Outline for Proposal of New Area of Specialization

This form is to be used for proposing new areas of Specialization to the office of Graduate Studies.

Name of the proposed Area or Interdepartmental Area of Specialization:
Bioinformatics

Specialization is:  Masters  Doctoral  Both  XX
Degree(s) to be offered:  M.S.  Ph.D.

List the participating Department(s):
Agronomy and Horticulture, Animal Science, Biochemistry, Biological Sciences, Chemistry, Computer Science and Engineering, Electrical Engineering, Food Science and Technology, Mathematics, Statistics, Plant Pathology and Veterinary and Biomedical Sciences

List the Participating Graduate Programs:
Agronomy, Animal Science, Biochemistry, Biological Sciences, Chemistry, Computer Science, Electrical Engineering, Food Science and Technology, Integrative Biomedical Sciences, Mathematics, Statistics, and Veterinary Sciences.

Names of the Advisory Committee members:


Computer Science and Engineering: Jitender Deogun (Chair), Etsuko Moriyama, Stephen Scott.

APPROVALS

I. This proposal is being submitted on behalf of the faculty for the proposed Area of Specialization.

Chair of Advisory Committees (Life Sciences)  Date

Chair of Advisory Committees (Computer Science and Engineering)  Date
II. This proposal has been reviewed and approved by the Graduate Committee(s) of the sponsoring department(s).

<table>
<thead>
<tr>
<th>Chair, Department of Agronomy Graduate Committee</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair, Department of Animal Science Graduate Committee</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Statistics Graduate Committee</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Food Science and Technology Graduate Committee</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Veterinary and Biomedical Sciences Graduate Committee</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Biochemistry Graduate Committee</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, School of Biological Sciences Graduate Committee</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Chemistry Graduate Committee</td>
<td>Date</td>
</tr>
</tbody>
</table>
II. [continued]

Chair, Department of Computer Science and Engineering Graduate Committee  Date

Chair, Department of Electrical Engineering Graduate Committee  Date

Chair, Department of Mathematics Graduate Committee  Date

III. The department(s) listed below agree(s) to sponsor the Area of Specialization proposed in this document. By serving as the sponsor for the proposed Area of Specialization, the department(s) is (are) making a commitment to provide sufficient resources for that Area of Specialization to thrive.

Name(s) of Sponsoring Department(s)

Chair, Department of Agronomy and Horticulture  Date

Chair, Department of Animal Science  Date

Chair, Department of Statistics  Date

Chair, Department of Food Science and Technology  Date
III. [continued]

<table>
<thead>
<tr>
<th>Chair, Department of Veterinary and Biomedical Sciences</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair, Department of Biochemistry</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, School of Biological Sciences</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Chemistry</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Computer Science and Engineering</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Electrical Engineering</td>
<td>Date</td>
</tr>
<tr>
<td>Chair, Department of Mathematics</td>
<td>Date</td>
</tr>
</tbody>
</table>
IV. Assurance that resources are available for the proposed Area of Specialization.

Dean, Arts and Sciences

Dean, College of Agricultural Sciences and Natural Resources

Dean, College of Engineering

V. This proposal has been reviewed and approved by the UNL Graduate Council.

Dean of Graduate Studies
What are the educational goals and objectives of the proposed specialization?

The specialization is designed to provide training for students in the general area of bioinformatics. The objectives are to provide students with instruction and experience in the computational, mathematical, and statistical analysis and interpretation of biological data. Students will be trained to acquire, format, and analyze data sets as well as to develop advanced information and computational technologies and mathematical/statistical methods for analysis.

This specialization proposal integrates the ‘Bioinformatics’ specialization already approved for the Department of Computer Science and Engineering (CSE), and creates a larger and broader interdisciplinary specialization in ‘Bioinformatics’.

This broader specialization is necessary due to the interdisciplinary reality of bioinformatics education. Students with strong backgrounds in computer science will be attracted to the Bioinformatics Specialization in Computer Science and Engineering and acquire higher levels of computer science education as well as basic training in molecular genetics and biochemistry. Students with strong backgrounds in life science will most likely enter the Bioinformatics Specialization in various participating life science departments (listed above) and acquire basic training in computer science, mathematics, and statistics in addition to higher levels of molecular genetics and other life science education.

We anticipate future development of an independent Bioinformatics graduate program. The broader specialization proposed herein will become a template for that graduate program by encouraging participating faculty to begin developing bioinformatics core courses and the interdisciplinary research and education system required for the independent program.

List the courses that will be offered in the specialization. NOTE: Except in cases of interdisciplinary specializations, one half of the courses (student credit hours) must come from the major or be cross-listed with another program’s courses.

BIOS 427/827 Practical Bioinformatics Laboratory
BIOS 477/877 Bioinformatics and Molecular Evolution
BIOS 942 Genetics, Genomics, and Bioinformatics of Prokaryotes
BIOS 915Z Bioinformatics Seminar
CSCE 496/896 Special Topics: Bioinformatics
CSCE 990 Bioinformatics Seminar
MATH 496/896 Mathematical Aspects of Bioinformatics
STAT 896A Statistical Methods in Bioinformatics

Are there guidelines or accreditations for such programs? If so, will this program meet the established standards?

None at present. Nationally and internationally, Bioinformatics is a new and rapidly emerging field.

Outline the requirements for students enrolled in the specialization. (At a minimum, students are required to complete a masters or doctoral degree in one of the participating programs in the specialization and complete 12 hours of specialization related coursework.)

Bioinformatics Specializations in Computer Science and Engineering, and Life Sciences, each has independent requirements.

1) Bioinformatics Specialization in Computer Science and Engineering
Bioinformatics Specialization in Computer Science and Engineering has already been approved. See Appendix for the requirements.

2) Bioinformatics Specialization in Life Sciences

This is an interdisciplinary specialization: course requirements will include meeting requirements within the home department. Specialization at the M.S. level will require a minimum of four courses including two credit hours at a minimum from each category (I-III) listed below. Specialization at the Ph.D. level will require at least six courses from the three categories with a minimum of two from any one category. For both M.S. and Ph.D. levels, at a minimum, 12 hours of specialization related coursework are required.

i) Participation in the Bioinformatics Seminar (BIOS 915Z) is required each semester the student is enrolled in the program provided that it does not conflict with departmental requirements.

ii) Participation in the BIOS 427/827 Practical Bioinformatics Laboratory is strongly encouraged depending on student’s background training.

iii) Students are expected to meet with their supervisory committee on an annual basis and provide an annual progress report to the Bioinformatics Advisory Committee before the end of the Spring semester. It is expected that students in the program will present their research results at scientific meetings and publish in scientific journals.

Recommended courses in each of the expected areas of study:
Note: Several undergraduate courses that cannot be taken for graduate level credit are recommended for those students who may have deficiencies in one or more of the categories identified below (indicated with *). These courses cannot be taken for graduate credit nor for 12 hours of specialization related coursework requirements. However, they may be used to cover the three categories listed below if approved by both of the supervisory committees and the Specialization Advisory Committee.

Equivalent courses can substitute for any of the courses listed below.

Category I – Biochemistry and Molecular Genetics
- BIOC 431/831 Biomolecules & Metabolisms
- BIOC 432/832 Gene Expression & Replication
- BIOC 839 Graduate Survey of Biochemistry
- BIOS 418/818 Advanced Genetics
- BIOS 420/820 Molecular Genetics

*BIOS 206 General Genetics
*BIOS 207 Ecology and Evolution
*BIOC 321 Elements of Biochemistry

Category II - Computer Sciences and Mathematical Methods
- MATH/CSCE 340/840 Numerical Analysis I
- MATH/CSCE 441/841 Approximation of Functions
- MATH/CSCE 447/847 Numerical Analysis II

*CSCE 155 Introduction to Computer Science I
*CSCE 156 Introduction to Computer Science II
*CSCE 235 Introduction to Discrete Structures
*CSCE 310 Data Structures and Algorithms

Category III – Bioinformatics and Computational Biology
- ASCI 896 Genomics and Systems Biology
- BIOS 427/827 Practical Bioinformatics Laboratory
- BIOS 477/877 Bioinformatics and Molecular Evolution
- BIOS 942 Genetics, Genomics, and Bioinformatics of Prokaryotes
- CSCE 496/896 Special Topics: Bioinformatics
CSCE 990 Bioinformatics Seminar
MATH 439/839 Mathematical Models in Biology
MATH 842 Methods of Applied Mathematics I
MATH 496/896 Mathematical Aspects of Bioinformatics
STAT 896A Statistical Methods in Bioinformatics

Additional courses recommended for in-depth training in specific areas:

AGRO 931/ANSCI 931 Population Genetics (introduction to quantitative genetics)
AGRO 932 Biometrical Genetics and Plant Breeding
AGRO xxx QTL detection (planning)
ANSCI 932 Quantitative Animal Genetics
ANSCI 934 Application of Biotechnology in Animal Science
ANSCI 896 Mixed Model Methods
ANSCI 933 Selection Index
ANSCI 896 Genomics and Systems Biology of Mammals
ANSCI 896 Parameter Estimation (not every year)
ANSCI 896 FORTRAN programming (not every year)
BIOS 412/812 Human Genetics (population genetics included)
BIOS 826 Population Biology
BIOS 429/829 Phylogenetic Biology
BIOS 924 Molecular Phylogenetics (starting Spring, 2004)
BIOC 932 Proteins
BIOC 933 Enzymes
BIOC 934 Nucleic Acids
CSCE 878 Machine Learning
CSCE 823 Design and Analysis of Algorithms
CSCE 923 Development and Analysis of Algorithms
CSCE 924 Graph Algorithms
CSCE 970 Pattern Recognition
MATH 830 Ordinary Differential Equations I
MATH 831 Ordinary Differential Equations II
MATH 833 Nonlinear Optimization
MATH 843 Methods of Applied Mathematics II
MATH 938 Mathematical Modeling
MATH 943 Seminar in Applied Mathematics
MATH/CSCE 942 Numerical Analysis III
STAT 873 Applied Multivariate Statistics
STAT 896 Statistical Genomics

**General Governance Procedures**

Describe the role of the faculty in the conduct of the specialization. Describe the admissions and advising procedures of students in the specialization.

Computer Science and Engineering and individual Departments in life sciences are responsible for the admission procedures of students in the respective departments.

Once students choose an advisor, a supervisory committee will be formed following the criteria defined by the individual Department or Unit. The supervisory committee members will be responsible for oversight of students conducting research in their laboratories or programs following the guidelines and course requirements for the specialization listed above. At least one member of the Bioinformatics Specialization Advisory Committees must serve on the supervisory committee. Faculty members will also work with students as part of larger teams on large-scale projects or projects requiring expertise from two or more disciplines.
Faculty will also participate in Bioinformatics Seminar (BIOS 915Z, required of lifesciences students), specialized tutorials, journal clubs, and other seminar series.

Each of the Bioinformatics Advisory Committees listed above oversees the respective Bioinformatics Specialization program. Specific duties include recommendations for graduate admission to individual departmental Graduate Committees, overall supervision of the Bioinformatics Specialization, monitoring Program of Study of each graduate student in the specialization. Questions and clarifications relating to these aspects of the specialization program can be directed to the chair of the Advisory Committees.

Since this specialization is part of the individual departmental graduate program, each departmental graduate committee has final authority on all aspects of the specialization program specific to their students, including admission of students into the program, dismissal of students from the program, qualifying exams, appeals to graduate committee decisions, and changes to degree programs.

**Availability of Resources and Funding**

What resources are necessary to make this program viable (library holdings, space requirements, special equipment or renovations, etc.)? Are these resources now available and, if not, how can they be obtained?

Most resources necessary for implementation of this program are currently available. They include biological research equipment and computational infrastructure in laboratories of individual faculty members, shared core facilities in the Center for Biotechnology, and facilities for high-level computation (RCF and Prairie Fire). The Bioinformatics Core Facility is currently funded by an NSF grant and will include hardware and software resources for computational analyses. The only resources that need to be acquired are additional library holdings for Bioinformatics related journals.

**Impact on Existing Academic Community**

What interactions will take place with other departments, units, and programs on all campuses? What participation will be required in terms of faculty from other programs? (Provide letters documenting willingness to participate.) What steps have been taken to insure that the proposed specialization does not overlap existing programs? (Documentation must be provided that relevant departments or areas have been informed of the proposal).

"Bioinformatics" is necessarily an interdisciplinary field. As such, this program will serve as a catalyst to unite faculty with expertise in biological sciences with those having skills in mathematical and statistical analysis of data, and those skilled in computation and algorithm development. Faculty from these programs and units will work collectively to address real problems in bioinformatics. Collaborations will be focused on analysis and interpretation of large sets of biological data and on development of databases, computational models, methods, and algorithms applied to biological information. Faculty participating in collaborative projects will share authorship on publications with the students as appropriate.

The program will emphasize strong and direct communication between students and their advisors and committee members from the biological and computational/mathematical disciplines. Participation in the seminar series is specifically designed to foster communication, exchange of ideas, and development of research clusters among biologists, computer scientists, mathematicians, and statisticians. As added evidence of the complementary nature of the two specializations, most of the participating faculty in this new interdisciplinary specialization program are also participants in the current CSE Bioinformatics specialization program.

Approval of this Interdisciplinary Graduate Program Specialization represents one of the specific goals of the Bioinformatics Priority identified for development as a campus-wide program last spring. Please refer to the UNL Priority Program Document for additional justification for implementing this program as an inter-departmental specialization.