Executive Summary: Bioinformatics

Mission
Bioinformatics Program carries out fundamental research in life sciences, and develops computational tools for modeling in molecular and systems biology, biophysics and drug design. The Program fosters national/international, regional and local scientific community-wide activities in bioinformatics and related disciplines, and provides education and training for the new generation of researchers in academia and industry in Kansas and worldwide.

Faculty
The Bioinformatics Program faculty performs world-class research and includes top experts in Bioinformatics. The Program is a hub of scientific community-wide Bioinformatics activities through its renowned International Conference on Modeling of Protein Interactions, international bioinformatics competitions (Critical Assessment of Structure Predictions and Critical Assessment of Predicted Interactions) and established ties with Bioinformatics programs in the US and abroad. The affiliated Bioinformatics faculty spans College of Arts and Sciences (Departments of Molecular Biosciences, Chemistry, Physics, and Mathematics), School of Engineering (Electric Engineering and Computer Sciences, and Chemical and Petroleum Engineering Engineering), School of Pharmacy (Pharmaceutical Chemistry, and Medicinal Chemistry), KUMC (Molecular and Integrative Physiology, and Pharmacology, Toxicology and Therapeutics), Bioinformatics Core Facility, and Stowers Institute. It brings in the diversity of the KU and larger Kansas City research environment, with top-notch research and training in Bioinformatics and related disciplines.

Doctoral Degrees (PhD)
The PhD degree in Bioinformatics was established in 2009. It incorporated KU students who had chosen Bioinformatics as their graduate research field, and has been admitting new domestic and international graduate students each year since. It now has 18 students enrolled, with more students joining the program this summer. Student demand for Bioinformatics PhD programs is growing. A comprehensive survey of Bioinformatics programs by Alfred P. Sloan Foundation indicated a dramatic increase in the number of such programs in recent years. According to the survey, when asked about the strength of demand for bioinformatics programs at their institution, the absolute majority of the responding institutions perceived demand to be high. Since our PhD program is new, we do not have track record of our graduates placement. In general, Bioinformatics PhD graduates are in growing demand. There is continuing lack of good applicants for PhD-level jobs in bioinformatics nationwide. According to the Sloan foundation, the job placements of students from bioinformatics programs included: Amgen, Duke University, GeneLogic, Harvard University, ISIS Pharmaceuticals, National Institutes of Health, Pfizer, Quallion, Rosetta, Stanford University, and University of Washington. The majority of institutions providing salary information for doctoral placements reported starting salaries in the range of $80,001-$90,000, with no salaries below $60,000.

Changes as a Result of the Review Process
The review determined that a major strength is that the Program provides an excellent dedicated academic home for Bioinformatics training. The scientific expertise of the Core faculty is ‘remarkable’ and the University should be commended for building an outstanding team of core
bioinformatics faculty. It is important that the core faculty is open to collaborations with faculty in other departments.

Another critical strength is a demonstrated University commitment to support the Program with faculty lines, dedicated space, and resources. The sustainability of any training program is determined by the administrative and financial help provided by the University. It is important that the University has committed TA lines to the Program and is prepared to commit additional lines as the program develops.

There is also a large pool of students who have chosen Bioinformatics as their graduate research field. This observation demonstrates that there is demand among graduate students for Bioinformatics training. There is a well-established demand in industry and academia for graduates from this type of program.

The principal recommendations were:
- To be as inclusive as possible across departments and Schools/Colleges at KU;
- Coordinate the coursework with other similar programs/courses on campus;
- Clearly define the role/position of Core Faculty and Affiliated Faculty based on their research interests rather than departmental/center affiliations;
- Articulate the long-term vision for the Program in terms of faculty base, student population and level of support by KU.

In response to the review, it was noted that the Bioinformatics Program strives for inclusivity in various aspects in order to be successful as an interdisciplinary program. The emphasis on inclusiveness, broad scope and diversity with regards to all faculty active in Bioinformatics related research and education and their home Departments/Programs is one of the key principles, along with academic excellence, that guides our work. Our program faculty comes from 14 departments/units on three campuses (KU Lawrence, KUMC, and Stowers Institute in Kansas City). Their research covers the broadest spectrum of Bioinformatics related subjects that exist in the Kansas City metro area. Our curriculum integrates these vast areas of expertise. The operation of the PhD program assumes full participation of its faculty, regardless of their home Departments/Programs, in all aspects of the PhD program. We will continue to coordinate the coursework with relevant graduate programs. Our curriculum currently includes courses from different graduate programs on campus.

To determine how well the program prepared students for the next step in their careers, we will track recruiting success, diversity of students in program, attrition, time to degree, job placement, career choice, and financial support during their graduate careers. Program review and assessment practices are well established within the College of Liberal Arts and Sciences for all of its graduate programs; the pattern and rigor already established will be used for the Bioinformatics PhD program. The program will use the benchmarks such as number of students graduating per year from Bioinformatics graduate programs at other universities, as well as number of students per number of faculty members in program graduating each year when compared with other Engineering and Natural Science graduate programs at KU.

**Overall Evaluation**

Bioinformatics is an interdisciplinary science at the interface of biology, chemistry, medicine, mathematics, and computer science. Its goal is development and application of computational
approaches to studies of life processes and improvement of human health and living conditions on Earth. In the post-genomic era, the training of a new PhD-level cadre in Bioinformatics is of primary importance to basic, clinical and applied science in academia, industry, and many other segments of society.

The faculty associated with the program represent the best at KU, KUMC and Stowers Institute in nationally and internationally recognized research programs, translating their research excellence to outstanding graduate training. Along with the Bioinformatics Program’s high-profile scientific community-wide activities, this provides a solid foundation for a graduate program that attracts top students and enhances KU’s and Kansas’ national and international standing.
Highlights: Bioinformatics

- The Bioinformatics Program was launched in 2005 with a vision to build an internationally recognized center of excellence in Bioinformatics. With this mission accomplished, Bioinformatics at KU is currently one of the few such centers, along with programs at institutions of much higher than KU ranking. Prior to this effort, Bioinformatics as a branch of science was virtually non-existent at KU. The Program brought KU to a prominent and widely recognized place on the Bioinformatics world map.

- Started as a one-man operation, the Bioinformatics Program currently has more than 30 members (faculty, staff, students and postdoctoral fellows) as well as a large number of affiliated members participating in bioinformatics research and training.

- Our entry-level core faculty recruits 'routinely' become Sloan fellows, a highly prestigious research fellowship awarded nationally to a selected group of top young researchers across disciplines. Our record is: three awards for three hires, remarkably the only ones in recent KU history. These faculty members successfully proceeded towards major federal research funding through National Institutes of Health and National Science Foundation, as well as extremely selective Human Frontier Science Awards.

- Our graduate (affiliate) faculty comes from 14 departments/units on three campuses (KU Lawrence, KUMC, and Stowers Institute in Kansas City). Their research covers the broadest spectrum of Bioinformatics related subjects that exist in the Kansas City metro area.

- Our doctoral program, established in 2009, is successfully developing, with recruitment of excellent domestic and international students and expanding research and training.

- The Program hosts biannual International Conference on Modeling of Protein Interactions. This unique conference brings to Lawrence world top experts in structural bioinformatics. It is widely recognized as the milestone worldwide bioinformatics event summarizing current state-of-the-art and setting goals for future developments.

- The Program continues to promote its national and international standing by further developing its ties with top bioinformatics labs worldwide. The high-profile scientific activities in the Program, such as Critical Assessment of Predicted Interactions, Critical Assessment of Structure Prediction, and Community-wide Protein Docking Benchmarking are prominently known internationally.
Proposed PHD in BIOINFORMATICS

BASIC PROGRAM INFORMATION

1. Proposing Institution: College of Liberal Arts & Sciences, University of Kansas

2. Title of Proposed Program: Bioinformatics

3. Degree to be Offered: PhD

4. Anticipated Date of Implementation: Fall, 2009

5. Responsible Department: Bioinformatics Program, KU


Version Date: May 20, 2008
A: PROGRAM NEED AND STUDENT CHARACTERISTICS

Centrality of proposed PhD program to Mission Statement for KU

According to the “Statement of Institutional Mission” (1992) approved by Board of Regents, The University of Kansas is “committed to offering the highest quality undergraduate, professional, and graduate programs, comparable to the best obtainable anywhere in the nation.” The proposed PhD program in Bioinformatics is an exact match for the KU mission.

Bioinformatics is an interdisciplinary science at the interface of biology, chemistry, medicine, mathematics, and computer science. Its goal is development and application of computational approaches to studies of life processes and improvement of human health and living conditions on Earth. In the postgenomic era, the training of a new PhD-level cadre in Bioinformatics is of primary importance to basic, clinical and applied science in academia, industry, and many other segments of society.

A current major effort in advancing Bioinformatics at KU involves establishment of the Bioinformatics Program / Center for Bioinformatics (http://www.bioinformatics.ku.edu). The Center carries out fundamental research in life sciences, develops computer modeling approaches, fosters community-wide activities in bioinformatics, and provides education for the new generation of researchers. The Center/Program is an academic unit with tenure track/tenured faculty appointments.

The faculty associated with the proposed program represent the best at KU, KUMC and Stowers Institute in nationally and internationally recognized research programs, translating their research excellence to outstanding graduate training potential. Along with the Bioinformatics Program’s high-profile scientific community-wide activities, this provides a solid foundation for a graduate program that will attract top students and enhance KU’s and Kansas’s national and international standing.

Student Demand for the Program

In general, the existing PhD programs in Bioinformatics are known to attract top-level student applicants. The most recent comprehensive survey of Bioinformatics programs (Bioinformatics: Recent Trends in Programs, Placements and Job Opportunities, Report to the Alfred P. Sloan Foundation; http://www.csuchico.edu/csuperb/ReportBioinfSloan_June04.pdf) indicated a dramatic increase in the number of such programs compared with the previous 1999 survey. The updated list of currently existing programs is provided below.

- Baylor College of Medicine, Ph.D. in structural and computational biology and molecular biophysics
- Boston University, M.S. and Ph.D. program in bioinformatics
- Carnegie Mellon University, B.S., M.S. and Ph.D. Merck Computational Biology and Chemistry Program
- George Mason University, M.S. and Ph.D. in bioinformatics and computational biology
• Georgia Institute of Technology, M.S. in bioinformatics; Ph.D. in Bioinformatics and Computational Biology
• Iowa State University, Ph.D. program in bioinformatics and computational biology
• Johns Hopkins University, Ph.D. program in computational biophysics
• Keck Graduate Institute, M.S. and Ph.D. in Bioinformatics and Computational Biology
• New Jersey Institute of Technology, M.S. and Ph.D. in Computational Biology
• North Carolina State University, M.S. and Ph.D. in bioinformatics
• Ohio State University, Graduate Program in Biomedical Informatics
• Rutgers University, Ph.D. in computational molecular biology
• Stanford University, M.S. and Ph.D. in biomedical informatics
• University of Medicine & Dentistry of New Jersey, M.S. and Ph.D. program in biomedical informatics
• University of Medicine & Dentistry of New Jersey, M.S. and Ph.D. Bioinformatics track
• University of Albany, Ph.D. program in comparative functional genomics
• University of California, Irvine, M.S. and Ph.D. Informatics in Biology and Medicine
• University of California, Los Angeles, M.S. and Ph.D. program in bioinformatics
• University of California, Santa Cruz, B.S., M.S. and Ph.D. in Bioinformatics
• University of California, San Diego, Ph.D. Bioinformatics
• University of California, San Francisco, M.S. and Ph.D. program in biological and medical informatics
• University of Illinois, Chicago, M.S. & Ph.D. Bioinformatics
• University of Michigan, Ann Arbor, M.S. & Ph.D. Bioinformatics
• University of Minnesota, M.S. & Ph.D. Bioinformatics
• University of Nebraska, Omaha, M.S. and Ph.D. in Bioinformatics
• University of North Carolina, M.S. & Ph.D. Bioinformatics and Computational Biology
• University of Pennsylvania, B.S., M.S. and Ph.D. programs in Computational Biology/Bioinformatics
• University of Pittsburgh, M.S. and Ph.D. in biomedical informatics
• University of Southern California, M.S. & Ph.D. in Molecular and Computational Biology
• University of Texas at Austin, Ph.D. in Cell and Molecular Biology-Structural Biology and Bioinformatics track
• University of Washington, Seattle, M.S. & Ph.D. Graduate program in computational molecular biology
• University of Wisconsin-Madison, Graduate Certificate in Bioinformatics
• Virginia Tech, Graduate program in bioinformatics
• Washington University St Louis, Graduate program in computational biology

According to the survey, when asked about the strength of demand for bioinformatics programs at their institution, the absolute majority of the responding institutions perceived demand to be high. The combined enrollment in all programs was ~300 students, out of ~1100 applicants.

The current high-profile advances in Bioinformatics at KU will put our Bioinformatics graduate program in an excellent position to compete at the national level for the strongest student candidates.

Demand for Graduates of the Program

There is continuing lack of good applicants for PhD-level jobs in bioinformatics nationwide. According to the Sloan foundation report, the job placements of students from bioinformatics programs between January 2002 and March 2003 included: Amgen,
Duke University, GeneLogic, Harvard University, ISIS Pharmaceuticals, National Institutes of Health, Pfizer, Quallion, Rosetta, Stanford University, and University of Washington. The majority of institutions providing salary information for doctoral placements reported starting salaries in the range of $80,001-$90,000, with no salaries below $60,000.

**Locational and Comparative Advantages of the Program**

*Similar programs in other regents institutions*

The Bioengineering program in the KU School of Engineering offers bioinformatics training from the engineering/computer science perspective, focusing on information technology aspects. This effort is complementary to our program’s subject of bioinformatics from the natural sciences perspective.

*Similar programs in the region*

Bioinformatics-related graduate programs exist at Iowa State University, University of Nebraska in Omaha, and Washington University in St. Louis. Although some of these programs involve well-established bioinformatics and computational biology research efforts, none of them is based in a dedicated Bioinformatics academic unit, with tenure-track/tenured faculty appointments in the unit, like the proposed PhD program at KU. The academic unit-based program offers a significantly more advanced level of faculty commitment, staff support, logistics, and funding, and at the same time is broad enough to include other departments. Importantly, also none of these programs, including Washington University, offers national and international scientific community-wide activities, comparable to the ones in the Bioinformatics Program at KU. Such exposure, coupled with the top-tier research programs, offers a unique environment to the graduate students’ professional development.

*Why the program should be located at KU*

KU is an ideal place for the proposed graduate program in Bioinformatics. It will be based in a dedicated academic unit – the Bioinformatics Program – with tenure-track/tenured faculty appointments within the Program. Such a department-like Bioinformatics unit is extraordinary (with known exceptions like the Computational Biology Department at the University of Pittsburgh, the Bioinformatics Program at Boston University, the Bioinformatics and Computational Biology Department at George Mason University and a handful of others, predominantly service oriented departments/programs). The Bioinformatics Program faculty performs world class research and includes top experts in Bioinformatics. The Program is also a hub of world scientific community-wide Bioinformatics activities through its renowned International Conference on Modeling of Protein Interactions, international bioinformatics competitions (Critical Assessment of Structure Predictions and Critical Assessment of Predicted Interactions) and established ties with Bioinformatics graduate programs in the US and abroad. The affiliated Bioinformatics faculty brings in the diversity of the KU and larger Kansas City research environment, with top-notch research in Bioinformatics and neighboring disciplines. Thus, the KU location provides a rare mix of international, national, state, and local Bioinformatics-related activities that provide an ideal environment for a world-class graduate program.
Advantages and Disadvantages of Program Being Freestanding, Cooperative, or Joint

Elements of a bioinformatics curriculum currently exist in several KU departments and programs. However, the interdisciplinary nature of Bioinformatics requires a dedicated graduate program that will combine participation of bioinformatics faculty from various KU departments and programs, as well as KUMC, Stowers Institute, and potentially other neighboring institutions. The program will provide consistent graduate education focusing on professional bioinformaticians, rather than on training experts in other fields who might be interested in a level of bioinformatics skills (which is the focus of cooperative/joint programs). Experience of stand-alone Bioinformatics PhD programs in other institutions supports this paradigm.

Characteristics of the Students Who Will Participate in the Program

Characteristics of the pool from which the students will be drawn

The program will recruit students with Bachelor's or Master's degrees who made their career choice to become professional bioinformaticians.

Recruitment materials describing the programs and application procedures will be mailed to research universities and four-year colleges throughout the country. The program will also be advertised in the American Chemical Society Directory of Graduate Research, Science magazine, Computational Chemistry List, BioPlanet, and other professional publications and on-line resources. Recruitment from schools in areas close to the University of Kansas will be accomplished by visits by faculty who will present talks on their research and distribute literature about the program. Selected graduate students will help in recruitment efforts by visiting their undergraduate institutions and giving seminars. Recruitment will also be part of the summer undergraduate research program. Such programs are supported by NSF, the Howard Hughes medical Institute, and by the departments, and provide an excellent opportunity for introducing potential graduate students to the faculty and their research programs at KU. The faculty will advertise the program at international conferences and other professional meetings. Sustained efforts will be made to provide information about the program to students on a continual basis. A web-page for the program will be created. The Bioinformatics Program/Center for Bioinformatics web site contains high-traffic bioinformatics resources well known in the international scientific community (web-servers, databases, etc.). This will substantially increase the range and spectrum of the program information dissemination.

Procedures and criteria for admission

The students will be admitted to the program by an Admission Committee consisting of the Bioinformatics Program core faculty and a representative of the affiliated faculty. Accepted students must fulfill standard admission requirements of the College Graduate Office. Additional requirements of the program:

- Overall undergraduate GPA: ~ 3.5 (out of 4.0)
- Personal statement about candidate's career goals
- Bachelor's or Master's degree in natural sciences, mathematics, engineering, or another relevant field
• GRE scores in the top 40 percentile in each category
• Three letters of recommendation
• For applicants with degrees from institutions in non-English speaking countries, TOEFL scores according to the College Graduate Office requirements.

Opportunities for student interaction

Students will organize and attend a seminar series with topics in bioinformatics. External speakers will be invited to present their current research results at an open seminar, and hold special discussions with the students during their visit to the campus. A Bioinformatics Annual Symposium will give all students an opportunity to present their own research results, usually in the form of oral presentations. This yearly event will feature a noted external speaker, a series of students’ presentations lasting most of a day, the keynote lecture, followed by dinner and a reception. This event will draw all of the students, their mentors, and other mentors in the program together.

B: CURRICULUM OF PROPOSED PROGRAM

Doctor of Philosophy Degree

The awarding of a Ph.D. degree requires the successful completion of formal courses and demonstration of accomplishments in basic research, qualifying examinations, scientific writing and formal presentations of research data. The student’s ultimate goal is to demonstrate his/her capabilities as an independent investigator. According to the College Graduate Office regulations a student admitted to the Program to study for the Ph.D. will be considered an “aspirant” for the degree until he/she passes the Comprehensive Oral Examination. After passing the Comprehensive Oral Examination, the student will become a “candidate” for the Ph.D. degree.

Goal and objectives

The goal of graduate education for the Ph.D. degree within the Bioinformatics Program will be to enhance students’ academic knowledge base, teaching ability, communication ability, and in-depth basic research ability within a particular scientific area in the discipline. The specific objectives are:
(1) to provide academic training in current knowledge in the field through graduate-level coursework;
(2) to develop in-depth basic research ability in a particular research area within the discipline, through basic research, which will advance the knowledge in the field and allow the student to operate as an independent investigator in applied or basic research;
(3) to develop instructional skills through teaching undergraduate laboratories;
(4) to develop substantive writing ability through completion of a dissertation and manuscripts on the research performed; and,
(5) to provide overall training which will: (a) allow the student to obtain further training in a post-doctoral program; (b) qualify the student for an instructional/undergraduate research position in a four-year college or university academic unit which offers bachelor's, master's, or PhD degrees; and/or (c) qualify the student for a research-scientist or post-doctoral position in industry.
The Bioinformatics PhD has two areas of emphasis: 1) Bioinformatics methodology development and theoretical/computational studies of life processes; 2) Experimental biology with a strong computational/bioinformatics component.

Degree Requirements

**College of Liberal Arts and Sciences (CLAS) requirements**

All CLAS requirements as explicitly stated in the *Graduate Catalog* must be fulfilled, including the Foreign Language or Research Skills (FLORS) requirement. The FLORS requirements may be satisfied by mastery of foreign/computer language.

**Bioinformatics PhD Program requirements**

1. At least two individual lab rotations are required for each new graduate student during the first year of graduate study.
2. Attendance at Bioinformatics seminar each semester.
3. Students must complete the required core courses and the 12 credit hours of elective courses for a total minimum of 31-48 credit hours.
4. Student will select the thesis Advisor by the end of the first year. The choice must be approved by the Executive Committee.
5. Students must complete and submit a research proposal for the Comprehensive Oral Exam.
6. The Comprehensive Oral Exam must be held in the same semester as the final semester of coursework.
7. Upon successful completion of formal coursework and comprehensive oral exam, candidates must complete and present a dissertation based on original research, for evaluation by a dissertation examination committee. The dissertation is presented and defended in a formal public lecture.
8. Students must complete the degree within seven years. Exceptions to this requirement require a recommendation for extension of study by the program's Graduate Studies Coordinator and the Director of Bioinformatics Program, and approval by the College Graduate Office.

**Required courses**

At least two laboratory rotations are required during the first year. In addition, each of the following courses should be completed. Waivers from these requirements will be considered on a case by case basis. The Executive Committee and the Advisor may recommend additional required coursework and may waive any requirements based on student's previous academic coursework.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<td>BINF 701</td>
<td>Bioinformatics Core I (fall) (5)</td>
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<tr>
<td>BINF 702</td>
<td>Bioinformatics Core II (spring) (5)</td>
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<tr>
<td>BINF 709</td>
<td>Topics in: _____ (1-3)</td>
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BIOL 636 Biochemistry I (3)
BIOL 638 Biochemistry II (3)
CHEM 803 Preparing Future Faculty in Science Education (1) or BIOL 801 Issues in Scientific Integrity (3)
BINF 999 Dissertation Research (1-18)

**Elective courses**

Given the diverse background of potential applicants the program will have a broad range of courses. Student must complete a minimum of 12 credit hours of elective coursework (generally, 6 of Biology/Chemistry and 6 of Analysis/Mathematics/Statistics). As the result of the coursework, the students are expected to master Bioinformatics methodology and applications, and to be proficient in the physicochemical and biological principles of molecular systems, applied mathematical/statistical analyses and scientific software development. Other courses may be used to substitute these requirements with the approval of the thesis advisor and the Executive Committee.

**Biology/Chemistry**
- BIOL 772 Gene Expression (3)
- CHEM 622 Fundamentals of Organic Chemistry (3)
- CHEM 640 Biological Physical Chemistry (3)

**Analysis/Mathematics/Statistics**
- C&PE 778 Applied Optimization Methods (3)
- MATH 526 Applied Mathematical Statistics I (3)
- MATH 530 Mathematical Models I (3)
- MATH 581 Numerical Methods (3)
- MATH 590 Linear Algebra (3)
- MATH 605 Applied Regression Analysis (3)
- MATH 727 Probability Theory (3)
- MATH 728 Statistical Theory (3)
- MATH 781 Numerical Analysis I (3)
- MATH 865 Introduction to Stochastic Processes (3)
- EECS 638 Fundamentals of Expert Systems (3)
- EECS 647 Introduction to Database Systems (3)

**Research proposal requirement**

Students must complete and submit a research proposal for the Comprehensive Oral Examination. This proposal will be written in the format of a National Institutes of Health (NIH) or National Science Foundation (NSF) grant proposal. The proposal must develop a research topic related to the general areas of bioinformatics. The topic of the research proposal is decided upon by the student in consultation with the Advisor. The completion of the research proposal is required before scheduling the Comprehensive Oral Examination.

**Comprehensive oral examination**

Once Ph.D. aspirants have successfully completed the required formal courses, research proposal requirement, and FLORS requirement, the Comprehensive Oral Examination will be scheduled. This examination must be held in the same semester as
the final semester of coursework. Exceptions to this deadline require approval by the student’s Executive Committee and the Graduate Studies Coordinator. Successful completion of the Comprehensive Oral Examination admits the student to candidacy for the Ph.D. degree. The exam is given by the Comprehensive Oral Exam Committee. The student’s Advisor must be a member of the Committee. At least two Bioinformatics Program core faculty members must be on the Committee. The Committee must be chaired by a member who is a core faculty member of the Bioinformatics Program, but not the student’s Advisor. The student must provide each committee member with a final copy of the proposal at least 3 weeks before the exam takes place. After the exam, the committee members will decide whether or not the student passed, thus becoming a “candidate” for the Ph.D. degree. The Graduate Program Assistant will forward this decision to the College Graduate Office.

The exam must be scheduled with the College Graduate Office at least two weeks before the exam actually takes place. This means that, after receiving approval from the Advisor and Comprehensive Oral Exam Committee, the student must notify the Graduate Program Assistant to get scheduling assistance (date, time, location) and complete the Do-All form to send to the College Graduate Office.

**Exam Format** - The student will defend his/her research proposal to the Comprehensive Oral Exam Committee. The committee will also examine the student with respect to more general subject areas (not necessarily related to the research proposal) associated with the student’s research, formal coursework and scientific literature of the discipline. Performance on the examination will be rated as “Honors,” “Satisfactory” or “Unsatisfactory” and this rating will be submitted to the College Graduate Office. If the student receives a rating of “Unsatisfactory” on the first Comprehensive Oral Exam, he/she may retake the exam no earlier than one (1) month, but no later than five (5) months after the date of the first exam. If the student does not retake the exam by the five-month time limit, he/she will not be allowed to complete the Ph.D. program. If there are unusual circumstances, the student may, with approval from the mentor and the Comprehensive Oral Exam Committee, petition the Executive Committee of the Program to retake the oral comprehensive examination after the five-month time limit. Under no circumstances the student will be allowed to take the Comprehensive Oral Examination more than twice. If the student fails to receive a rating of at least “Satisfactory” after the second attempt, he/she will not be allowed to continue in the Ph.D. program.

**Final defense of dissertation**

Once the Comprehensive Oral Exam has successfully been completed, the student will form a Ph.D. Dissertation Defense Committee (usually the Comprehensive Oral Exam Committee). This committee is responsible for giving permission to begin writing the dissertation. At least three members of this committee will be selected as dissertation readers (one of these being the Advisor). Once the final draft of the dissertation has been accepted, but before it has been signed and bound, and only after receiving approval from the Ph.D. Dissertation Defense Committee, the Final Dissertation Defense is scheduled with the Graduate Program Assistant. All dissertation readers must be present at the exam. Following the successful defense of dissertation, the Committee will decide if the result was deemed “Honors” or “Satisfactory.” This decision will be forwarded to the College Graduate Office. In case of unsatisfactory defense, a decision on the possibility of repeated defense will be made by the Dissertation Defense
Committee, the program’s Graduate Studies Coordinator, and the Director of Bioinformatics Program. Under no circumstances a student will be allowed to defend the thesis more than twice. If the student fails to defend the thesis, he/she will be dismissed from the Ph.D. program.

**C: PROGRAM FACULTY**

The 39 program faculty members represent all participating units and are a healthy mix of professional bioinformaticians, computer scientists/mathematicians, and life scientists interested in bioinformatics applications. The list includes a combination of senior and junior faculty:

- 22 full professors
- 5 associate professors
- 12 assistant professors

The more senior faculty members have years of experience in providing training for predoctoral and postdoctoral students, and junior faculty are mentored in their respective departments to ensure successful academic careers. The faculty members are also well-funded (with the possible exception of some of the very junior mentors). Faculty CV’s are provided in Appendix A.

Bioinformatics broadly relates to application of computers to biological problems. The current research activities at KU address the bioinformatics issues in a broad sense. However, the major research effort concentrating around the Center for Bioinformatics focuses on a more narrow interpretation of Bioinformatics as Computational Biology on a Genomic Scale.

The faculty activities involve two major types of bioinformatics research:

(A) Bioinformatics methodology development and theoretical/computational studies of life processes.
(B) Experimental biological research with a strong computational/bioinformatics component.

The Program Faculty is split between these types of bioinformatics research (16 in Type A and 23 in Type B). Typically the Type A research projects involve the computational faculty only or in collaboration with the experimentalists. The Type B projects, in our environment, almost always involve the experimentalists/computational researchers’ collaboration. Publications of participating faculty describing their research can be found in their biosketches.

The faculty represents various departments. Credit for chairing PhD committees will be given to the faculty home department.

The Computational faculty (Type A projects) are based in the following departments/programs:
Bioinformatics Program: The research primarily focuses on modeling of protein interactions in genomes and other aspects of protein modeling, docking, and protein structure-function relationships. The Program has four tenured/tenure-track faculty and will be in the process of recruiting two more in 2007 – 2008 within the same research area. The faculty with the appointments in the Bioinformatics Program are the core faculty. The core faculty forms the Executive Committee, which will be responsible for admission, mentor approval, oversight, review, and important decisions involving changing policy. The detailed duties of the Executive Committee are described in corresponding sections of this application.

- **Ilya Vakser**, Director and Professor, is one of the leading experts in modeling of protein interactions and protein docking. His is focused on the development of molecular recognition methods for structural genomics and bioinformatics. He is the Director of the Bioinformatics Program.
- **Gennady Verkhivker**, Professor, a world leading scientist in modeling of biomolecular interactions, structure-based drug design, bioinformatics and computational pharmacogenomics. He joined the Program in 2006 from Pfizer and University of California in San Diego.
- **Yang Zhang**, Assistant Professor, joined the Center for Bioinformatics in 2005, from the laboratory of Jeffrey Skolnick at the University of Buffalo. His research focuses on protein modeling on genomic scale. The winner of the last CASP world competition of structure predictors – the most prestigious event in Computational Biology and Bioinformatics.
- **Wonpil Im**, Assistant Professor, graduated from Cornell University Medical Center and received postdoctoral training at Scripps Research Institute. He joined the Center for Bioinformatics in 2005. Dr. Im’s lab focuses on applications of theoretical and computational methods to chemical and physical problems in biology and material science. Dr. Im is an Alfred P. Sloan Fellow, an extraordinarily competitive award, involving nominations for the very best young scientists.

The following faculty from other departments/program are the bioinformatics graduate program faculty. The responsibilities of the program faculty are: to mentor students, teach program courses, participate in the program seminars and symposia, and serve on Admission, Dissertation and Oral exam committees.

Department of Electrical Engineering and Computer Science: The projects involve knowledge discovery and data mining and analysis from large-scale biological research projects. The research is advancing key bioinformatics methods and tools for genomics and proteomics data analysis and other life-sciences-related research.

- **Victor Frost**, Dan F. Servey Distinguished Professor and Director of Information & Telecommunications Technology Center, focuses on bioinformatics, high-performance networks, network measurement, modeling, control, and simulation.
- **Costas Tsatsoulis**, Professor and Chair, is focusing on case-based reasoning for the retrieval of biological information and selection between conflicting solutions.
- **Xue-wen Chen**, Assistant Professor, is developing new computational models for inferring domain-domain interactions and for predicting protein-protein interactions.
- **Terry Clark**, Assistant Professor, is developing methods to study genome structure and function.
- **Luke Huan**, Assistant Professor, is developing data mining techniques as applied to pattern discovery in biomolecular structures.

Departments of Molecular Biosciences and Chemistry: The departments conduct basic computational/theoretical research in life sciences.

- **Krzysztof Kuczer**, Professor, focuses on the use of methods of modern computational chemistry to study structure, dynamics and thermodynamics of complex molecular systems.
Department of Chemical and Petroleum Engineering: The research in the department involves computational studies of biological systems.

- **Kyle Camarda**, Associate Professor, focuses on the use of high-performance computers to design new biological agents.

Department of Mathematics: The research involves applications of mathematics to biological problems.

- **Rodolfo Torres**, Professor, works in the spectral analysis of nanostructures in biological tissues.
- **Bozenna Pasik-Duncan**, Professor, research interests are in stochastic adaptive control and Mathematics and Science education.

Bioinformatics Core Facility

- **Gerry Lushington**, Director, applies a diverse array of computational tools to problems in chemistry, biology and pharmacology, with primary interests in deriving structure-based QSAR models, activity-based chemical diversity metrics and in predicting biomolecular structure.
- **Jianwen Fang**, Research Assistant Professor, computational biology tools and applications to problems of biological interest.

Stowers Institute: The Institute computational research relates to analysis of proteins, gene regulation and other aspects of genomics and proteomics.

- **Arcady Mushegian**, Investigator, Stowers Institute and Professor of Microbiology, Molecular Genetics & Immunology, uses computational methods to study structure, function and evolution of genes, proteins and entire genomes. He is the Director of Bioinformatics at the Institute.

The Experimental biologists with integral bioinformatics research (Type B) come from the following departments/programs:

**Department of Pharmaceutical Chemistry:**

- **Christian Schoneich**, Professor and Chair, focuses on the oxidative post-translational modification of proteins in vitro and in vivo.
- **Russ Middaugh**, Takeru and Aya Higuchi Distinguished Professor, studies stability of peptides, proteins, nucleic acids, macromolecular assemblies, virus like particles, viruses and bacteria that are of pharmaceutical interest.

**Department of Medicinal Chemistry:**

- **Robert Hanzlik**, Professor, has a major interest in studying the cytochrome P450 family of enzymes.
- **Barbara Timmermann**, Professor and Chair, performs research at the natural products chemistry-biology interface.

**Department of Molecular Biosciences:**

- **Kathy Suprenant**, Professor and Chair, focuses on understanding how cells convert a mechanical stimulus into a physiological or behavioral response.
- **Susan Egan**, Associate Professor, has primary research interest in regulation of gene expression at a molecular level.
- **Erik Lundquist**, Associate Professor, is concerned with the molecular signaling events that underlie cellular morphogenesis.
- **Brian Ackley**, Assistant Professor, studies the interaction between neurons and their environment.
- **Robert Cohen**, Professor, molecular genetics of Drosophila development; stem cell biology; mRNA localization.
- **Roberto DeGuzman**, Assistant Professor, structural studies of protein-protein and protein-RNA interactions in bacterial and viral pathogenesis.
• **Bill Dentler**, Professor, focused on the growth and disassembly of microtubules in eukaryotic cilia and flagella

• **Edina Harsay**, Assistant Professor, focuses on delineating the membrane transport pathways and the mechanisms of cargo packaging and vesicle formation in the late secretory pathway.

• **Bill Picking**, Professor, explores the biochemical and structural basis by which bacterial virulence proteins are delivered to human cells to cause changes in normal cellular activities.

• **Mark Richter**, Professor, application of gene engineering, biochemical and biophysical experiments aimed at elucidating the relationship between the structure and biological function of oligomeric proteins.

• **Liang Tang**, Assistant Professor, structure and dynamics of large molecular assemblies by X-ray crystallography and electron cryomicroscopy.

• **Fusao Takusagawa**, Professor, focuses on the structure-function relationships of the key biomacromolecules that are involved in various biological processes.

• **Rob Ward**, Assistant Professor, understanding the mechanisms that provide spatial and temporal specificity for morphogenesis.

**Department of Chemistry:**

• **Mario Rivera**, Professor, is interested in structure-function and dynamic-reactivity relationships in heme proteins.

**Department of Physics:**

• **Christopher Fischer**, Assistant Professor, kinetics and the thermodynamics of protein-protein and protein-nucleic acid interactions.

**Department of Molecular and Integrative Physiology:**

• **Peter Smith**, Professor, is concerned with nerve regulation in a variety of systems including the cardiovascular system, eye, skin, and reproductive tract. He is also the Director of Bioinformatics at KU Medical Center.

• **Leslie Heckert**, Associate Professor, is studying the molecular mechanisms that regulate cellular differentiation and organ development of the reproductive system.

**Department of Pharmacology, Toxicology and Therapeutics:**

• **Yvonne Wan**, Professor, has the major focus on retinoic acid and its receptors.

**Stowers Institute:**

• **Olivier Pourquie**, Investigator, Howard Hughes Medical Institute, Investigator, Stowers Institute, Professor of Anatomy & Cell Biology, has a goal to gain a better understanding of the segmentation process in vertebrates.

**D: ACADEMIC SUPPORT**

All courses listed in the curriculum already exist on campus. The computing resources in the Bioinformatics Program (the supercomputer, multiple servers and workstations, network connectivity) provide a more than adequate foundation for students training. The Bioinformatics Program has administrative support staff and computer managing personnel available for the graduate program.
E: FACILITIES AND EQUIPMENT

The Bioinformatics Program has access to adequate classrooms with sophisticated presentation equipment.

F: PROGRAM REVIEW, ASSESSMENT, AND ACCREDITATION

Faculty Evaluation of Student Success

Students will be evaluated by the faculty in their required and elective coursework. Students must submit a research proposal on a research topic related to the general areas of bioinformatics, which they will defend to the Comprehensive Oral Exam Committee. The committee will also examine the student with respect to more general subject areas (not necessarily related to the research proposal) associated with the student’s research, formal coursework and scientific literature of the discipline. Upon successful completion of formal coursework and Comprehensive Oral Exam, candidates must complete and present a dissertation based on original research, for evaluation by a dissertation examination committee. The dissertation is presented and defended in a formal public lecture.

Student-Centered Program Evaluation

Students must complete the degree within seven years. The Comprehensive Oral Examination will be held in the same semester as the final semester of coursework. Performance on the examination will be rated as “Honors,” “Satisfactory” or “Unsatisfactory.” If the student receives a rating of “Unsatisfactory” on the first Comprehensive Oral Exam, he/she may retake the exam no earlier than one month, but no later than five months after the date of the first exam (the student will not be allowed to take the Comprehensive Oral Examination more than twice). Once the Comprehensive Oral Exam has successfully been completed, the student will form a Ph.D. Dissertation Defense Committee. Following the successful defense of dissertation, the Committee will decide if the result was deemed “Honors” or “Satisfactory.” In case of unsatisfactory defense, a decision on the possibility of repeated defense will be made by the Dissertation Defense Committee, the program’s Graduate Studies Coordinator, and the Director of Bioinformatics Program (the student will not be allowed to defend the thesis more than twice).

The Bioinformatics students working at the interface of different disciplines may confront potential challenges due to different cultures in computer science/engineering and biology. In some cases the research settings will be interdisciplinary and collaborative. In such cases, assigning co-advisors will be appropriate. The Graduate Studies Coordinator will interview students periodically to determine if milestones are being reached in a timely fashion and if the relationship(s) with his/her mentor(s) are productive. Exit interviews will be conducted to measure students’ perceptions of mentoring, availability of funding, teaching loads, advising at the program and College levels, career counseling, student life, and any barriers that might have had an impact on time to degree.
Overall Program Evaluation

The Executive Committee will conduct review of trainees, addition and review of preceptors, supervision of bioinformatics trainee symposium, and important decisions involving changes in policy. To determine how well the program prepared students for the next step in their careers, it will track recruiting success, diversity of students in program, attrition, time to degree, job placement, career choice (academia research, academia teaching, or industry), and financial support during their graduate careers.

Program review and assessment practices are well-established within the College of Liberal Arts and Sciences for all of its graduate programs; the pattern and rigor already established will be used for the Bioinformatics Ph.D. program. The program will use the benchmarks such as number of students graduating per year from Bioinformatics graduate programs at other universities, as well as number of students per number of faculty members in program graduating each year when compared with other Engineering and Natural Science graduate programs at KU. An external review committee is scheduled to evaluate the program in FY 2011 during a two-day review.