school, and research grants from participating faculty members, mainly used to support student teaching and research assistantships. A training grant application will be submitted to several external granting agencies (such as the National Science Foundation and Howard Hughes Medical Institute) as soon as an initial indication is provided concerning the approval of this degree program. A goal of the program is to be as financially independent as soon as possible and to use external funds to provide long-term financial support to the graduate students admitted to the program.

We expect that this program will not only train highly qualified M.S.-level scientists to join the work force of the biotechnology and pharmaceutical industries, private and government research labs, and academia, but that it will also catalyze stronger interactions across colleges and departments through students taking interdisciplinary bioinformatics courses from participating departments and via the interaction of faculty members beyond typical departmental and college boundaries.

2. Program Objectives

The mission of the proposed M.S. degree program in Bioinformatics is to educate and prepare graduate students to attain mastery and leadership in bioinformatics research and its applications to contribute to the advancement of this new interdisciplinary field. The program has three major objectives:

(A) ESTABLISH A STRONG GRADUATE PROGRAM. The proposed M.S. program will integrate and channel the existing strengths on campus towards a common goal. We will build on the strength of the existing programs in the allied areas at the university. A two-track degree program will be developed to meet the needs of training different types of students, (i) tool development oriented bioinformatics and (ii) application oriented bioinformatics. A co-mentoring system for M.S. students, with one mentor from the biological science and one from the computational, mathematical, or physical sciences, will be implemented to facilitate interactions between biologists and computational, mathematical, and physical scientists. The combination of profound questions asked by the biologists and the powerful computational and mathematical techniques studied by computational, mathematical and physical scientists should provide a highly stimulating training environment for the IOB graduate students. All courses offered by the program will be made available to students with the prerequisites from any department on campus. Mechanisms will be set up to encourage active interactions between IOB students with students from the home departments of the IOB faculty members.

(B) GENERATE AND FOSTER A NATIONALLY AND INTERNATIONALLY RECOGNIZED RESEARCH PROGRAM IN BIOINFORMATICS. The University has one of the top biology research programs in the nation and eminent research programs in computational, mathematical and physical sciences. This new interdisciplinary degree program will help foster strong interactions between scientists working in areas of bioinformatics, ranging from theoretical studies of complex biological problems, to computational prediction and modeling of biological systems and processes, to bioinformatics applications to various biological problems, including biomedical research such as cancer studies, pharmacology, plant genetics and genomics, microbiology, and structural biology. This interdisciplinary degree program will help (a) draw national and international attention to bioinformatics research at the university, (b) attract top candidates for

faculty positions, and (c) attract top graduate students and postdoctoral research fellows to the University of Georgia. We have already had some success attracting outstanding young faculty members. In 2005, the IOB recruited two young scientists as Assistant Professors, one from Stanford and one from The Institute of Genomics Research (TIGR). Such enhanced interactions among bioinformatics researchers and new faculty and students will position the university to compete for large center grants in systems and integrative biology as well as the traditional disciplines of biological, computational and physical sciences.

(C) BUILD STRONG TIES BETWEEN THE UNIVERSITY AND EXTERNAL CONSTITUENCIES. The ultimate goal of the IOB degree program is to train first-rate M.S. level scientists and engineers in bioinformatics, who will make our world a better place through bioinformatics research and applications. Building strong ties with the local industry and biotechnological industry in general will help IOB to better set its goals in training and mentoring of graduate students. An external advisory committee, made up of bioinformatics leaders from academia, national research laboratories and industry, will be established to guide the IOB as it attempts to meet the research and educational needs within the State. Summer internship and exchange programs will be established with other bioinformatics organizations, such as the IBM/TJ Watson Computational Biology Center and The Institute of Genome Research, to facilitate the interaction of our graduate students with the industrial side of bioinformatics. In addition, the proposed degree program will create opportunities for scientists from other universities, research organizations and industry labs to visit with our students and guest-lecture in our advanced topical courses on a regular basis.

3. Justification and Need for the Program

Bioinformatics: A New Field in the Biological Sciences. Bioinformatics is one of the most rapidly growing fields in science today. It is a powerful technology that is playing key roles in revolutionizing the biological sciences. In the complex field of systems biology, bioinformatics is becoming the thread for stitching together information generated using genomics and proteomics technologies. Currently, there is a widely held belief that, while physics has been the key driving force for the advancement of mathematical and computational sciences in the past few centuries, biology will become the driving force for the advancement of mathematical and computational sciences. Integration of biology and computation is clearly where science is going. Our proposed degree program is set to meet the needs of science in the 21st century.

The University of Georgia is a logical institution to establish an interdisciplinary research and graduate training program in bioinformatics. Bioinformatic approaches are required to assemble and characterize the enormous amount of DNA sequence data that is being generated daily; to find genes of interest; to suggest the cellular and molecular functional roles of these genes and to study the evolution of organisms. For these reasons, bioinformatics interacts closely with biological sciences, mathematical and computational sciences, physical sciences, engineering, and medical sciences (including pharmacy). The University of Georgia has many academic and research strengths in the disciplines that interact mostly closely with bioinformatics. These strengths can be utilized to develop a strong program. These conclusions are echoed in the strong letter of support from Mark Borodovsky, Regent's Professor and Director of the Center for Bioinformatics and Computational Biology at the Georgia Institute of Technology (Appendix 1).

Societal Needs for this Program. In 1998, BusinessWeek magazine published an article entitled "We now are starting the century of biology", citing the major impacts that biological research and its application have had on medicine and agriculture and the potential future impacts on our lives in general. Computation is playing an

increasingly more important role in realizing many of the impacts promised by the new biology. For example, personalized medicine will rely on detailed information about tens of thousands of genes encoded in our genome. Detailed treatment plans for a particular illness will depend on the specific gene and protein (expression) profiles of different individuals, which will require sophisticated bioinformatic analyses. Prevention of particular diseases such as cancer might require computational modeling of dynamic behaviors of complex biochemical networks in our cells. Further improvements of corn yields through bioengineering will require identification of "choking-points" or bottlenecks in complex metabolic networks in corn cells, which would further require sophisticated computational modeling of these metabolic networks. To deliver these and other promises of the powerful biological and bioengineering techniques will require training of a new generation of biologists who are capable of using computational and mathematical techniques to solve complex biological problems. Rigorous education and training in biology and computational/mathematical sciences will be necessary for the development of technical staff in academia and the biotechnology industry.

Specifically, students with a M.S. degree are expected to obtain employment in academic, government and industrial research laboratories under the direction of doctoral-level scientists. A person seeking an M.S. degree will typically have specific career aspirations, which do not involve performing fully independent research as a principal investigator, but rather will be working as part of a large research team, such as those common in an industrial research setting, a government laboratory or a major genome sequencing center. A nonthesis M.S. degree is also proposed for specific employment opportunities. This opportunity has been available in the department of Statistics for many years, and it has been used by students who are already in another degree program but wish to supplement their formal course work in another discipline. In addition, students who would like to expand their knowledge base in bioinformatics without performing research, such as computer science students interested in tool building, would find this degree attractive. This goal of expanding one's knowledge base will be accomplished by additional course work in an area of specialization instead of thesis research.

Letters from Yahwant Deo, President of AviGenics, Inc., and Clifton Baile, GRA Eminent Scholar in Agricultural Biotechnology elaborate upon these points (Appendix 1). As Dr. Deo states, "The state of Georgia will benefit significantly by establishing a center of excellence and a graduate training program in Bioinformatics by providing a much needed boost to the region's emergent biotechnology industry." Dr. Baile states that a training program in bioinformatics will "… add another very important resource for the research community and provide new employment opportunities…"

Student Interest and Demand. Student demand for courses in bioinformatics has been consistent and growing over the last decade. Students correctly feel that training in this area will help them obtain jobs in the health-care, pharmaceutical and biotechnology industries, and often it forms an essential component of their research. Evidence for this demand comes from several sources and crosses many discipline boundaries. First, throughout the University, faculty have begun offering bioinformatics courses. These courses typically have excellent enrollment. Some diverse examples of these graduate-level courses include:

Course	Title	Instructor	Enrollment (2004-2005)
BCMB 8210	Computational Methods in Bioinformatics	Ying Xu and Team	14
BCMB 8140	Advanced Topics in Genomics and Bioinformatics	Michael Adams & Claiborne Glover	30
(BIOL)PBIO 4550/6550	Bioinformatics Applications	Russell Malmberg	22
CSCI4490/6490	Algorithms for Computational Biology	Liming Cai	11
GENE8940	Genome Analysis	Jessica Kissinger	12
MIBO8110L	Electronic Exploration of Prokaryotic Biology	Mark Schell & Ellen Neidle	12
STAT6630	Statistical Methods in Bioinformatics I	Paul Schliekelman	8

Second, evidence for the demand of a degree program in bioinformatics also comes from the interest generated by the proposed graduate Certificate in Bioinformatics. This certificate was proposed by the Institute of Bioinformatics and has just received approval from the Board of Regents. Throughout its development, we have been constantly receiving student inquiries, which currently number greater than 25, even though the program has only recently been formally approved. Many of these students also expressed considerable interest in earning a graduate degree in bioinformatics. There is also strong interest among the undergraduates; multiple departments are already offering undergraduate bioinformatics training.

Additional reasons.

Consultant reports. These reports are included in Appendix 2.

Other institutions with similar programs.

Similar programs in Georgia:

Emory University: The Department of Biostatistics offers an M.S. in biostatistics for Ph.D. students.

Georgia Institute of Technology. Georgia Tech offers both a Master of Science and a Ph.D. degree in bioinformatics. This is a joint program between Schools of Biology, Chemistry and Biochemistry, Biomedical Engineering, Computing, and Mathematics.

Georgia State University. The Department of Biology offers a Master of Science degree in bioinformatics.

Five similar programs in the southeast:

North Carolina State University. NCSU offers both M.S. and Ph.D. in bioinformatics.

Medical University of South Carolina. The Department of Biostatistics, Bioinformatics, and Epidemiology offers a bioinformatics track at both M.S. and Ph.D. levels.

University of Tennessee. The Graduate School of Genome Science and Technology, a joint program with Oak Ridge National Lab offers M.S. and Ph.D. in both bioinformatcs and computational biology.

Florida State University The Department of Mathematics offers both M.S. and Ph.D. degrees in biomedical mathematics.

University of Alabama at Birmingham. The Department of Computer and Information Sciences offers both M.S. and Ph.D. degrees with specializations in bioinformatics.

4. Procedures Used to Develop the Program

The need for an interdisciplinary program in bioinformatics at UGA has been recognized since the late 1990s. Researchers conducting bioinformatics research were scattered in various departments and centers around the campus. Communication was difficult and training efforts were often duplicated. In 2001, a committee was formed to establish an Institute of Bioinformatics (IOB). This committee was comprised of research faculty from biological, physical, computational, and mathematical sciences as well as engineering departments and research centers, such as the Complex Carbohydrate Research Center and Center for Tropical and Global Emerging Diseases. Soon after it was approved by the University Council in 2002, the IOB was established with Dr. John McDonald of the Genetics Department as the acting director. An Eminent Scholar (Dr. Ying Xu) joined the Institute in 2003 and he was subsequently appointed as the Director of the Institute in 2004.

The office of IOB has been established in the Davison Life Sciences Building, currently with one office manager and a budget from the OVPR for a second office staff person. A seminar room/lecture hall which can accommodate up to 60 students is shared with the Departments of Biochemistry & Molecular Biology and Genetics. A computer laboratory has been established through efforts of active IOB members and is currently equipped with 30 PC workstations. This computer lab has been extensively used for a number of bioinformatics classes currently offered by different departments, including a bioinformatics short course in the Summer of 2005. Two junior faculty members were hired into IOB in the Spring, 2005 (jointly with Departments of BCMB and Microbiology, respectively). More faculty hires in bioinformatics are expected over the next few years, based on an agreement with the Office of Vice President for Research.

A large number of faculty from various departments and colleges of the university recognized that an advanced program was necessary to facilitate active and formal interdisciplinary and interdepartmental research and grant collaborations in bioinformatics. Towards establishing a degree program, the Director of the IOB appointed a Program Development Committee to propose a Masters and Ph.D programs in bioinformatics. The Program Development Committee includes Ying Xu (Director of IOB), Dan Kannan (Chair of the Program Development Committee and Professor of Mathematics), Barny Whitman (Chair of the IOB Education Committee and Professor of Microbiology), Liming Cai (Associate Professor of Computer Science), Jessica Kissinger (Assistant Professor of Genetics), Russell Malmberg (Professor and Head of the Department of Plant Biology), Jaxk Reeves (Associate Professor of Statistics), Paul Schliekelman (Assistant Professor of Statistics), Bernd Schuttler (Professor and Head of Department of Physics), and John Rose (Associate Professor of Department of

Biochemistry and Molecular Biology). This proposal for the M.S. program in bioinformatics was developed with input from all members of the Program Development Committee of IOB.

Since its inception, the Program Development Committee of IOB focused much of its attention on the design of a state-of-the-art M.S. and Ph.D curriculum that will prepare students for the challenges that lay ahead. Existing courses were surveyed and new courses were proposed. New courses will be taught by recent new hires with joint appointments in the IOB.

5. Curriculum for Master Students in Bioinformatics

Because of its interdisciplinary nature, bioinformatics will attract students from diverse backgrounds. Moreover, it also leads to multiple careers paths, depending upon the background and interests of the students. Thus, the goal of the curriculum is to provide flexible training of a diverse student body while insuring the rigor of the program. To achieve these objectives, the M.S. program will offer thesis and non-thesis options. Both options require the M.S. student to take the five courses or 17 hours of core courses BINF 8XX1, BINF 8XX2, STAT 6630, CSCI 6490 and GENE 8490. Students will also be required to complete or possess an equivalency for up to four or 13 hours of foundation courses. Students with a largely biology background will be required to take appropriate foundation courses to strengthen their quantitative and computational skills, while students with largely quantitative science background will be required to take appropriate foundation courses to strengthen their knowledge of biology. It is expected that most students will have completed the equivalency for two of the foundation courses during their undergraduate studies. Students with a strong background in both the biological and quantitative science who already possess equivalent course work for all the foundation courses will develop a second area of specialization with electives. In addition, 6 hours of 7000 (master research) and 3 hours of 7300 (master thesis) course work are required for students with the thesis option. In the absence of a thesis, students will take 9 hours of 8000 courses in an area of specialization to be approved by their committee as well as prepare a final technical report on a topic assigned by the student's advisor.

Core courses. All M.S. students, regardless of background, will be required to take the following five courses.

BINF 8XX1 Bioinformatics I (new course)
Prerequisite or corequisite: BCMB6000 or equivalent
Credits: 4 hours, 3 hours lecture + 1 hour laboratory
Description: Computational, statistical, and theoretic analyses of genomic sequences and high throughput transcriptomic and proteomic experiments leading to new biological insights. Topics include: data and algorithms appropriate for sequence analyses including gene finding, functional annotations, repeat finding, identification of regulatory elements; comparative genomics; transcriptomic and proteomic data analyses; predictions of gene regulatory networks. A computer laboratory is a component of this course.

BINF 8XX2 Bioinformatics II (new course)
Prerequisite: Bioinformatics I or equivalent
Credits: 4 hours, 3 hours lecture + 1 hour laboratory
Description: Computational, statistical, and theoretical analyses of protein and nucleic acids structures, protein-protein and protein-nucleic acid interactions, and high throughput metabolomic experiments leading to new biological insights. Topics include: data and algorithms appropriate for X-ray crystallography and NMR structure determination; protein and nucleic acid structure modeling; docking; analysis and predictions of networks of interacting proteins; analysis of metabolomic data. A computer laboratory is a component of this course.

STAT 6630. Statistical Methods in Bioinformatics I
Oasis Title: STAT METH BIOINF I.
Graduate prerequisite: STAT 4210 or STAT 6220
Credits: 3 hours
Methods for analysis of DNA sequence data, with an emphasis on the probabilistic basis of the methods. Topics include analysis of single DNA sequences, sequences alignment, BLAST searches, and related topics, as well as relevant topics from probability theory.

CSCI 6490. Algorithms for Computational Biology
Oasis Title: ALG FOR COMP BIO
Credits: 4 hours
Description: Application of discrete algorithms to computational problems in molecular biology. Topics are drawn from such areas as classical sequence comparison, multiple sequence alignment, DNA sequence assembly, DNA physical mapping, genome rearrangement, evolutionary tree construction, and protein folding. Background in molecular biology is not required.

GENE 8940 Genome Analysis (Bioinformatics Laboratory)
Oasis Title: GENOME ANALYSIS
Prerequisite: GENE 6200 or permission of the department
Credits: 2 hours
Description: This laboratory course covers modern approaches to whole genome analyses. Topics include: genome sequence assembly, automated annotation, molecular databases, EST analysis, SAGE analysis, microarray analysis, SNP analysis, proteomic techniques and analysis, and comparative genomics. This class will be a "hands-on" exercise in how to conduct genome analysis. Emphasis will be placed on understanding the approaches and algorithms used to generate, store and analyze very large data sets and a discussion of the strengths and limitations of genome-scale analyses.

Foundation courses. Four to 13 hours. A student is required to complete the following four foundation courses or to have completed their equivalent prior to admission: STAT 6310, CSCI 7010, BCMB 6000, and BIOL 6000. It is expected that a typical student will have completed the equivalent of two of these courses prior to admission. For instance, many biological sciences students will require only STAT 6310 and CSCI 7010. Many quantitative sciences students will require only BCMB 6000 and BIOL 6000. Students who have obtained equivalency (as determined upon admission by the IOB Graduate Affairs Committee) for more than 9 hours of these foundation courses will earn additional hours with graduate level courses in an area of specialization (see below).

STAT 6310. Statistical Analysis I.
Oasis Title: STATIST ANALYSIS I
Prerequisite: Permission of department
Credits: 3 hours
Description: Statistical analysis, including principles of sampling and descriptive statistics, elementary probability and discrete random variables, normal distribution, sampling distributions, statistical inference and hypothesis testing for one and two samples, simple linear regression, basic nonparametrics, chi-squared tests.

CSCI 7010. Computer Programming
Oasis Title: COMPUTER PROG.
Prerequisite: MATH 1113
Credits: 4 hours
Description: Algorithms, programs, and computing systems. Topics studied include: fundamental techniques of program development and supportive software tools; and programming projects and applications in a structured computer language. Hands-on experience using microcomputers.

BIOL 6000 – Essential Biology for the Quantitative Scientist (new course)
Credits: 3 hours
Description: This course is designed for students with little or no biology background that are working in Bioinformatics. It will cover essential biological concepts necessary for understanding the basic questions facing modern biology and the most commonly applied molecular techniques used to generate data for bioinformatics analysis. Specifically the course will cover an introduction to: taxonomy and biological diversity, evolution, basic eukaryotic and prokaryotic genetics concepts, recombination, alleles and populations, the chemical and structural components of the cell, the genetic code, the central dogma, genome structure and composition, replication, transcription, and translation.

BCMB 6000. General Biochemistry and Molecular Biology
Oasis Title: BIOCHEM & MOL BIOL.
Not open to students with credit in BCMB 4010/6010 or BCMB 4020/6020 or BCMB 8010 or BCMB 8020.
Prerequisite: CHEM 2212 and CHEM 2212L
Credits: 3 hours
Description: Beginning intensive one-semester graduate-level course in biochemistry and molecular biology covering the structure and function of biological molecules, enzymology, metabolism, bioenergetics, and recombinant DNA technology.

Elective courses. These courses will be used to obtain the minimum of 21 hours required for this degree when more than nine hours of foundation courses have been waived. The student's selection of electives must be approved by the thesis committee, and may be any graduate level course in the biological and quantitative sciences that develops an area of specialization within bioinformatics.

> Examples of Specializations. Some typical specializations for bioinformatics M.S. students are listed below. The actual specialization taken will be decided in consultation with the student's advisory committee.
>
> Applied Probability:
> STAT 6510 Mathematical Statistics I
> STAT 6520 Mathematical Statistics II
> STAT 8700 Applied Stochastic Processes
> STAT 8730 Sequential Analysis
>
> Computer Algorithms:
> CSCI 6470 Algorithms
> CSCI 6490 Algorithms for Computational Biology
> CSCI 8470 Advanced Algorithms
> CSCI 8610 Topics in Theoretical Computer Science

CSCI 6140 Numerical Methods and Computing
CSCI 8140 Parallel Processing and Computational Science
CSCI 8150 Advanced Numerical Methods and Scientific Computing

Database and Software Systems:
CSCI 6350 Global Information Systems
CSCI 4370/6370 Database Management
CSCI 4800/6800 Human-Computer Interaction
CSCI 8350 Semantic Web
CSCI 8351 Semantic Web Services and Processes
CSCI 8370 Advanced Database Systems
CSCI 8380 Advanced Topics in Information Systems
CSCI 8820 Computer Vision and Pattern Recognition
CSCI 8950 Machine Learning

Ecology:
ECOL 6580 Foundations of Ecology.
ECOL 8310 Population Ecology.
ECOL 8320-8320L Modeling Population Ecology
ECOL 8580-8580L Theory of Systems Ecology.

Microbiological Processes:
MIBO 6090 Prokaryotic Biology
MIBO 8110L Electronic Exploration of Prokaryotic Biology
MIBO 8600 Fundamental Processes of Prokaryotic Cell Biology
MIBO 8610 Prokaryotic Physiology and Diversity

Microbiological Interactions:
MIBO 6220 Pathogenic Bacteriology
MIBO 6300 Environmental Microbiology and Biotechnology
MIBO 6500 Bacterial Symbioses
MIBO 8610 Prokaryotic Physiology and Diversity

Plant Genomics:
PBIO 6510 Genome Evolution Across the Tree of Life
PBIO 6720-6720L Plant Variation and Evolution
PBIO 8100 Plant Genetics
PBIO 8111 Plant Development
GENE 8940 Genome Analysis
GENE 8950 Molecular Evolution

Statistical Bioinformatics:
STAT 6320 Statistical Analysis II
STAT 6630 Statistical Methods in Bioinformatics I
STAT 6640 Statistical Methods in Bioinformatics II
STAT 8090 Statistical Analysis of Genetic Data

Statistical Genetics:

STAT 6320 Statistical Analysis II
STAT 6810 Probability Distributions
STAT 6820 Statistical Inference
STAT 8090 Statistical Analysis of Genetic Data

Typical Program of Study

A typical program of study for a student with an undergraduate degree in biological sciences.

Year 1		
Fall	Spring	Summer
BINF 8XX1	BINF 8XX2	BINF 7000
STAT 6310	STAT 6630	BINF 7000
CSCI 7010	CSCI 6490	BINF 7300
	GENE 8940	

A typical program of study for a student with an undergraduate degree in quantitative sciences.

Year 1		
Fall	Spring	Summer
BINF 8XX1	BINF 8XX2	BINF 7000
BIOL 6000	STAT 6630	BINF 7000
BCMB 6000	CSCI 6490	BINF 7300
	GENE 8940	

A preliminary program study, developed by the major professor and the master student and approved by a majority of the advisor committee, will be submitted to the graduate coordinator by the end of the student's first year of residence. The expected time for completion of the degree is three semesters.

Expected Student Outcomes

Graduates will have obtained a solid understanding of bioinformatics theory and methods. They will be familiar with and able to implement the major methods in bioinformatics.

6. Inventory of Faculty Directly Involved

Full members of the Institute of Bioinformatics will serve as thesis and dissertation advisors for students in this program. Membership to the IOB is open to all faculty of the University of Georgia actively involved in research and education in the field of bioinformatics and its allied fields upon application to the IOB and approval by the IOB Board. Applications for membership are available at the institute's website (http://www.bioinformatics.uga.edu). A list of the current members of the IOB is below. Their curriculum vitae are in Appendix III.

Full Members of the Institute of Bioinformatics.

Name	Title	Department
Aggrey, Sammy	Assistant Professor	Poultry Science
Bennetzen, Jeff	Professors	Genetics
Bhandarkar, Suchi	Professor	Computer Science
Cai, Liming	Associate Professor	Computer Science
Cordonnier-Pratt, Marie Michele	Senior Research Scientist	Plant Biology and Biochemistry and Molecular Biology
Dean, Jeff	Associate Professor	Warnell School of Forestry Resources
Jackwood, Mark	Professor	Avian Medicine
Kannan, Dan	Professor	Mathematics
Karls, Anna	Associate Professor	Microbiology
Kissinger, Jessica	Assistant Professor	Genetics
Kraemer, Eileen	Associate Professor	Computer Science
Kushner, Sidney	Professor	Genetics
Malmberg, Russell	Department Head	Plant Biology
Moran, Mary Ann	Professor	Marine Sciences
Mrazek, Jan	Assistant Professor	Microbiology; Institute of Bioinformatics
Paterson, Andrew	Research Professor	Crop and Soil Sciences
Prestegard, James	Professor	Complex Carbohydrate Center
Rekaya, Romdhane	Assistant Professor	Animal Science Research College
Scott, Robert	Research Professor	Chemistry
Schell, Mark	Professor	Microbiology
Schuttler, Heinz-Bernd	Department Head	Physics and Astronomy
Schliekelman, Paul	Assistant Professor	Statistics
Sheth, Amit	Professor	Computer Science
Shimkets, Lawrence	Professor	Microbiology
Summers, Anne	Professor	Microbiology
Taha, Thiab	Professor	Computer Science
Tarleton, Rick	Professor	Cellular Biology
Verma, Brahm	Professor	Biological and Agricultural Engineering
Wessler, Susan	Research Professor	Plant Biology
Whitman, William	Professor	Microbiology
Xu, Ying	Professor	Biochemistry and Molecular Biology; Institute of Bioinformatics
York, William	Assistant Professor	Complex Carbohydrate Center
Zhao, Shaying	Assistant Professor	Biochemistry and Molecular

7. Outstanding programs of this nature at other institutions

Location:	North Carolina State University, Bioinformatics
Web Site:	http://genomics.ncsu.edu/bioinfo.html
Name of Official:	Dr. Bruce Weir, weir@stat.ncsu.edu
Features that standout:	This program builds on a long tradition at North Carolina State University of interactions between statistics, mathematics, and the biological sciences; in particular quantitative genetics has been a traditional strength. The program benefits from strong ties to academic, government and private institutions in the Research Triangle Park. They require new graduate students to have already completed a course in each of calculus, linear algebra, genetics, beginning programming, and statistics.
Degrees offered:	Master of Bioinformatics (non-thesis degree) Ph.D., Bioinformatics Co-major in Bioinformatics Minor in Bioinformatics (for students pursuing a Ph.D. in Functional Genomics or another discipline; there is no minor offered for M.S. degrees)

Location:	Stanford University, Biomedical Informatics
Web Site:	http://bmi.stanford.edu/
Name of Official:	Christine Hilliard, hilliard@smi.stanford.edu Russ B. Altman, Russ.Altman@stanford.edu
Features that standout:	This program is defined as a combination of bioinformatics and medical informatics. Prerequisites for new students include calculus, linear algebra, statistics, and beginning programming. The core curriculum requires training in five areas: 1. Biomedical Informatics: the methods used to represent knowledge and develop biomedical models. 2. Computer Science: the expertise required to implement these representations and models, 3. Probability, Statistics and Decision Science: the methods for managing uncertain biomedical data. 4. Biomedical Domain Knowledge: the specialized knowledge necessary to identify and make impact upon important biomedical problems. 5. Ethics and Social Policy (3 units): to understand the societal implications of novel informatics technologies.
Degrees offered:	Ph.D. , Professional M.S., Academic M.S.

Location:	Washington University, St. Louis
Web Site:	http://www.dbbs.wustl.edu/
Name of Official:	Gary Stormo, stormo@genetics.wustl.edu
Features that standout:	Course work in molecular biology and computer science with an emphasis on mathematical modeling. The curriculum is very flexible, customized to a student's background and interests. Students do laboratory rotations the first year before joining a thesis lab, and then their primary effort is on the thesis research. All students are required to take 3 courses - Nucleic Acids and Protein Biosynthesis, Computational Molecular Biology, Modeling Biomolecular Systems. Students without prior programming are expected to take a beginning programming course. Students then choose electives from a wide diversity of choices, one of which must be a graduate class in computer science.
Degrees offered:	Ph.D., Computational Biology

8. Inventory of pertinent library resources

The University of Georgia has a top-level research library with access to most journals relevant to the bioinformatics field. Current faculty performing research in bioinformatics have not noted any shortcomings in the library holdings and services, and it is not anticipated that any additional library resources will be required.

9. Facilities

Most classes in the proposed curriculum are currently being taught. Thus, the current physical facilities are adequate for classroom needs of the program. All involved faculty have office and laboratory space allocated by their individual departments. The administration will be housed in the Institute of Bioinformatics, which has space in the Davison Life Sciences Building. The University of Georgia Research Services has an IBM P655 super computer with 168 cpu, an SGI Altix with 24 cpu, and a new Linux Cluster is on order specifically targeted for bioinformatics researchers. These computational resources are freely available to UGA faculty and graduate students. These computational resources were funded by UGARF which has committed to spending approximately $1,000,000 per year to keep these current.

10. Administration

The Bioinformatics Program will be administered by the Institute of Bioinformatics. The Graduate Coordinator will work in collaboration with the Director of the Institute and the IOB Graduate Affairs Committee and will be responsible for coordinating all aspects of the program including instruction, policy development, admission and retention of students, and financial support. This includes coordinating the admission of students and assuring that the policies and standards of the Graduate School are implemented within the Bioinformatics Program. The IOB Graduate Affairs Committee will consist of the Graduate Coordinator and three members of

the Bioinformatics faculty. These faculty will be chosen to represent the diverse and interdisciplinary character of the institute and will be appointed by the Director of the Institute. They will serve three year terms, and they many not consecutively serve more than two terms. No more than two members of the committee may be from the same department. This committee will serve as a resource for faculty and student input and provide assistance in the establishment and implementation of the policies of the program. This administrative structure will provide clearly defined lines of participation by all institute members and is similar to that which exists in other highly successful programs on campus.

Student Admission and Program Requirements. The candidates for the M.S. degree must apply to the Graduate School and meet its admission criteria for master programs. Admissions decisions for qualified applicants will be made by a Graduate Affairs Committee within the IOB. The admission standards set by the IOB will be consistent with those of the Graduate School and will include the GRE (Graduate Records Examination), GPA (Grade Point Average), three letters of recommendation, and a personal statement describing the student's interest in bioinformatics. Successful applicants will be expected to have mastered one or more of the undergraduate disciplines that serves as a foundation for bioinformatics, such as biology, computer sciences, mathematics or statistics. Mastery will be demonstrated by course work equivalent to a major in an area. Applicants for the M.S. program in bioinformatics must have completed two semesters of calculus or the equivalent.

While in the program, students will fulfill all the requirements for the Graduate School for the M.S. degree. Student progress in the program will be monitored by the Graduate Coordinator and the IOB Graduate Affairs Committee. Upon arrival at the university, students will be assigned a curriculum advisor for guidance and mentoring. Because this program is interdisciplinary, students will be advised to take prerequisite courses in areas where the student does not have the necessary background. Students will select their major professor and establish an advisory committee by the end of their first year in the program. The major professor must be a full member of the IOB and the Graduate Faculty. The advisory committee must consist of the major professor and at least two other faculty members. At least two members of the advisory committee must be full or associate members of the IOB. The advisory committee will also be composed of representatives of both the biological and the quantitative sciences. For the thesis option, the student is required to take an oral examination conducted by the advisory committee and to have his/her thesis approved by the committee. For the non-thesis option, the student will prepare a technical report in a research project in bioinformatics under the direction of a designated full member of the IOB faculty. The technical report must be approved by a committee of at least three full members of the IOB, including the project director. This committee will be appointed by the Graduate Coordinator.

11. Assessment

Direct student assessment. During the first year in the program, students will form an advisory committee. In addition to its mentoring responsibilities, the advisory committee will evaluate the student's progress at least once per year. The advisory committee will submit annual reports to the IOB Graduate Affairs Committee containing their appraisal of each student's progress and recommendation for continuation or termination from the program. A written evaluation will be provided to the student and copies maintained for program review. Upon receipt and consideration of the recommendations of the advisory committee, the IOB Graduate Affairs Committee will render a final decision regarding continuation or termination of the student in the program. All

requirements for the program, including preparation and defense of the thesis, will be in accordance with existing Graduate School policies.

Learning Outcomes Assessment. Outcomes assessment will be based upon the document "Guidelines and Procedures for Assessment of Student Learning Outcomes in Graduate Programs at the University of Georgia". Because there are no standardized examinations for bioinformatics, the IOB Graduate Affairs Committee will establish specific guidelines to judge the quality and effectiveness of the program. These may include but are not limited to the following:

-Student interest in the program and referral of student by previous graduates

-Timely progress by students through the program

-Exit polls of student satisfaction upon graduation

-Success of graduates in obtaining employment

-Student participation at regional, national and international conferences and workshops

-Generating interest from industry to support internships.

12. Accreditation

There is no accreditation for bioinformatics. However, the International Society for Computational Biology is working to develop an accreditation program, and these developments will be followed closely.

13. Affirmative action impact

Recruitment efforts will be directed to stress the importance of underrepresented groups as professionals in bioinformatics. Faculty and student representatives will visit targeted campuses in the southeast on placement service and career days. Promotional and recruitment brochures will be mailed to schools with significant enrollment of underrepresented groups. Examples of such schools include, but are not limited to: Atlanta University Center, Albany State, Armstrong Atlantic and Tennessee State. Faculty in bioinformatics will also participate in the Summer Undergraduate Research Program and the Graduate Recruitment Opportunities Program. These programs target students from underrepresented groups or economically disadvantaged.

14. Degree inscription

The diploma will be inscribed with Master of Science.

15. Fiscal and enrollment impact and estimated budget

The program will include approximately thirty full time faculty members from a variety of departments who are already members of the IOB. A part-time administrative assistant is currently available from the Institute of Bioinformatics. The Director of IOB, who has ultimate administrative responsibility for the program, is also in place. Release time for the Graduate Coordinator is also available from EFTs currently assigned to the IOB. Therefore, no additional resources will be required for these components of the program. Student enrollment is expected to be 4-8 students per year for the first three years, and it is expected to increase to 10 students per year thereafter. The program envisions that most M.S. students will be self-supported, supported by teaching assistantships from other departments, or supported by research assistantships from IOB faculty.

I. ENROLLMENT PROJECTIONS (indicate basis for projections in narrative)	FY 1 First Year	FY 2 Second Year	FY 3 Third Year
A. Student Majors			
1. Shifted from other programs	0	0	0
2. New to institution	4	6	8
TOTAL MAJORS	4	6	8
B. Course sections satisfying program requirements			
1. Previously existing	4	7	8
2. New	3	0	0
TOTAL PROGRAM COURSE SECTIONS	8	8	8
C. Credit hours generated by those courses			
1. Existing enrollments	0	0	0
2. New enrollments	100	150	200
TOTAL CREDIT HOURS	100	150	200
D. Degrees awarded	4	6	8
	(yr 2)	(yr 3)	(yr 4)

II. COSTS	EFT	Dollars	EFT	Dollars	EFT	Dollars
A. Personnel-reassigned or existing positions						
1. Faculty	0.325	46,000	0.325	46,000	0.325	46,000
2. Part-time faculty						
3. Graduate Assistant						
4. Administrators	0.25	25,000	0.25	25,000	0.25	25,000
5. Support Staff		32,000		32,000		32,000
6. Fringe benefits		26,780		26,780		26,780
7. Other personnel costs						
TOTAL EXISTING PERSONNEL COSTS		129,780		129,780		129,780

COSTS	EFT	Dollars	EFT	Dollars	EFT	Dollars
B. Personnel – new positions						
1. Faculty						
2. Part-time faculty						
3. Graduate Assistant						
4. Administrators						
5. Support Staff						
6. Fringe benefits						
7. Other personnel costs						
TOTAL NEW PERSONNEL COSTS		0		0		0

C. Start-up costs (one-time expenses)	First Year	Second Year	Third Year
1. Library/learning resources			
2. Equipment			
3. Other (_____)			
D. Physical facilities: construction or major renovation			
TOTAL ONE-TIME COSTS	0	0	0
E. Operating costs (recurring costs – base budget)			
1. Supplies/expenses	2,000	2,000	2,000
2. Travel	1,000	1,000	1,000
3. Equipment			
4. Library/learning resources			
5. Other (Colloquium Speakers)	6,000	6,000	6,000
TOTAL RECURRING COSTS	9,000	9,000	9,000
GRAND TOTAL COSTS	138,780	138,780	138,780

III. REVENUE SOURCES

A. Source of funds			
1. Reallocation of existing funds	138,780	138,780	138,780
2. New student workload	xxxxxxxxxx	xxxxxxxxxx	
3. New tuition	37,536	56,304	75,072
4. Federal funds	0	0	0
5. Other grants			
6. Student fees			
7. Other (_____)			
Subtotal			
New state allocation requested	0	0	0
GRAND TOTAL REVENUES	176,316	195,084	213,852
B. Nature of funds			
1. Base budget	176,316	195,084	213,852
2. One-time funds			
GRAND TOTAL REVENUES	176,316	195,084	213,852

Appendix 1. Letters of support

Dr. Yashwant M. Deo, President AviGenics, Inc., Georgia bioBusiness Center, 111 Riverbend Rd., Athens, GA 30605

Dr. Mark Borodovsky, Regents' Professor, Schools of Biology and Biomedical Engineering and Director of the Center for Bioinformatics and Computational Biology, Georgia Institute of Technology, Atlanta GA 30332-0230

Dr. Clifton A. Baile, Distinguished Professor of Animal Science and Foods & Nutrition and Georgia Research Alliance Eminent Scholar in Agricultural Biotechnology, Edgar L. Rhodes Center for Animal and Diary Science, Athens GA 30602-2771

AviGenics, Inc.

June 13, 2005

To Whom It May Concern:

This letter is to express my enthusiastic support for the proposed, new graduate program in Bioinformatics at the University of Georgia (UGA), Athens, Georgia. Based on my fifteen years of experience in the biotechnology industry, I believe such a program will both help the existing biotechnology companies in Georgia and attract new biotechnology companies and increase venture capital investment to the region.

Bioinformatics combines diverse scientific disciplines and has emerged as a cutting edge tool for developing new commercial applications. The recent advances in genomics, proteomics as well as micro-array based diagnostic, screening and analytical techniques have created an urgent need for scientists trained in the use of computational methods to organize, classify, process and analyze the vast amount of biochemical data generated using these research tools. Such scientists need to have an expertise in mathematics, computer programming, statistics and data analysis combined with a very good understanding of molecular biology, biochemistry, immunology and genetics. The proposed program in Bioinformatics at UGA will accomplish this goal. This program will train M.S. and Ph.D. scientists to become proficient in providing the much needed data analysis expertise to biotechnology companies and inventing new methods to evaluate biological data for modern drug discovery research.

During the past twenty-five years, the biotechnology industry has rapidly grown from its infancy to generating revenues of over $20 billion per year. The history of the biotechnology industry in the US clearly shows that most new ventures are initiated and new companies are established within regions which boast state-of-the-art academic research centers, offer a pool of graduates well-trained in the cutting edge technologies and have clusters of eminent researchers and faculty engaged in developing innovative and revolutionary technologies. The best examples of these include the Bay Area, Boston, the Washington D.C./Maryland area and Research Triangle Park (RTP). The state of Georgia will benefit significantly by establishing a center of excellence and a graduate training program in Bioinformatics by providing a much needed boost to the region's emergent biotechnology industry. Professor Xu and his colleagues have designed a very comprehensive program to advance the frontiers of Bioinformatics research as well as to train young scientists in the applications of modern computational tools to analyze, interpret and exploit the plethora of information obtained from the genomics, proteomics and molecular biology research.

Georgia BioBusiness Center • 111 Riverbend Road • Athens, GA 30605
Office: 706-227-1170 • Fax: 706-227-2180

UGA will become one of the very few academic institutions in the world to offer such an integrated, comprehensive and commercially relevant training program in Bioinformatics. If such a program is established, our Company will use this expertise and, in the future, hire a few graduates to assist in our product development projects. I am sure other biotechnology companies in Georgia will also find this a very useful and valuable resource for their endeavors. Eventually, this program will attract new ventures to the state of Georgia and create new, high-paying employment opportunities for the residents of this state. In summary, I believe that a graduate training program in Bioinformatics will uniquely position Georgia as a premier location for biotechnology.

Please contact me if you need any additional information and I will be happy to elaborate on my resounding endorsement for this visionary proposal to initiate a graduate training program in Bioinformatics at UGA.

Sincerely,

Yashwant Deo

Yashwant M. Deo
President
AviGenics, Inc.

Georgia Institute of Technology

School of Biology
Atlanta, Georgia 30332-0230 U.S.A.
PHONE 404-894-3700
FAX 404-894-0519

August 31, 2005

Ying Xu, Ph.D.
Regents-GRA Eminent Scholar and Professor
Dept of Biochemistry and Molecular Biology
Director, Institute of Bioinformatics
University of Georgia
120 Green Street, Athens, GA 30602-7229

Dear Ying:

I have learned with great interest that you are leading the effort of establishing at the University of Georgia a graduate program in Bioinformatics which will offer both Master and PhD degrees.

I strongly believe that this development will advance the interdisciplinary research at the University of Georgia and presence of enthusiastic graduate students will facilitate interactions between faculty conducting biological science related and motivated research while being affiliated with different departments.

In the previous years we have established the Master of Science (1999) and PhD degree (2003) programs in Bioinformatics at Georgia Tech. My observations made upon the years of these developments have shown that forming critical mass of graduate students has initiated a large scale transformation of the intellectual environment of biological research at Georgia Tech. Currently, faculty members of the School of Biology are very interested in getting graduate students who will carry on research in bioinformatics and be co-advised by a faculty from quantitative science or engineering department and vice versa. Students with background in computer science or electrical engineering are currently involved in first class biological research. Similar needs exist at Emory University, and currently, before a training program of the same level is established at Emory, many Emory faculties are interested in co-advising Georgia Tech Bioinformatics graduate students.

There is a rapidly unfolding process of changing the conceptual essence of biological research which takes advantage of massively generated data on primary structures of genomes and proteomes. This process takes place in many top research universities which actively seek to develop scientifically rich and well organized programs of research training in Bioinformatics.

A Unit of the University System of Georgia An Equal Education and Employment Opportunity Institution

As I am aware of, the University of Georgia has a constellation of outstanding faculty whose research interests are overlapping the area of Bioinformatics. I understand that this group has been consolidated into the Institute of Bioinformatics (IOB) with you as a Director. The IOB web site (www.bioinformatics.uga.edu/people.php) shows that IOB has already 34 full members and 15 associate members. The IOB structure is already well developed and several committees have been set up, such as Program Development Committee (chaired by Dr. Dan Kannan) and Curriculum Committee (chaired by Dr. Barny Whitman).

Having said all this, I can state with full confidence that at this time the University of Georgia research environment would greatly benefit from establishing a graduate program in Bioinformatics (MS and PhD). There is also an excellent potential for successful development of such a program in terms of available resources and determination of faculty involved in the Bioinformatics research.

I firmly support the idea of creating this new graduate program at the University of Georgia, and will be happy to help and share the experience that we have accumulated at Georgia Tech

Yours sincerely



Mark Borodovsky, PhD
Regents' Professor, Schools of Biology and Biomedical Engineering
Director, Center for Bioinformatics and Computational Biology
Founder, MS and PhD Program in Bioinformatics
Georgia Institute of Technology
Atlanta, GA 30332-0230

The University of Georgia

College of Agricultural and Environmental Sciences
Animal and Dairy Science Department
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Fax: 706-542-7925
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July 5, 2005

Dr. Ying Xu, Director
Institute of Bioinformatics
University of Georgia
120 Green Street
Athens, GA 30602-7229

Re: Doctor of Philosophy in Bioinformatics degree program

Dear Dr. Xu:

I wish to add my support for the proposal to establish the Doctor of Philosophy in Bioinformatics degree program at the University of Georgia in the Institute of Bioinformatics. I understand that the mission of this degree program is to educate and prepare the next generation of leaders in research and innovation in the rapidly growing field of bioinformatics, and to establish the University of Georgia as a national leader in this emerging interdisciplinary field. I think this a very important addition to the opportunities offered by the University of Georgia.

As you know, in my role as an entrepreneurial GRA Eminent Scholar I have been involved in establishing several biotechnology based startup companies in Athens. Bioinformatics has to date played little role in the enhancement of the technology being commercialized from discoveries made at the University of Georgia. I am sure that students trained in bioinformatics capable of tackling very complex biological problems at a systems level will add another very important resource to the research community and provide new employment opportunities for the Athens community. There are many other opportunities in Georgia where people with training in bioinformatics will add a new dimension to existing and emerging technologies.

I strongly support developing the Doctor of Philosophy in Bioinformatics degree program at the University of Georgia in the Institute of Bioinformatics. I believe that this new activity will fill an unmet need and will generate many opportunities to create value from existing technologies and will help create novel and very competitive new programs for the University and for Georgia. Please contact me if I can provide any further information.

Sincerely,

Clifton A. Baile

Clifton A. Baile, Ph.D.
Distinguished Professor of Animal Science and Foods & Nutrition &
Georgia Research Alliance Eminent Scholar in Agricultural Biotechnology

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An Equal Opportunity/Affirmative Action Institution

Appendix 2: Consultant Reports

Dr. Keith Dunker, Indiana University

Dr. Eric Jakobsson, University of Illinois at Urbana-Champaign

Dr. Bruce Weir, North Carolina State University

Assessment of the Proposed MS and PhD Degree Programs in bioinformatics at the University of Georgia.

From: A. Keith Dunker
Professor of Biochemistry and Molecular Biology
Professor of Informatics
Director of the Center for Computational Biology and Bioinformatics
Indiana University
Indianapolis, IN 46202.

Section 1: Program Abstract

A good case has been made for the need and for the importance of developing both MS and PhD Degree Programs in computational biology/bioinformatics. The number of courses already in place documents that researchers across many biological fields at the University of Georgia are already using bioinformatics methods in their research. In my experience, in the absence of formal courses, the various bioinformatics methods are often used incorrectly by inexperienced biologists. The courses that have already been developed demonstrate recognition of the importance of education in this area. In light of these already existing courses, developing the described MS and PhD Degree Programs seems like a very logical next step.

It is claimed that over 70 US universities have established advanced degree programs in computational biology or bioinformatics with (http://www.sloan.org/main.shtml) given as a reference for this statement. No list of 70 programs could be found by this reviewer at the indicated website (perhaps the list is there, but it is not obvious how to find it). An alternative, world-wide list with more than 70 advanced degree programs in the US is to be found at the website of the International Society for Computational Biology (ISCB), namely at (http://www.iscb.org/univ.shtml).

It would also be reasonable to mention the ISCB, a vigorous, growing international society, as further evidence that computational biology or bioinformatics is developing as a field.

Section 2: Program Objectives

The objectives for the MS and PhD Degree Programs are both the same: to establish a strong graduate program, to foster and generate nationally and internationally recognized research in bioinformatics, and to build strong ties between the university and external constituencies.

It would be helpful to differentiate the MS and PhD Degree Programs. The program objectives for the PhD match those already given. However, the objectives for the MS program should be geared more towards providing competent technical workers for Georgia's nascent biotechnology industry.

Section 3: Justification and Need for the Program

It is difficult to overstate the need for developing MS and PhD Degree Programs in bioinformatics and computational biology. At its core, biology is fundamentally an information science. In the last 100+ years, efforts in biology and biochemistry have focused on understanding the various chemical parts of the living cell; in the next 100+ years, efforts will focus on understanding how the interactions, control, regulation, and signaling among the various parts leads to a living cell. Computer and information science will be at the core of

these activities. Arguably, bioinformatics will become the most central yet the most widely impacting of the biological sciences.

Again, it would be helpful to differentiate the MS and PhD Degree Programs in this justification and need for the program. As indicated above, some consideration of the different responsibilities of MS versus PhD holders would help to clarify the distinctions.

Section 4: Procedures Used to Develop the Program

This section contains an historical narrative of the steps that led to the proposal of the two degree programs. This history adds weight to the justification.

Section 5: Curricula

For both the MS and PhD Degree Program, the courses have been thoughtfully chosen with the recognition that the course requirements will be different for students with a biology background as compared to students with a more quantitative science background. Also, the differentiation between thesis and non-thesis MS Degree Programs seems to closely follow the norms for other fields of science. Overall, the MS and PhD curricula seem both appropriate and carefully devised.

Section 6: Inventory of Faculty Directly Involved

The list of faculty is long and spans many if not all of the biological sciences departments on the University of Georgia campus. This document would be much stronger if each member provided a one sentence description of the bioinformatics methods being used in his or her research.

Section 7: Outstanding Programs of This Nature at Other Institutions

North Carolina State, Stanford, and Washington University are listed as having outstanding programs. These are certainly among the best programs in the US, but there are several other programs worthy of mention, including those at the following institutions: University of Illinois, Boston University, and Iowa State University to name three more. The Iowa State University program has substantial collaboration with researchers at the University of Iowa; this could be a model for a collaboration between the University of Georgia and Georgia Tech.

Section 8: Inventory of Pertinent Library Resources

The library resources seem good, but Bioinformatics is an emerging field and several new journals have started in the last 4 years. Additional library resources may be required due to the newness of this field.

Section 9: Facilities

No mention is made of current and future computer resources. Current computer resources should be described along with estimates of future needs.

Section 10: Administration

The plan for the administration is minimal, but is likely to be adequate for the purpose. Nevertheless, this reviewer finds many details to be lacking. To give one example, it is stated that "The IOB Graduate Affaires Committee will consist of the Graduate Coordinator and four members of the bioinformatics faculty. These faculty will be chosen to represent the diverse and interdisciplinary character of the institute…" There is no indication who will do the choosing. Will the four faculty be elected by other faculty in the institute? Or will the four faculty be chosen by the Director? How long will their terms be? Will a new group of four be chosen or will a small number rotate off and others rotate on to keep continuity? Perhaps all of these issues will be settled by the local customs of the University of Georgia and therefore need not be spelled out this document. However, an attention to some of these details might be helpful by settling a number of administrative issues in advance.

Section 11: Assessment

The assessment states that the "students will form an advisory committee. In addition to its mentoring responsibilities, the advisory committee will evaluate the student's progress at least once a year." This reviewer is confused. Does this mean that each student's progress will be evaluated once a year by a student advisory committee? Ordinarily, a faculty committee would carry out such an evaluation. Otherwise, the assessment plan seems appropriate.

Section 12 Accreditation; Section 13: Affirmative Action Impact; Section 14: Degree Inscription; and Section 15: Fiscal and Enrollment Impact and Estimated Budget

Sections 12 to 15 all seem to be appropriate.

Summary Comment:

The proposed MS and PhD Degree Programs in Bioinformatics are both timely and necessary. These programs are necessary for the University of Georgia to maintain its long-standing leadership role in the biological sciences. The many biological science departments at the University of Georgia will be negatively impacted in a very severe way without the development of these degree programs.

Assessment of proposed Ph.D. program in bioinformatics—University of Georgia
From: Eric Jakobsson, University of Illinois at Urbana-Champaign
Emphases on sections 3, 7, 10, 11

Section 3 in general the stated rationale is accurate and compelling. I have one editorial suggestions. On page 6, where is stated, "Currently, there is a widely held belief that while physics has been the key driving force for the advancement of mathematical and computational sciences in the past few centuries, biology is probably going to become the main driving force for the future advancement of mathematical and computational sciences." I wonder if it is necessary to do a comparison in which the importance of physics is downplayed. One could say something like "The necessity to model and understand massive amounts of genomic and functional biological data are leading to the development of new mathematical and computational techniques, in much the same way that mathematical and calculational techniques have been developed for centuries to model and understand physical phenomena."

Section 7, in listing outstanding comparable programs at other institutions, one should mention Boston University and the University of Michigan.

In considering the potential value of the program to your institution, you could point out that Stanford and Michigan between them obtained grants for 3 of the 7 NIH National Centers for Biomedical Computing, beating out other schools with superb researchers in the field but without formal graduate degree programs. I think one can reasonably argue that there is a strong institutional value to a Ph.D. program, in that the degree program develops faculty cohesiveness for support of collaborative projects and programs, in addition to the educational and training benefit to the students.

Section 10. What is there is fine, but I would add consideration of the following issues:

What is the role of the Institute of Bioinformatics and the leadership of the Ph.D. in tenure and promotion of faculty in the IOB? I strongly suggest spelling out that the role of the IOB be purely in terms of providing additional supporting documentation for tenure and promotion decisions for participating faculty, and that participating faculty need not be approved for promotion or tenure by the IOB. Perhaps everybody involved at Georgia agrees on this, but I saw a misunderstanding about this in a promotion decision on our campus blow up into a very destructive situation, so I would make the understanding explicit.

I think the extent to which students in the program have other support than research assistantships on faculty grants will be important to the success of the program. Of course, if you have a productive faculty you will have a lot of RA support. But the more time you can give beginning students to be on other support, up to an average of two years if possible, the farther your faculty's research dollars will go, and the more attractive your program will be to the best students.

Section 11, I would add as a criterion for assessing the program:

Importance of the student research in providing a foundation for securing research funding from outside agencies.

Assessment of proposed Master's Degree program.

Section 3. The rationale in the document is essentially the same as for the Ph.D. program. I wonder if the rationale should be somewhat different. If one thinks of Master's programs in engineering disciplines, they are aimed at producing workers for particular niches in industry or other specifically mission-driven enterprises, whereas the Ph.D. is aimed at producing professors and other thought leaders.

In designing the Master's degree program, I would recommend taking a look at the array of Master's degree professional bioinformatics programs supported by the Sloan Foundation (see http://www.sciencemasters.com/cmb/), and consider the issues discussed there, and the experiences of the programs that they have supported.

Section 7. Look at the Sloan list at the Web site cited above as a starting point for excellent Master's programs in bioinformatics.

Section 10. The first paragraph of my comments on the Ph.D. program apply here as well.

Section 11. The criterion I suggested for the Ph.D. program would not apply here. However I would suggest a different additional criterion for the MS. program:

Generating interest from industry to support internships of Master's students. (I think this is a common attribute of successful professional Master's programs.)

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http://statgen.ncsu.edu

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November 5, 2005

Professor Ying Xu
Institute of Bioinformatics
Life Sciences Building B118
University of Georgia
120 Green Street
Athens, GA 30622

Dear Professor Xu,

Thank you for the opportunity to review your proposal for degree programs in bioinformatics at the University of Georgia. I congratulate you and your colleagues on good planning for an important development. I have some comments on the overall program and then on the Masters and Doctoral programs separately. These comments are based on my experience over the past five years of directing similar programs at North Carolina State University.

Overall Program

I endorse the statements in the proposal on the need for graduate training in bioinformatics. The need is acute at the international, national and regional levels. Our dependence on advances in agriculture and medicine means that there must be scientists and technicians with training to manage and analyze increasing amounts of genomic, proteomic and metabolomic data. Traditional training programs in the mathematical, computational or biological sciences do not have the breadth that these datasets require. The University of Georgia is unusually well suited to embark on this new interdisciplinary training, and indeed is rather late in making this proposal.

The proposal does not describe program pre-requisites but it implies that entering students will have either biological or quantitative science backgrounds but not both. Given that demand is likely to exceed capacity, some thought might be given to requiring a minimal level of interdisciplinary training prior to admission: programming or statistics experience for biologists, basic genetics for statisticians or computer scientists for example. The core curricula, however, are sufficiently broad.

The proposal does not mention training in the responsible and ethical conduct of science. Such training should be required for all graduate students, quite apart from it being mandated by NIH training grants. There is also no mention of a provision for exposure to current research and literature. I expect that the Institute of Bioinformatics has a seminar series that could well be required for bioinformatics students. Thought could also be given to requiring a journal club so that students gain experience in reading and discussing current literature.

The list of Full Members of the Institute of Bioinformatics is impressive, although it lists only one (junior) statistics faculty member. The role of statistics in bioinformatics is no less important than that of computer science and the biological sciences and increased participation by the Department of Statistics, or new hires in statistical aspects of bioinformatics, would be desirable.