

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

### SPONSORS

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### BRIEF DESCRIPTION

The Department of Animal Sciences and the College of Agricultural, Consumer and Environmental Sciences (ACES) propose to establish an Animal Sciences concentration within the campus-wide M.S. program in Bioinformatics. This is one of two initial concentrations of the M.S. in bioinformatics with a 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. Nowadays, everything can and will be measured at a global scale, stored and archived 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 giant 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 ACES and the Department of Animal Sciences have a wide-encompassing 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 adequate 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 Animal 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 Animal 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 truly interdisciplinary field that is always changing. Much like biotechnology and genomics, bioinformatics is moving from applied to basic science, from developing tools to developing hypotheses. The proposed Animal 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 in interaction 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 Agricultural, Consumer and Environmental Sciences and Animal 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 Animal 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 US 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 Animal 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 ANIMAL SCIENCES CONCENTRATION**

The Animal Sciences concentration within the M.S. degree program in Bioinformatics requires a minimum of 36 hours, including at least 12 hours at the 500-level. Of the 36 hours, 8 hours must be on thesis research in the Department of Animal Sciences and 28 hours must be on course work distributed as follows:

1. *Core courses.* At least 12 hours distributed as follows:

1a. *Fundamental Bioinformatics* (4 hours)  
ANSC 542 Applied Bioinformatics

ANSC 543 / CHBE 571 / MCB 571 STAT 530 Bioinformatics

1b. *Biology* (4 hours)

- ANSCI 446 Population Genetics
- ANSCI 447 Quantitative Genetics
- CPSC 452 Genetics of Higher Organisms
- CPSC 568 Recombinant DNA Technology Lab
- CPSC 556 Plant Gene Regulation
- CPSC 564 Molecular Marker Data Analysis

1c. *Computer Science* (4 hours)

- CS 411 Database Systems
- CS 473 Algorithms

2. *Computational, Quantitative and Statistical Biology* courses. At least 7 hours distributed as follows:

2a. One course to be selected between:

- ANSC 440 Applied Statistical Methods I
- ANSC 540 Applied Statistical Methods II

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

- ANSC 441 Human Genetics
- ANSC 444 Applied Animal Genetics
- ANSC 440 Applied Statistical Methods I
- ANSC 540 Applied Statistical Methods II
- ANSC 446 Population Genetics
- ANSC 447 Quantitative Genetics
- ANSC 542 Applied Bioinformatics
- ANSC 543 Bioinformatics
- ANSC 545 Statistical Genomics
  
- CPSC 432 Genetic Toxicology
- CPSC 440 Applied Statistical Methods I
- CPSC 452 Genetics of Higher Organisms
- CPSC 453 Principles of Plant Breeding
- CPSC 454 Plant Breeding Methods
- CPSC 540 Statistical Methods II
- CPSC 541 Applied Statistical Methods III
- CPSC 558 Quantitative Plant Breeding
- CPSC 563 Molecular Cytogenetics
- CPSC 564 Molecular Marker Data Analyses
- CPSC 567 Bioinformatics and Systems Biology
  
- CS 400 Data Structures, Non-CS Majors
- CS 411 Database Systems
- CS 413 Intro to Combinatorics
- CS 418 Computer Graphics
- CS 420 Intro to Parallel Programming

CS 446	Machine Learning & Pattern Rec
CS 450	Intro 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 / STAT 563	Information Theory
CHBE 580	Laboratory Techniques in Bioinformatics
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	Mol and Evol Epidemiology
MCB 418	Human Genetics
MCB 421	Microbial Genetics
MCB 423	Evolution in a Microbial World
MCB 432	Computing in Molecular Biology
MCB 554	Genomics, Proteomics, Bioinformation
IB 402	Molecular Evolution
IB 405	Ecological Genetics
IB 504	Genomic Analysis of Insects
LIS 451	Intro to Network Systems
LIS 501	Info Org and Access
BIOP 420	Molecular Biophysics
BIOP 541	Macromolecular Modeling
CHEM 574	Genomics, Proteomics, and Bioinformation

3. *Seminar*: 2 hours of Animal Sciences Seminar.

#### 4. *Elective Graduate Courses*

Graduate courses selected by the student in consultation with his/her advisor. Animal Sciences courses are highly recommended.

No double-counting of course work is allowed; the same course cannot be used to satisfy the Core and the Computational, Quantitative and Statistical Biology requirements simultaneously. Students must maintain a grade point average of at least 3.00 (4.00=A) while they are enrolled in the program. Students must defend a thesis that is approved by a committee of at least three UIUC Graduate faculty and submitted to the Graduate College in conformance with Graduate

College requirements. All requirements must be completed within five years of initial registration in the Graduate College.

### **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 U of I MATH 220 or 234 or more advanced,
- at least one Statistics course equivalent to U of I STAT 100 or ACE 261 or CPSC 241 or MATH 161 or more advanced,
- at least one Plant (Animal) or Microbe Biology course equivalent to U of I ANSC 100 or IB 104 or MCB 100 or more advanced,
- at least one introductory Computer Science course equivalent to U of I 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 Animal 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 Animal 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**

Department Head	Date
Courses and Curricula Committee, College of ACES	Date
Dean, College of ACES	Date
Dean, Graduate College	Date
Assoc. Provost	Date

**STATEMENT FOR THE BULLETIN**

Animal Sciences concentration within the M.S. IN BIOINFORMATICS

Director: Bryan White

Executive director: Sandra Rodriguez-Zas

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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 Animal Sciences concentration within the M.S. degree in Bioinformatics requires students to complete a minimum of 36 hours, including 28 hours of course work and 8 hours of thesis research. Students must complete a set of required and elective courses including 12 hours in 500-level courses, 8 hours in courses within the Department of Animal Sciences, and 2 hours in the Department of Animal Sciences seminar.

**EFFECTIVE DATE:        Fall 2007**