PROPOSAL FOR A CROP SCIENCES CONCENTRATION WITHIN THE MASTER OF SCIENCE (M.S.) IN BIOINFORMATICS

SPONSORS

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BRIEF DESCRIPTION

The Department of Crop Sciences and the College of Agricultural, Consumer and Environmental Sciences (ACES) propose a Crop Sciences concentration within the campus-wide M.S. program in Bioinformatics, one of two initial concentrations that focus on interdisciplinary studies in bioinformatics within the agricultural and life sciences.

JUSTIFICATION FOR AN ACES CONCENTRATION WITHIN THE M.S. IN BIOINFORMATICS

The discipline of Bioinformatics addresses the need to manage and interpret the data that is being massively generated by genomic and proteomic research. This discipline represents the convergence of biology, computer and information technology sciences, and encompasses analysis and interpretation of biomolecular data, modeling of biological phenomena, and development of algorithms and statistical approaches. With current technology, scientific discovery occurs in a global arena and data are stored and archived massively in databases, disseminated through cable or wireless conduits, and analyzed. This includes information on genomes, biomolecules, biomolecular circuitry, and biological processes at the molecular, cellular, individual and population levels. Our world expects substantial pay-offs from the analysis of multi-dimensional data structures, including proactive control and clear understanding of chemical, biological and cosmological processes. Ultimately, we expect a better life. The College of Agricultural, Consumer and Environmental Sciences (ACES) and the Department of Crop Sciences have a comprehensive mission that relates to agriculture, food, and environment, and is driven mainly by a human-community dimension. This involves addressing important issues in biology. Within this framework, bioinformatics plays an important role in the management and exploitation of microbial, plant and animal genomic resources.

Biology, Agriculture and Science in Bioinformatics

Researchers in the microbial, plant and animal sciences have contributed to developments in bioinformatics, mostly through advances in genetics, genomics, proteomics, population biology, ecology and evolution. Departments within agricultural campuses throughout the US offer courses in genomic science that have immediate applications to agriculture. Many life sciences and agricultural colleges offer undergraduate and graduate Bioinformatics programs including the College of Agriculture and Life Sciences at North Carolina State University, the College of Natural and Agricultural Sciences at University of California at Riverside, and the College of Agriculture, Natural Resources and Science at Utah State University. The Department of Crop

Sciences and our College of ACES have resident expertise and can support a bioinformatics curriculum that stresses its underlying mission.

Why Should a Bioinformatics Concentration Be Offered by the Department of Crop Sciences within the College of ACES?

Bioinformatics is at the cross roads of experimental and theoretical science and includes biological fields as diverse as molecular evolution, biological modeling, statistical genomics, and systems biology. Bioinformatics has immediate applications in the agricultural sciences. These applications include understanding the molecular basis of biological phenomena related to plants, animals and associated microbes, and their impact in plant and animal improvement. Bioinformatics is a dynamic interdisciplinary field. Much like biotechnology and genomics, bioinformatics is moving from applied to basic science, from developing tools to developing hypotheses. The proposed Crop Sciences concentration within the M. S. in Bioinformatics will provide advanced training in aspects of bioinformatics that pertain to the dynamic and complex behavior of biomolecular systems interacting with biotic and abiotic environments. This will prepare students for employment in research laboratories in academia, government and the private sector, especially those with a biotechnology, pharmaceutical, agrochemical and agrobiological focus. Our concentration will ensure that molecular biology and biotechnological principles as well as more traditional fundamentals (genetics, breeding, population biology, quantitative genetics, statistical genomics, systems approaches, etc.) are adequately covered in the M.S. degree, together with training in computer sciences and bioinformatics. This comprehensive training should satisfy the specific demands of a degree based on the agricultural and life sciences.

By offering this concentration, we ensure that Bioinformatics applications unique to the College of ACES and the Department of Crop Sciences are thoroughly addressed in the M.S. in Bioinformatics degree offered at the University of Illinois at Urbana-Champaign. Numerous research initiatives in the Department of Crop Sciences and the College of ACES are generating large quantities of complex biology data that require the integration of expertise in computer and life science. Likewise, the private industry partners and federal agencies have described their demand for a highly qualified workforce in ag-informatics, computer and biology sciences. The U.S. Department of Agriculture and the National Institutes of Health (NIH) have ongoing intramural and extramural bioinformatics programs, and the key role of bioinformatics at NIH resulted in the creation of the Biomedical Information Science and Technology Initiative in 2000. In addition, the Department of Crop Sciences and the College of ACES have close physical and scientific relationships to leading campus-wide Genomics, Proteomics and Biotechnology efforts, namely the Institute for Genomic Biology, the W.M. Keck Center for Comparative and Functional Genomics, and the UIUC Biotechnology Center. The graduates of our Bioinformatics M.S. program will have the theoretical basis and experience to apply their skills towards doctoral programs, and academic, industry and government positions.

DEGREE REQUIREMENTS FOR THE CROP SCIENCES CONCENTRATION

The Crop Sciences concentration within the M.S. in Bioinformatics will be offered in both thesis and non-thesis versions.

The thesis option, requires a minimum of 32 hours, including 28 hours of coursework with at least 12 hours at the 500-level and 8 hours within the Department of Crop Sciences. Of the 32 hours, a minimum of 12 hours must be within a General core, equally distributed between

Fundamental Bioinformatics, Biology, and Computer Science courses. The General core complies with the requirements of the campus-wide Master of Science in Bioinformatics. In addition, a minimum of 7 hours of courses in Computational, Quantitative and Statistical Biology must be completed, together with a minimum of 5 hours of electives. Within the Computational, Quantitative and Statistical Biology core, the students must take CPSC 440 (Applied Statistical Methods I), or CPSC 540 (Applied Statistical Methods II) if CPSC 440 or an equivalent course has been fulfilled. No double counting is possible; the same course cannot be used to satisfy the General core and the Computational, Quantitative and Statistical Biology core requirements simultaneously. The courses approved for the General core and the Computational, Quantitative and Statistical Biology core are listed below. Electives can be satisfied with any graduate-level course; however, students must select elective courses in consultation with their departmental advisor and are strongly encouraged to select from among courses offered by the Department of Crop Sciences. Students must also complete a minimum of 4 hours of thesis within Crop Sciences research (CPSC 599). Students are required to register each semester for 1 h of seminar in one of the sections of Crop Sciences. A student may be exempted from seminar for the semester or register for a seminar in another department upon the recommendation of his/her advisor and approval of the graduate coordinator. Students are required to present a seminar on their thesis research during the last semester of their study program.

With the permission of their advisor, students in the Department of Crop Sciences may choose to pursue a non-thesis option within the M.S. in Bioinformatics. The non-thesis option requires a minimum of 36 hours with the same course requirements specified in the thesis option. Supplementary requirements towards satisfying the 36 hours include an additional minimum of 3 hours of General Core courses, an additional minimum of 3 hours of Computational, Quantitative and Statistical Biology core courses, and an additional minimum of 3 additional hours of elective courses, for a minimum total of 9 hours. The student may incorporate supervised research experiences including internships and projects to complete the remaining required hours of the non-thesis option. No course can be used to satisfy more than one requirement.

Courses

1. <u>General courses</u>

At least one course in each of the following three areas:
1a. Fundamental Bioinformatics (4 hours)
    CPSC 569 / ANSC 542   Applied Bioinformatics
    ANSC 543 / CHBE 571 / STAT 530 / MCB 571   Bioinformatics
1b. Biology (4 hours)
    CPSC 452 Genetics of Higher Organisms
    CPSC 568 Recombinant DNA Technology Lab
    CPSC 556 / HORT 566   Plant Gene Regulation
1c. Computer Science (4 hours)
    CS 411   Database Systems
    CS 473   Algorithms

2. <u>Courses in Computational, Quantitative and Statistical Biology</u>

At least 7 hours distributed as follows:

2a. One required course to be selected between:

    CPSC 440   Applied Statistical Methods I
    CPSC 540   Applied Statistical Methods II

2b. And at least one elective course to be selected among:

ANSC	441	Human Genetics
ANSC	444	Applied Animal Genetics
ANSC	445	Statistical Methods
ANSC	446	Population Genetics
ANSC	447	Quantitative Genetics
ANSC	543	Bioinformatics
ANSC	545	Statistical Genomics
CPSC	432	Genetic Toxicology
CPSC	440	Applied Statistical Methods I
CPSC	540	Applied Statistical Methods II
CPSC	541	Regression Analysis (approval in progress)
CPSC	452	Genetics of Higher Organisms
CPSC	453	Principles of Plant Breeding
CPSC	454	Plant Breeding Methods
CPSC	558	Quantitative Plant Breeding
CPSC	563	Molecular Cytogenetics
CPSC	564	Molecular Marker Data Analyses
CPSC	567	Bioinformatics and Systems Biology (approval in progress)
CPSC	569	Applied Bioinformatics
CS	400	Data Structures, Non-CS Majors
CS	411	Database Systems
CS	413	Introduction to Combinatorics
CS	418	Computer Graphics
CS	420	Intro to Parallel Programming
CS	446	Machine Learning & Pattern Recognition
CS	450	Introduction to Numerical Analysis
CS	473	Algorithms
CS	484	Computer Data Acquisition Sys
CS	512	Data Mining
CS	519	Scientific Visualization
CS	542	Artificial Neural Networks
CS	578	Information Theory
STAT	424	Analysis of Variance
STAT	425	Applied Regression and Design
STAT	429	Time Series Analysis
STAT	525	Computational Statistics
STAT	571	Multivariate Analysis
VP	554	Molecular and Evolutionary Epidemiology
MCB	421	Microbial Genetics

MCB   432   Computing in Molecular Biology

IB   402   Molecular Evolution
IB   405   Ecological Genetics
IB   504   Genomic Analysis of Insects

LIS   451   Introduction to Network Systems
LIS   501   Info Org and Access

BIOP   420   Molecular Biophysics
BIOP   541   Macromolecular Modeling

CHEM   470   Computational Chemical Biology
CHEM   574   Genomics, Proteomics, and Bioinformation

3. *Elective Graduate Courses*
At least two courses (5 hours) selected by the student in consultation with his/her advisor. Crop Sciences courses are highly recommended.

Prerequisites

To ensure the success of all students pursuing this concentration within the M.S. in Bioinformatics in a timely manner, applicants to the program must have a solid background in biology, training in mathematics, and some experience in computer science. Expected background includes:
- at least one Calculus course equivalent to University of Illinois MATH 220 or 234 or more advanced,
- at least one Statistics course equivalent to University of Illinois STAT 100 or ACE 261 or CPSC 241 or MATH 161 or more advanced,
- at least one Plant or Molecular and Cellular Biology course equivalent to University of Illinois CPSC 112 or IB 103 or MCB 100 or more advanced,
- at least one introductory Computer Science course equivalent to University of Illinois CS 101 or 110.

Students with deficiencies in these prerequisites are expected to remediate this situation even when the remediation does not amount to credit towards the Crop Sciences concentration within the M.S. in Bioinformatics degree.

Applications

Students may enter this concentration within the M.S. in Bioinformatics program through the Department of Crop Sciences.

GUIDELINES FOR UNDERGRADUATE EDUCATION: Not applicable

EXPECTED ENROLLMENT

We expect that approximately 8 new students will enter this degree option every year and that the time to graduation will be two to three years.

BUDGETARY, FACILITIES AND STAFF REQUIREMENTS

a. Additional staff and dollars needed
None.

b. Additional Facilities required
None. The College of ACES and, in general the University of Illinois, have state-of-the-art computer laboratories and library resources located in the LIAC. In addition, the Biotechnology Center and Institute for Genomic Biology support the program's training and educational efforts.

c. Internal reallocations
We do not expect significant changes in the teaching loads in courses currently offered by the department in the short term. In addition, we anticipate that current and future faculty hires related to the Post-Genomic Initiative and faculty associated with the Institute for Genomic Biology may offer courses on the most recent Genomic and Proteomic techniques.
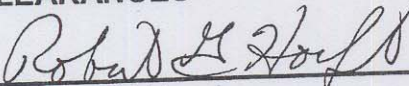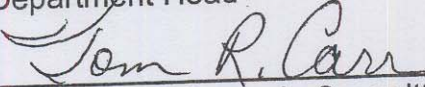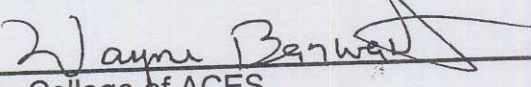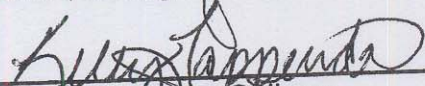
d. Effect on course enrollments in other departments and explanations of discussions with representatives of these departments.
Although the students enrolling for the proposed concentration are encouraged to take courses across departments and colleges, only one requirement, the General Core Computer Science, relies solely on non-ACES resources. We expect that the proposed concentration will have minor impact on the Computer Science courses, based on their current enrollment relative to the number of students expected to be enrolled in this concentration.

e. Impact on library, computer use, laboratory use, equipment, etc.
No significant impact is expected.

CLEARANCES

_____   11-02-06
Department Head   Date

_____   11/03/06
Courses and Curricula Committee, College of ACES   Date

_____   11/03/06
Dean, College of ACES   Date

_____   11/8/06
Dean, Graduate College   Date

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Assoc. Provost   Date

STATEMENT FOR THE BULLETIN

Crop Sciences concentration within the M.S. IN BIOINFORMATICS
Executive director: Gustavo Caetano-Anolles

Correspondence Information: Department of Crop Sciences, University of Illinois, 1102 S. Goodwin Ave. Urbana, IL 61801; (217) 333-3420; E-mail: gca@uiuc.edu. Website for the Crop Sciences concentration: URL, http://cropsci.uiuc.edu/academics/bioinformatics (under construction).

The genomic and proteomic projects are generating large amounts of complex biological data that require effective storage, retrieval, analysis and interpretation. The bioinformatics degree program provides students with the skills necessary to augment the understanding and use of agricultural, biological and medical information and resources through the application of molecular, chemical, physical, computational, statistical, mathematical and informatic techniques. Students interested in this program may come with undergraduate training in one of the following areas: (a) biological and agricultural sciences, (b) statistical, mathematical and computer sciences, (c) informatics and engineering sciences. Graduates from the bioinformatics program will be able to integrate basic and applied concepts in the three areas and applied them to biotechnology and medical research.

The Crop Sciences concentration within the M. S. degree in Bioinformatics with thesis option requires students to complete a minimum of 32 hours, including a set of core courses in fundamental bioinformatics, biology, and computer science, 12 hours in 500-level courses, 8 hours in courses within the Department of Crop Sciences, at least 4 hours of thesis work, and seminars in the Department of Crop Sciences. The non-thesis option requires students to complete a minimum of 36 hours including the same requirements for the thesis option, additional course work and optional supervised research experiences.

EFFECTIVE DATE: Fall 2007