Ph.D. in Informatics
'05 Handbook[1]

The Indiana University School of Informatics, the first of its kind in the country, was created as a place where innovative multidisciplinary programs could thrive, a program where students can apply the skills of technology to a range of other fields. The School announced a new Doctor of Philosophy (Ph.D.) degree program in Informatics beginning in the fall of 2005 and offered on the Bloomington (IUB) and Indianapolis (IUPUI) campuses. (The IUPUI program is administered with the approval of Indiana University, Bloomington.)

This handbook is a "work in progress." Over the 2005-2006 academic period, we expect that the program requirements and responsibilities will evolve as faculty and students gain experience with this new and innovative degree program. In particular, we expect that the first student cohort will have significant input into its design. [2]

Areas of Research

Faculty research projects often involve representatives from several different research areas, working together to develop innovative and even revolutionary new solutions. While students can expect to concentrate in particular areas, they will also be expected to explore the broader significance of their work as well as ways that their expertise can be leveraged to solve problems outside of their own domains. The following lists the main research areas in the School of Informatics; the existing and potential combinations of these domains are too numerous to list.

- **Bioinformatics** (IUB and IUPUI)
  Sequence pattern recognition, comparative genomics, structural genomics, fragment assembly in DNA sequencing, systems biology, models of evolution, molecular modeling and drug design.

- **Chemical Informatics** (IUB and IUPUI)
  Molecular modeling, computational chemistry, computer-aided drug design, 2D and 3D chemical structure coding and searching systems, analysis of data from high throughput screening and combinatorial chemistry.

- **Complex Systems, Networks, Modeling and Simulation** (IUB)
  Artificial Life, complex networks, modeling and simulations of complex systems, self-organization, Multi-agent systems, computational biology, nonlinear dynamics for chemical

[1] On July 1, 2005, the Department of Computer Science transferred administrative authority from the College of Arts and Sciences to the School of Informatics. The Ph.D. in Computer Science will follow the rules specified by that department. The Ph.D. in Informatics will follow the rules described in this document.

[2] The Ph.D. degree is administered by the University Graduate School. All students should read and become familiar with the University Graduate School Bulletin. Unless specifically stated, this handbook does not replace the rules set forth in the Bulletin. A portion of the Bulletin is excerpted here for your convenience, beginning on page 15.

and biological systems, adaptive systems; evolutionary computation; machine learning; neural networks, Internet/Web modeling and mining, computational intelligence.

- **Cybersecurity** (IUB)
  Economics of security, user-centered design of security, cryptographic primitive design, security modeling, foundational cryptography, threat assessment and analysis, protocol design, provable security, security heuristics, light-weight cryptography, network security, privacy, security auditing, security and computer forensics.

- **Discovery and Application of Information** (IUB)
  Discovery from the Web, text, databases, and data streams; algorithms, technologies, and applications for mining, filtering, and classifying those sources; and modeling, managing, and integrating information and knowledge.

- **Health Informatics** (IUPUI)
  Electronic health records, health data exchange, standards and terminology for health data, clinical decision support, consumer health informatics, technology to enhance patient safety, teleheath application development and implementation, ontologies, mining clinical data, natural language processing.

- **Human-Computer Interaction Design** (IUB and IUPUI)
  Interaction design, computer supported cooperative work, new media, dynamic visualizations, computer-mediated communication, usability and evaluation methods, collaborative shared surfaces, external representations, augmented reality, learning systems.

- **Logical and Mathematical Foundations of Informatics** (IUB)
  Computational complexity theory, mathematical foundations of computation, analysis of algorithms, models of computation, substructural logics such as linear and relevance logic, category theory, proof theory, information based logics, algebraic logic, and relations between computation and logic.

- **Music Informatics** (IUB)
  Digital music libraries, music recognition (audio, optical, time-sequence), modeling musical expression, musical accompaniment systems, computational music analysis, music information retrieval.

- **Social and Organizational Informatics** (IUB)
  Gender and technology; gender and informatics; cultural variation and informatics; free/libre and open source software; social dimensions of information and communications technology; methodologies for developing an informatics knowledge base; the ethics of information and informatics; privacy; file sharing, blogging and other mechanisms of collaborative ad-hoc filtering.

Program of Study

Students in the doctoral program will explore the connections among technology, theory, social analysis, and application domains in a diverse and multidisciplinary curriculum. This curriculum

will include core courses and seminars in informatics; an informatics subdiscipline (the current subdisciplines are bioinformatics, chemical informatics, health informatics, human-computer interaction, and social informatics, and more are in development); courses in methodology and theory; electives in related disciplines inside and outside of the School leading to a Ph.D. Minor; and a dissertation. In addition, students will be encouraged to pursue internships as part of the elective courses or independent studies of their program.

The School is also exploring other possible tracks for future implementation, which may include new media, cybersecurity, music informatics, and complex systems, networks, and modeling and simulation.

Employment Opportunities

Graduates of this program are expected to enter academic positions in research and teaching universities or to conduct research for industries that use informatics. They should be able to shape the direction of information technology in the scholarly work they do on the social, organizational, and design environment of technologies as well as in designing solutions for the issues confronting the biological, chemical and health-based scientific communities.

Values

Ours will be the first Ph.D. program (in the U.S.) to carry the label "Informatics." Moreover, we recently expanded our staff significantly, bringing in new faculty from around the world, who transit across a diverse array of disciplines. For both reasons, we thought it important to be as explicit as possible about the values that we intend to pursue in implementing the Ph.D. A statement of each value is accompanied by a list of at least some of the aspects of the program that we intend to be primary sites for its implementation. As this list is a "work in progress," we hope you will both think about the values and suggest ways to refine both the list and additional ways to pursue them.

Value	Program Features that Support It
1. The primary purpose of our Ph.D. program is to **educate students who will make original scholarly contributions** to the emerging field of informatics.	• The broad faculty that we have assembled • The program, including its course requirements, into which you have been accepted • The high accessibility of the other, excellent educational resources of Indiana University
2. Central to achieving this primary objective is **respect for and interest in creating scholarly work of the highest standard,** respect and interest both being	• The research culture that we are creating in the School • The general program requirements • The annual faculty evaluations • The frequent public presentations of student

sensibilities that are important to successful professional careers.	work • The several means of support for both student and faculty participation in scholarly conferences, workshops, and training
3. We place high value on **learning by doing**, in regard to both what goes on in the classroom and in a deep and continuous exposure to and involvement in the actual research process.	• The required research rotations with diverse faculty • The opportunities to work with faculty on their research • The research projects required in courses • The dissertation project that each of you will complete • The summer internship option
4. We view informatics as a profoundly **interdisciplinary** endeavor.	• The relatively heavy course requirements that promote deep knowledge of areas beyond the student's sub-field • The system of postponing formation of dissertation committees until completion of at least two rotations • The inducements which we have instituted to promote cross-disciplinary projects among our faculty • Course selections in both the major and minor that enable a degree of choice within specialization • The multiple disciplinary influences built into required courses, as by team teaching
5. Further, we see **collaboration, with a focus on mentoring toward independence,** essential to all research, as particularly crucial to an interdisciplinary field like Informatics.	• Team projects that will feature heavily in your course experiences • Your research work with faculty, both in and outside of your sub-discipline • Your immediate activity in research upon program entry • Associate instructor positions, which build mastery
6. Successful collaborative research and education in turn depend upon **learning environments and experiences which students and faculty create together**, based on each bringing substantial	• The ability of students to change their program adviser, with the consent of the new adviser • Students' own selection of dissertation chair and committee, again with the consent of all involved

resources to the program.	• Substantial student participation in program governance, both within the School of Informatics and the Indiana University Graduate School • Evaluation modalities, such as take-home exams and portfolio analysis, that aim to minimize anxiety
7. An **ability to teach well**, in either formal or informal contexts, or both, is also an important skill for the Ph.D. informatician.	• The required course on pedagogy • The modeling of good teaching promoted among our faculty • Students' experiences as Associate Instructors (AIs) • Promotion of involvement in the IUB learning community
8. Since Informatics is a new field, it is especially important that its first Ph.D.s are committed to **serving the profession**.	• Support for student clubs and organizations • Program support for service to the university and the profession among faculty and staff • Faculty and staff who individually and collectively take active, even leadership roles and positions in organizations promoting Informatics
9. Finally, since our ideas regarding what Informatics is will doubtless change as the field develops, and since there may well be specific situations in which values articulated above conflict with one another, we need to approach program implementation with some **humility and, where justified, a degree of flexibility**.	• Our adoption of an iterative approach to program design • Our active governance procedures that include student involvement

Advising

Students admitted to the Ph.D. Program are assigned a faculty person who may be consulted for advice. The Associate Dean for Graduate Studies and Research is also available for general consultation. The student may change adviser upon the consent of the new faculty person and the Associate Dean. The student must inform the existing adviser that a switch has been made. This adviser is the chair of the student's program committee.

Upon successfully completing all parts of the written qualification exam (and typically earlier), each student will consult with appropriate faculty members and designate, with their consent, members of a suitable program committee to oversee and conduct the oral qualifying exam in the student's research area. The program committee must by University Graduate School rules include at least two members from the student's major area, and at least one from another area; at least two must be members of the graduate faculty. The names of the committee members presented by the student will be forwarded to the University Graduate School upon approval by the Associate Dean for Graduate Studies and Research in the School of Informatics.

The program committee oversees the student's progress until the passing of the oral qualifying examination, whereupon the student consults with the committee concerning a thesis supervisor. When the student has a thesis adviser, the student and adviser designate, with their consent, members of a suitable dissertation committee (the program committee is abolished).

The members of the dissertation committee must meet the requirements of the University Graduate School: the committee includes the director, normally the professor directing the dissertation, two or more additional faculty members from the same department, and a representative of each minor; with certain exceptions, the members must belong to the graduate faculty. This committee supervises the dissertation research, conducts the thesis proposal examination, and conducts the Ph.D. thesis defense final examination.

Research Group Rotations

Each student will engage in two to three research rotations during the first two to three semesters of the program. The student chooses a faculty person with whom to study for one semester. The faculty person integrates the student into his/her research group/program. Minimally, the student will engage in readings and apprenticeship work with the faculty and other students in that group. The goal is to engage in research with the faculty person (typically at a beginning level) and to decide if this person is a potential thesis adviser for the student's dissertation work.

Annual Reviews

Each year, graduate students will be required to file an annual review with their adviser and program or dissertation committee. The review is due on June 1st. The annual review covers the period of the previous academic year. Four areas will be included in the report: course work, research, teaching, and service. The exact format will be determined later. The purpose of the annual report is to provide written feedback to the student, including any recommendations or required actions. The feedback will be signed by the student's committee chair as well as by the Associate Dean for Graduate Studies and Research.

Curriculum

Credit Hours:

A total of 90 credit hours will be required for this degree. No more than 30 of those hours would be counted from a master's degree taken at Indiana University or a graduate program at another university. (An additional 6 hours of master's thesis or capstone project may be counted toward the Ph.D. at the discretion of the student's program committee, assuming the thesis or capstone

project is of sufficient research quality.) The 90 credit hours will consist of:

- 27 hours of required Informatics courses:
  - I501-I502: 6 hours
  - Core: 12 hours
  - Seminars: 6 hours
  - Professionalism/Pedagogy 3 hours
- 12 hours in theory and methodology courses
- 21 to 30 hours in electives
- 21 to 30 hours for dissertation work

Required Informatics courses (27 hours). Six hours of informatics common core courses will be required of all students who begin the program after completion of an undergraduate degree. An additional 12 hours (4 courses) will also be required in an informatics subdiscipline ("track") offered in the school. These currently are bioinformatics, chemical informatics, health informatics, human-computer interaction, or social informatics. Six hours of seminars in the student's subdiscipline will be taken in the school. One 3 hour course in professionalism and pedagogy will be required to prepare students for entry to careers in industry or academia.

Theory and Methodology (12 hours). Twelve credits of theory and methodology applicable to the student's specialty in informatics will be selected from courses both inside and outside the school.

Electives (21 to 30 hours). Additional elective courses could be taken outside the school. These would be in disciplines related to bioinformatics, chemical informatics, health informatics, social informatics, or human-computer interaction. A student could include a minor among these courses in a related field to be approved by the student's program committee.

For students planning to focus on bioinformatics or chemical informatics, a high level of computer programming competence would be required. Students focusing in health informatics would be expected to have a background in one of the health care professions. Students planning to specialize in social informatics or human-computer interaction should have familiarity with design principles and have some grounding in the social sciences.

Dissertation (21 to 30 hours). The remainder of hours to total 90 will be used for dissertation credits.

Program Description

Description of program and its objectives:
The Ph.D. in informatics will encompass a range of informatics-based options for the student. Informatics is an integrated multidisciplinary field. The doctoral program will provide a balance between technological, scientific, and social dimensions involved in the development and application of information technology.

Whatever the specific focus of their informatics doctoral study, students will draw on course work taken from several disciplines. In the science informatics areas, the degree is built on a base

of advanced computer programming skills, mathematics, and statistics; and scientific disciplines like molecular biology for bioinformatics and organic chemistry for chemical informatics. Knowledge acquired from the integrated study of these areas is applied to research topics related to the storing, retrieving and analyzing of data in the fields of bioinformatics and chemical informatics.

For the student interested in health informatics, the program offers the resources of one of the largest academic health centers in the country. The School of Informatics works closely with the School of Medicine (collaboration in and support of bioinformatics, primarily in the Center for Computational Biology and Bioinformatics), School of Nursing (faculty appointments in the Health Informatics Graduate Program, dual curricular development), and School of Health and Rehabilitation Sciences (Health Education for the 21st Century Project). The School also collaborates with the Regenstrief Institute, one of the premier research centers for medical informatics, located on the IUPUI campus.

For the student interested in human-computer interaction, the multidisciplinary program brings together computer prototyping skills, behavioral science theory, and design principles to allow the student to address research topics related to the design, evaluation and implementation of interactive computing systems in social settings. For the student interested in social informatics, the program offers a combination of knowledge of computing with the interdisciplinary study of the uses and consequences of information technologies that takes into account their interaction with institutional and cultural contexts.

We anticipate that several different tracks in the degree will be added as the school evolves. Any new tracks of the Ph.D. would carry the same core requirements as those outlined here. Any new tracks must be approved by the Graduate Council and vetted through the University.

Admission requirements, anticipated student clientele, and student financial support:
Admission requirements in the areas of undergraduate grade point average and GRE score levels are those of the University Graduate School. We also require the student to have some skill in computer programming. The student who expects to pursue a specialization in the science informatics areas will need to have excellent programming skills, but can acquire some of that skill in the program. Some basic skill level is needed for all doctoral applicants, however. Currently the requirement for entry to the master's degree in bioinformatics requires at least six undergraduate credit hours of computer science or informatics coursework that covers areas of programming, discrete structures and data structures. These requirements would be the same for anyone entering the Ph.D. program focused on science informatics with an undergraduate background.

Students with professional experience will be encouraged to apply. Since the program seeks to prepare students to enter careers in academia where professional degrees will be offered, it is important that students have experience in the field they will prepare others to enter.

Relationship between Master's and Ph.D.

The current master's degree is a professional program in these areas: (at IUB) bioinformatics, chemical informatics, and human-computer interaction; (at IUPUI) bioinformatics, chemical

informatics, human-computer interaction, health informatics, laboratory informatics, and media arts and science. We anticipate that these programs will continue, perhaps with new areas (such as cybersecurity or music informatics) augmenting the current degrees. Students accepted into the Ph.D. program will be admitted with a bachelor's degree or with a master's degree. Students with master's degrees in informatics will be allowed to apply for admission to the Ph.D.

For those who enter the Ph.D. program directly from their bachelor's program, there will be a formal assessment after two years of coursework, an "up or out" evaluation. For those who wish to enter the Ph.D. program from their master's program, there will be an application process. In this case, there is a natural evaluation of the student's record.

Description of the Proposed Curriculum

A total of 90 credit hours are needed for this degree. If a student comes into the program having received a master's degree from another institution or program within IU, no more than 30 semester credits may be applied to the requirements for the Ph.D. in informatics. An additional 6 hours of master's thesis or capstone project may be counted at the discretion of the student's program committee, assuming the thesis or capstone project is of sufficient research quality.

Required courses in the School of Informatics (27 credits):

- I501 (3 credits) Introduction to Informatics
- I502 (3 credits) Information Management [special Ph.D. section designed to work on a collaborative complex problem]

The Ph.D. core:

Every student in the program will take four courses (12 credits total) from the following list of proposed courses:

- I601 (proposed-3 credits) The Informatics of Complex Systems
- I604 (proposed-3 credits) Human-Computer Interaction Design Theory
- I605 (proposed-3 credits) Social Foundations of Informatics
- I608 (proposed-3 credits) Cognitive Science for Human-Centered Informatics
- I610 (proposed-3 credits) Design, Technology, and Representation
- I611 (proposed-3 credits) Mathematics and Logical Foundations of Informatics
- I617 (proposed-3 credits) Science and Other Domain Informatics

Seminars in subdiscipline (3 credits each; total 6 credits):

Every student will be required to take a pair of these seminars. They would include I627 and I637 for bioinformatics specialists, I647 and I657 for chemical informatics specialists; I530 and I667 for health informatics specialists; I624 and I634 for human-computer interaction (HCI) specialists; and I625 and I635 for social informatics specialists.

Professionalism and pedagogy in informatics (proposed-3 credits):

I600 will prepare students for entering careers in teaching and research in the industry or the academy.

Required courses in theory and methodology appropriate for informatics (12 credits):
Students in one of the scientific or health informatics areas may select programming courses, advanced statistics courses, algorithm and computing theory courses, and research development and evaluation courses.

Students in HCI and social informatics may choose statistics courses, quantitative or qualitative data analysis courses, ethnographic methods, cognitive science theory, etc.

These course areas are not exclusive. Particular courses for this core will be specified by the student's adviser in consultation with the student's program committee.

Electives (from 21 to 30 credits):
These courses would be selected by the student with the help of the advisory committee.

One of the recommended, but not required, electives for all students would be I629 (proposed-3 credits) Readings in Informatics, a course with several sections, each related to the specialization of the students in bioinformatics, social informatics, etc. Students would be encouraged to enroll in this course following the paired seminars. Some subdisciplines may choose not to offer a readings course.

Minor:
All students will be required to have an appropriate minor outside or partially inside the school. Minors will be selected with the adviser's recommendation. The selected minor should be appropriate to the student's choice of subdiscipline within informatics. Some appropriate minors would include biology, chemistry, cognitive psychology, computer science, history and philosophy of science, information science, or sociology. In all cases the number of hours to be included in the minor will be consistent with the requirements of the unit granting the minor. Some of the courses included in the minor may also count towards the student's methodology or other requirements.

Qualifying examinations - written (required):
All students will take a written qualifying examination that covers the four core courses selected by the students. The examination will be set by a group of faculty who are familiar with the content of the core courses. Questions will cover the material pertinent to the students' selections. Examinations will be offered at the end of August and at the beginning of the second semester in January. Examinations must be completed by the beginning of the student's fourth year in the program but can be completed before that time when the core courses are completed. Students who do not successfully complete the examination can retake the exam a second time.

Qualifying examinations - oral (required):
The oral qualifying examination covers in-depth knowledge of the student's primary research area. This examination is administered by the student's program committee. That committee consists of the adviser, a representative from the student's minor, a faculty member representing the student's primary research area (who can be, as appropriate, from outside the School of Informatics), and another faculty member of the student's choosing from the School of Informatics. The examination will normally be completed at the end of course work, before the

student embarks on the dissertation. The student must pass this examination before passing on to candidacy. Only two attempts to pass this examination will be allowed.

Dissertation proposal:
The research proposal for the dissertation must be approved by the student's research committee. That committee may have the same membership as the program committee or the student may choose different members. The adviser for the dissertation will be a faculty member in the School of Informatics and a member of the Graduate Faculty. At least one of the three other members of the committee will be based outside of the school. The student will defend the proposal at a public colloquium in the school.

Dissertation (from 21 to 30 credits):
A written elaboration of significant original research, which must be successfully presented to the research committee in a public defense as described in the Graduate School Bulletin.

Sample curriculum:
The following example will cover a curriculum for a bioinformatics student who enters the program after the bachelor's degree in computer science or a bachelor's degree in biology with a background in computer science and database structures:

Semester One
I501 (3 credits) Introduction to Informatics
I585 (3 credits) Discovery and Application of Information
I611 (3 credits) Mathematical and Logical Foundations of Informatics

Semester Two
I502 (3 credits offered every spring semester) Information Management
I592 (Proposed-3 credits) Data Mining for Bioinformatics
I519 (3 credits) Bioinformatics: Theory and Application

Semester Three
I600 (3 credits) Professionalism and Pedagogy of Informatics
L529 (3 credits-offered every fall) Bioinformatics in Molecular Biology and genetics: Practical Applications
I511 (Proposed-3 credits) Algorithms for Bioinformatics

Semester Four
I617 (3 credits) Science and Other Domain Informatics
I601 (3 credits) Complex Systems, Modeling, and Simulation
I605 (3 credits) Social Foundations of Informatics

Semester Five
I627 (3 credits) Seminar in Bioinformatics I
M467 (3 credits) Advanced Statistical Techniques
Z620 (3 credits) Topics in Informatics: Evolution of Genes and Genomes

Semester Six
I637 (3 credits) Seminar in Bioinformatics II
I629 (3 credits) Informatics Readings
M560 (3 credits) Applied Stochastic Techniques

Semester Seven
L600 (3 credits) Special Topics in Genetics
L585 (3 credits) Molecular Genetics

Semester Eight
Z620 (3 credits) Genomics and Bioinformatics
B480 (3 credits) Microbial and Molecular Genetics

The proposed curriculum contains the following existing courses:

I501 Introduction to Informatics (3 credits)
I502 Information Management (3 credits)
I503 The Social Impact of Information Technologies (3 credits)
I510 Data Acquisition and Lab Automation (3 credits)
I511 Laboratory Information Management Systems (3 credits)
I512 Scientific Data Management and Analysis (3 credits)
I530 Seminar in Health Informatics (1-3 credits)
I532 Seminar in Bioinformatics (1-3 credits)
I533 Seminar in Chemical Informatics (1-3 credits)
I534 Seminar in Human-Computer Interaction (1-3 credits)
I535 Clinical Information Systems (3 credits)
I550 Legal and Business Issues in Informatics (3 credits)
I575 Informatics Research Design (3 credits)
L519 Bioinformatics: Theory and Practice (3 credits)
L529 Bioinformatics in Molecular Biology and Genetics: Practical Applications (4 credits)

The proposed curriculum contains the following new courses. (Note: We will review existing courses in other units for significant overlap that would allow their use in our curriculum. Some new courses might most naturally and efficiently be developed in cooperation with other units and cross-listed, for example I601 below with the biophysics faculty in the Physics Department.) All courses not listed currently in the University Graduate Bulletin will be submitted for appropriate vetting and approval within the University.

I585 Discovery and Application of Information
Information discovery from the Web, text, databases, and data streams. Algorithms, technologies, and applications for mining, filtering, and classifying those sources. Modeling, managing, integrating, and visualizing information and knowledge. Applications in biology, medicine, Web search, information retrieval, business, security, and other domains.

I600 Professionalism and Pedagogy in Informatics
I600 will prepare students for entering careers in teaching and research in the industry or the

academy.

I601 Complex Systems, Modeling and Simulation
The study of complexity in mathematical, physical and living systems with a focus on computational modeling and simulation techniques. Occam's razor and minimal models. Linear and nonlinear parameter fitting and statistical analysis of both simulation and empirical data. Measures of complexity. Other topics may explore various aspects of complex systems including but not limited to: chaos theory, self-organized criticality, agent-based models, emergent behavior, network structure, neural networks, artificial life, evolutionary algorithms, economic models, stigmergy, ecological models, dynamical systems, cellular automata, and pattern dynamics.

I604 Human-Computer Interaction Design Theory
The study of theories that have been associated with HCI design including grounded theory and ethno methodology, post-cognitive approaches such as language/action, activity theory and distributed cognition, and human-centered design methods from design traditions that emphasize human contexts over technologies.

I605 Social Foundations of Informatics
As information technology is adopted in various sectors of society, it creates changes in the social fabric of our lives by enabling uses of information that were not possible earlier and by shaping changes in our social institutions. This course uses the perspectives of sociology, anthropology, political science, and economics to examine the changes created by information and information technology in our social institutions. Topics include the economics of information businesses and information societies, legal and regulatory factors that shape information and information technology use, the relationship between organizational cultures and their use of information and information technology, and ownership of intellectual property.

I608 Cognitive Science for Human-Centered Informatics
An introduction to cognitive processing and its relation to the comprehension and production of language, attention, perception and memory and applied to the issues of design for human capabilities, including visual interfaces and information visualization systems.

I610 Design, Technology, and Representation
Advanced concepts of modeling and representation, descriptive geometry, digital imagery in research, and constructing virtual environments.

I611 Mathematics and Logical Foundations of Informatics
Advanced survey of the mathematical and logical tools used in informatics, including topics from set theory, probability theory, information theory, graph theory, combinatorics, and logic.

I617 Science and Other Domain Informatics
Survey of the content and focus of various domain informatics—bioinformatics, chemical informatics, etc. and their common elements and relationship to one another.

I629 Readings in Informatics
Can be taken in bioinformatics, chemical informatics, health informatics, etc.

I627-637 Seminar in Bioinformatics I and II
I647-657 Seminar in Chemical Informatics I and II
I667 Seminar in Health Informatics II
I624-634 Seminar in Human-Computer Interaction I and II
I625-I635 Seminar in Social Informatics I and II
I699 Topics in Informatics

Ph.D. Program Faculty and Administrators

(See the Informatics web site for the most up-to-date list of faculty and their research interests. Not all faculty may be members of the graduate faculty.)

Evaluation Plan

The Ph.D. program will be reviewed and modified each year by the school's Graduate Program Committee. However, two formal and external evaluations of the doctorate will take place during year three and again during year five. The third year review will be a small one to two-day review that includes an external person. The fifth year review will be a systematic three-day review that includes three external people. These reviews are not school reviews, but rather examine the strengths and weaknesses of the Ph.D. program. In both reviews, a written set of recommendations would be delivered to the University Dean of Informatics and to the Graduate School Dean. Prior to each of these reviews, procedures for the review process will be established consistent with similar reviews at Indiana University and other universities.

Indiana University Graduate School Bulletin[3]

Requirements for the Degree Doctor of Philosophy

The Ph.D. degree requires completion of at least 90 credit hours of an advanced course of study. The degree is awarded in recognition of a candidate's command of a broad field of knowledge and accomplishment in that field through an original contribution of meaningful knowledge and ideas.

Major Subject

The student will select a major subject from the departments and programs listed in this bulletin.[4] The major department or program is responsible for monitoring the student's progress toward the degree and for making recommendations to the University Graduate School regarding the nomination to candidacy, the appointment of a research committee, the defense of the dissertation, and the conferring of the degree.

Minor Subjects

The student will select at least one minor subject. A minor provides additional breadth and depth to the individual's program. It must be taken outside the major department from among those areas of study listed in this bulletin or in a specifically approved inter- or intradepartmental area (see departmental entries). The determination of the minimum requirements and examination procedure (if any) for the minor is entirely at the discretion of the minor department or program. In certain cases, special interdepartmental minors (12 or more credit hours of work in two or more departments) or minors not specifically listed in this bulletin may be approved by the dean upon recommendation of the student's advisory committee, provided such approval is requested prior to pursuit of any of the proposed courses of study. Examination procedures (if any) or other requirements (for example, stipulation of the minimum grades acceptable) should also be specified in the proposal to the dean.

Advisory Committee

The student's major department or program shall assign the student to an advisory committee no later than one year after admission to the Ph.D. program. The advisory committee must include at least two members from the major area and one from another. At least two members of the advisory committee must be members of the graduate faculty. The names of faculty members nominated to serve on the advisory committee shall be forwarded to the student's school or college for approval no later than one year after the student has been admitted to the Ph.D. program. The advisory committee shall approve the student's program of study and counsel the student until the passing of the qualifying examination.

Qualifying Examination

[3] Relevant sections from the Indiana University Graduate School Bulletin are excerpted here for your convenience. Other sections are *not* reproduced here. Consult the complete bulletin for the most up-to-date and official information.

[4] Students majoring in programs will use the word "Program"; students majoring in departments outside of the College of Arts and Sciences will use the word "School."

This examination, given at such time and in such manner as the major department shall determine, shall be written, although additional oral examinations may be required. The qualifying examination shall cover the major subjects and may, at the discretion of the minor department(s) or the interdepartmental committee, cover the minor subjects as well.

Normally, the qualifying examination is taken after the student has completed all course work for the Ph.D. All such work offered in partial fulfillment of degree requirements must either have been completed within seven consecutive calendar years of the passing of the qualifying examination or be revalidated according to procedures outlined in this bulletin. Reading proficiency required in one or more foreign languages must also have been demonstrated, whether by course work or examination, no more than seven years before the passing of the qualifying examination. In the case of an examination of more than one part, the date of passing is regarded as the date of passing the final portion of the examination, typically the oral examination. Students who fail the qualifying examination are normally allowed to retake it only once. The qualifying examination must be passed at least eight months before the date the degree is awarded.

Admission to Candidacy

Following the passing of the qualifying examination and the completion of all course work and departmental language or research-skill requirements (if any), the student's advisory committee will submit a Nomination to Candidacy Form to the University Graduate School. Upon approval of the dean, the student will be admitted to candidacy and awarded a Certificate of Candidacy. The date of successful completion of the qualifying examinations (not the date of final approval of candidacy) is the one used in determining the seven-year periods for currency of courses (see Qualifying Examination) and completion of the dissertation (see Submission of the Dissertation).

Continuing Enrollment

Students who have passed the qualifying examination must enroll each semester (excluding summer sessions) for any remaining required course work or dissertation credits. Once such students have accumulated 90 credit hours in completed course work and deferred dissertation credits, they must enroll for a minimum of 1 hour of graduate credit each semester until the degree is completed. Failure to meet this requirement will automatically terminate the student's enrollment in the degree program. Students who have completed 90 credit hours and all requirements for the Ph.D. are eligible to enroll in G901 for a flat fee of $150 per semester. Enrollment in G901 is limited to a total of six semesters. (For students not on campus, enrollment may be completed by mail.)

A candidate who will be graduated in June, July, or August of any year must enroll in a minimum of 1 hour of credit as described above in either the current or the immediately preceding summer session.

Dissertation

The culmination of the Ph.D. program is the writing of the dissertation, which is required of all doctoral students. The dissertation must be an original contribution to knowledge and of high scholarly merit. The candidate's research must reveal critical ability and powers of imagination and synthesis. The dissertation is written under the supervision of a research director and a research committee, as described below. Although work published by the student may be incorporated into the dissertation, a collection of unrelated published papers, alone, is not acceptable. There must be a logical connection between all components of the dissertation, and these must be integrated in a rational and coherent fashion. It is the responsibility of the student's research committee to determine the kind and amount of published materials which may be included in a dissertation.

Research Committee

To initiate research for the dissertation, the student chooses a professor who will agree to direct the dissertation. The department shall then recommend to the dean for approval a research committee composed of the chosen director (who will also normally serve as chairperson of the committee), two or more additional faculty members from the major department, and a representative of each minor. The committee should be selected from the members of the graduate faculty who are best qualified to assist the student in conducting the research for the dissertation. In the event that the dissertation research does not involve the area(s) of the minor(s) whether outside or inside the department the major department may request, with the consent of the minor-field representative(s), the substitution of a representative or of representatives from some other field(s) more appropriate to the topic of the dissertation. The committee has the responsibility of supervising the research, reading the dissertation, and conducting the final examination.

All chairpersons of research committees and directors of research must be full members of the graduate faculty. If, however, special expertise in an area is held by an associate or an affiliate member which is not held by a full member, the departmental chairperson may request that the dean approve such an individual as research committee chairperson or director of the dissertation research.

All members of a research committee must be members of the graduate faculty. At least half of the members of the committee must be full members of the graduate faculty; others may be associate or affiliate members.

After consultation with and approval by the dissertation director and research committee, the student will submit to the University Graduate School a one- or two-page prospectus of the dissertation research. If the proposed research involves human subjects, biohazards, or radiation, approval from the appropriate university committee must also be obtained. The membership of the research committee and the dissertation prospectus must be approved by the University Graduate School at least six months before the defense of the dissertation.

Defense of the Dissertation

When the dissertation has been completed, the student should submit an unbound copy to each member of the research committee as the initial step in scheduling the defense of the dissertation. All members of the research committee should read the dissertation in its entirety before attending the defense. At this stage both the student and the faculty members must extend certain courtesies to each other. It is the responsibility of the student to give faculty members sufficient time to read the dissertation without making unreasonable requests of them based upon University Graduate School time limitations, immediate job possibilities, contract renewal, or some other reason. Similarly, a faculty member should not keep a student's work for inordinate periods of time because of the press of other duties. Once a faculty member assumes membership on a research committee, it becomes another part of his or her teaching assignment, comparable to conducting regularly scheduled classes.

After the committee members have read the dissertation, there should be direct communication (either in writing or orally) between the research committee chairperson and the other committee members about its readiness for defense. Readiness for defense, however, is not tantamount to acceptance of the dissertation; it means that the committee is ready to make a decision. The decision to hold a doctoral defense, moreover, is not entirely up to the research committee. If a student insists upon the right to a defense before the committee believes the dissertation is ready, that student does have the right to due process (i.e., to an oral defense) but exercises it at some risk.

If the decision to proceed with the defense of the dissertation is made against the judgment of one or more members of the committee, or if one or more members of the committee disapprove of parts or all of the dissertation, the committee member(s) should not resign from the committee in order to avoid

frustration or collegial confrontation. The University Graduate School urges that such committee members, after ample communication with both the student and the chairperson, remain on the committee and thus prevent the nomination of a committee that might eventually accept what could be unsatisfactory work. Such a committee member could agree that a dissertation is ready for defense but should not be passed (or should not be passed without substantial modification). There will, of course, be situations in which the membership of research committees should or must be changed (e.g., turnover of faculty), but changes because of modifications in the dissertation topic or some equally plausible reason should be made early in the writing of the dissertation.

Thirty days prior to the scheduled defense of the dissertation, the candidate must submit to the University Graduate School a one-page announcement of the final examination. This announcement must follow a format available in the University Graduate School *Guide to Dissertations and Theses.* The announcement contains, among other things, a summary of the dissertation (not less than 150 words) which is informative and contains a brief statement of the principal results and conclusions. The announcement must bear the signature of the research committee chairperson. If the candidate has published any scholarly articles relevant to the topic of the dissertation, bibliographical references should be included in the summary. A copy of such announcements will be sent to any member of the graduate faculty upon request.

Once the final examination has been scheduled, the announced time and place of the defense must not be changed without the approval of the dean. Any member of the graduate faculty who wishes to attend the final examination is encouraged to do so; it is requested, however, that the faculty member notify the chairperson of the research committee in advance so that space can be arranged. With the approval of the research committee and the consent of the candidate, other graduate students may attend the defense of the dissertation; normally such students will act as observers, not as participants.

At the end of the oral examination, the research committee must vote on the outcome of the examination. Four options are available to the committee: (1) pass, (2) conditional pass, (3) deferred decision, and (4) failure. If the decision to pass is unanimous, the dissertation is approved once it is received by the University Graduate School along with an acceptance page signed by the members of the research committee. If the decision is not unanimous, majority and minority reports should be submitted to the dean who, within 10 working days, will investigate and consult with the research committee. Upon completion of the dean's investigation and consultation, another meeting of the research committee will be held, and if a majority votes to pass, the dissertation is approved when it is received by the University Graduate School with an acceptance page signed by a majority of the members of the research committee.

The student must have received acceptance of his or her dissertation and must submit a copy to the University Graduate School within seven years after passing the qualifying examination. Failure to meet this requirement will result in the termination of candidacy and of the student's enrollment in the degree program. Any student whose candidacy lapses will be required to apply to the University Graduate School for reinstatement before further work toward the degree may be done formally. To be reinstated to candidacy in the University Graduate School, the student must: (1) obtain the permission of the departmental chairperson; (2) fulfill the departmental requirements in effect at the time of the application for reinstatement; (3) pass the current Ph.D. qualifying examination or its equivalent (defined in advance)[5]; and (4) request reinstatement to candidacy from the dean. Such reinstatement, if granted, will be valid for a period of three years, during which time the candidate must enroll each semester for a minimum of one credit.

Submission of the Dissertation

Following acceptance by the research committee, the dissertation is submitted to the University Graduate School. Each dissertation must include a title page bearing the statement: "Submitted to the faculty of the University Graduate School in partial fulfillment of the requirements for the degree Doctor of Philosophy in

the School of Informatics, Indiana University." The date of this page should be the month and year in which the degree will be granted. Following the title page there must be an acceptance page with the statement: "Accepted by the faculty of the University Graduate School, Indiana University, in partial fulfillment of the requirements for the degree Doctor of Philosophy." The acceptance page must be signed by members of the research committee. For guidelines regarding the typing and duplication of dissertations, see above under "Preparation of Theses and Dissertations."

The original (unbound, in a box suitable for mailing) and one copy (bound) of the dissertation must be filed with the University Graduate School, and one copy (bound) must be filed with the major department. (The copies filed with the University Graduate School will later be placed in the University Library.)

The candidate must also submit to the University Graduate School a 350-word abstract of the dissertation that has been approved by the research committee. This abstract will appear in *Dissertation Abstracts International*, published by University Microfilms, Ann Arbor, Michigan. The original copy of the final, approved version of the candidate's dissertation will be submitted on loan to University Microfilms for complete microfilming, the resulting copy or copies to be available for purchase by all who request them. Copyright may be secured; see the University Graduate School for details. The original copy will be returned by University Microfilms to the library, where it will be bound. The required fee for publishing the abstract and for microfilming the dissertation is currently $60.