Survey of Bioinformatics Programs in the US

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Abstract:
Bioinformatics is a rapidly growing field, and educational programs for bioinformatics are increasing at a similar pace to answer the demand for qualified professionals. This paper surveys currently available bioinformatics programs. We have compiled summaries of these programs, including university, state, degree type, department, entrance requirements, degree requirements, links to course web pages, research interests, and funding. Complete details are presented in the web version, and an abbreviated listing of the primary attributes of all programs is included in this article.

Keywords: bioinformatics, programs, degree, survey

Background
Bioinformatics is a quickly expanding discipline.   One area of growth is in educational programs associated with bioinformatics (Zauhar 2001).   A survey of programs in bioinformatics serves two purposes: it provides a resource for prospective students or faculty, and records the magnitude (number of programs) and growth (increase in last three years) of bioinformatics programs. We electronically published an initial survey (Hemminger, 2002)[2] in the fall of 2002 in association with a presentation (Hemminger, 2002)[3] at the ASIS&T 2002 conference. Several other Web resources have provided similar information, including the International Society of Computational Biology (ISCB) (2003), 123 Genomics (2003), the National Library of Medicine (2001), Petersen's Guide (2003), the University of Texas (1998), BioQUEST (2003), and the *Bio-IT World* magazine (2002). We updated our survey in February of 2004 and present the results in this paper.

Methods
In the emerging field of bioinformatics there is a debate concerning whether bioinformatics should be a separate discipline, or a subpart of other existing fields (Russell 2003; Stein 2003). Bioinformatics programs commonly grow out of different departments or schools within universities, much as other new technology disciplines such as computer science have in the past. Most commonly, these new programs are initially housed in biology, genetics, statistics, biomedical engineering or computer science departments, although we are beginning to observe more stand-alone bioinformatics programs.

Because bioinformatics programs are mostly offered as subprograms or specializations of existing programs, it can be challenging to discover them. Programs are identified by several terms (including bioinformatics, medical informatics, informatics, health informatics, computational biology) making it difficult to identify them with simple web searches. Furthermore, most programs have started in just the last three years and have not been entered into a program directory. To identify programs, we incorporated multiple methods using different sources: web pages at universities, existing summaries, and email queries of people working in bioinformatics related areas.   We formed an initial list of potential programs by searching web pages and reviewing existing summaries. We then investigated these programs in detail, and removed

programs from our list that did not meet our selection criteria. After a preliminary list was prepared, we published it on the web, and solicited feedback from people with a direct knowledge of the programs via postings on newsgroups and listservs related to bioinformatics.

Searching web pages: We used Google (2003) to search web pages for bioinformatics programs. Because bioinformatics programs are sometimes listed under other "informatics" disciplines such as medical informatics, we included "informatics" in our search strings as well.   We combined "bioinformatics" with "program" for our initial search, which resulted in 311,000 hits. We tried adding four secondary terms ("university", "degree", "health", and "medical") in addition to each of the two base terms ("bioinformatics program" and "informatics program") to narrow the search scope to increase relevancy. Lastly, we searched with "bioinformatics degree" (leaving out program) to procure listings that did not use the term "program". Because the number of hits returned by these Google searches was so large for most of our selections, we only reviewed the most relevant returns (assuming that the higher the Google ranking the more relevant). We initially invested the most effort on the results of the basic term searches, and then searched the basic terms in combinations with the other four terms to look for new programs not captured in the initial searches. The searches and approximate numbers of how many hits (initial web pages) were reviewed for each search are shown in table 1. These searches were performed during June and July of 2003, and followed up in February of 2004.

Search Selection	Number of Hits	Number of Hits Reviewed
bioinformatics program	311,000	375
bioinformatics program university	180,000	325
bioinformatics program degree	57,000	325
bioinformatics degree	149,000	300
informatics program university	315,000	150
informatics program degree	137,000	125
informatics program health	273,000	100
informatics program medical	247,000	100
informatics program [combinations of 4 terms]	multiple conditions	100 each
bioinformatics program [combinations of 4 terms]	multiple conditions	100 each

Table 1. Primary search selections, number of hits (links) returned, and number of hits manually reviewed when searching for bioinformatics programs using Google. The number of hits means the first N hits were reviewed since these were the highest ranked responses. The last two lines summarize four different conditions, i.e. the same base term, combined with each of the four different secondary terms. In each of those cases only the top 100 links were examined.

Existing Reviews Utilized: Other lists of programs we reviewed and incorporated sites from included the International Society of Computational Biology (ISCB) (2003), 123 Genomics (2003), the National Library of Medicine (2001), Petersen's Guide (2003), the University of Texas (1998), BioQUEST (2003), and the *Bio-IT World* magazine (Schachter 2002; Toner 2003] and our 2002 listing (Hemminger, 2002)[2].

Program Information Recorded: Each university or college's program web site was then searched to find what degrees were offered by the institution, location (state) of institution, what department or school the program is under, entrance requirements, degree type(s) and requirements, links to the Web page listing of courses in the program, a sampling of the faculty's research interests, financial aid that is available, and any other pertinent information found.

Program Inclusion Criteria: Once the program's website had been located using the methods above, certain criteria were applied to determine whether the program would be included in our list. Most important was the presence of a degree or certificate granted at the conclusion of the program that specifically mentioned "informatics" in some variation. This meant some long standing programs, as well as large scale or inter-disciplinary programs, may not have been not included. Also as a result, medical, chemical, and biological informatics were all included while many computational biology programs were excluded unless they specifically mentioned an option or a track in bioinformatics. We made every effort to discover all schools and degrees that fit these requirements. Some web pages corresponded to defunct programs, programs in preparation, or programs not granting formal degrees for certificates. These programs were not included unless commencement of the program was scheduled for a stated date. Once these selection criteria had been applied, we then compiled the results, formatted them into an Excel document, and created an abbreviated version in HTML and Word document formats for Web posting. We also have begun compiling an associated list of the computational biology or biophysical mathematics programs that we chose not to include (Hemminger, 2004)[13].

Feedback from colleagues: Once the initial survey results were compiled, we placed them online, and solicited feedback from people in the field via newsgroups (bionet.biology.computational, bionet.software, bionet.software.www, bionet.info-theory) and email listservs (asis-l@asis.org, bioinfo@listserv.unc.edu, bioinformatics@labs.oreilly.com, bioinfo-sils@listserv.unc.edu, sigbioinform-l@asis.org, sigmed-l@asis.org, sigsti-l@asis.org).   We reviewed all feedback, and updated the program listing to its final form as summarized here.

Results

The complete listing of all our results can be found on the web as an Excel spreadsheet (Hemminger, 2004)[14]. A more concise version matching the table below is maintained on the web as well (Hemminger, 2004)[15]. The bioinformatics degree-granting program summary information is updated formally once a year, with occasional updates occurring during the year. The web addresses in the print version of this article are not included because of space considerations, and because of the frequent changes to web pages and addresses. Thus, the online version should be consulted for the most current and complete information (Hemminger, 2004)[16].

Institution	Host Department	Degrees Granted	Degree Requirements	Research Interests
Arizona State University	The Sloan Foundation of Computational Biosciences in the Department of Life Sciences	Professional MS	30 credit hours of courses, 6 credits of internship, and 6 credit hours of professional development. 42 credit hours total.	Mathematical biology, cell biotechnology, protein structure and enzyme kinetics
Baylor	Department of	BS of	124 credit hours required	Natural language

University	Computer Science, Department of Biology	Informatics w/ Bioinformatics major		processing, parallel computation
Boston University	Department of Bioinformatics	MS, PhD	MS: 32 credits required and internship. PhD: 64 credits required and exam	System biology, microarray analysis, genomics
Brandeis University	Office of Continuing Studies	MS Software Engineering/ Bioinformatics Dual Degree; Graduate Certificate in Bioinformatics	MS: 3 core courses, with 7 electives chosen from a list. 45 credits total. Certificate: 1 core course (Statistics), and 4 electives chosen from a list	Computational biology, protein folding, protein mass spectrometry
Canisius College	Department of Computer Science	BS	37 courses (128 credits) required. Full undergraduate curriculum.	No information available on specific research interests
Cedar Crest College	Department of Biological Sciences	BS Minor	Biology, Genetics, Evolution, Biostatistics, 2 courses in Bioinformatics	Rare plants, invertebrate neurophysiology, viral genetics
Columbia University	Department of Biomedical Informatics	BA, MA (applied), MA (research), PhD	MS (applied): 30 credits required, MS (research): Previous PhD and 30 credits, PhD: 60 credits required	Standards for encoding and sharing clinical guidelines, diabetes informatics, clinical data mining
Drexel University	Drexel Biomed Integrated Bioinformatics Program	All degrees with Concentrations in Bioinformatics, BS, MS, PhD	BS: 2 core classes and senior thesis, MS: 4 required classes, electives, and optional thesis, PhD: 4 required courses, electives, and thesis.	Cell adhesion and signaling, molecular profiling
Duke University	Center for Bioinformatics and Computational Biology	PhD; Certificate for PhDs in other departments at Duke	PhD: Core classes, electives, graduate seminars, rotations, and dissertation; Certificate: Four courses in bioinformatics and seminars.	No information available on specific research interests
Florida International University	Department of Computer Sciences	MS in Computer Science w/Specialization	15 credits of required CS classes, 9 electives, and option of thesis	Bioinformatics and pattern discovery, primer design, protein motif mining
Foothill College	Divisions of Biological and	Associate Degree; Career	53 credits for Associate Degree, 49 for Certificate	No information available on specific

	Health Science with the Computer Technology and Information System	Certification		research interests
Georgetown University	School of Medicine, Department of Biochemistry and Molecular Biology	MS in Biochemistry with emphasis in Bioinformatics	9 courses specific to the bioinformatics track. Internships are also possible.	Developmental genetics, DNA replication in E. coli, DNA damage, second messengers
George Mason University	School of Computational Sciences	MS, PhD	MS: 31 credit hours with master's thesis. PhD: 72 credits total, 48 course credits and 24 credits of thesis research.	Computational neuroscience, biomedical genomics, data mining, human genetic variation
George Washington University	Multiple participating departments	BS in Computer Science or Biology w/ concentration in Bioinformatics or Dual BA in CS and Biology, MS in Genomics and Bioinformatics with tracks in Biology or CS	BS: 130 credit hours required along prescribed curriculum, Dual BA: 132 credit hours required Biology MS: non-thesis option, 35 credits required with a final project. Thesis option: 32 credits plus thesis. CS MS: 38 credits required.	Phylogenetics, information systems, genomics and proteomics of HIV and cardiovascular disease
Georgia Institute of Technology	School of Biology	MS, PhD in Biology w/Specialization and PhD in Bioinformatics	37 credits, three semesters of specific courses in biology, mathematics, computer programming, and chemistry.	Protein structure analysis, molecular genetic databases, x-ray crystallography
Harvard and MIT	Harvard-MIT Division of Health Sciences and Technology	MS Medical Informatics	Core courses and thesis requirement	Information processing in medicine
Harvard and MIT	Harvard-MIT Division of Health Sciences and Technology's Program of Medical Engineering and Medical Physics	PhD	Core courses and thesis requirement, interdisciplinary courses among both schools.	No information available on specific research interests
Indiana University at Bloomington	School of Informatics with Depts of Biology, Computer Science, and Chemistry	MS, PhD minor	MS: 36 credits, 6 core credits, with thesis, PhD minor: 12 credits	FlyBase/Drosophila research.

Indiana University/ Purdue University - Indianapolis	Department of Informatics	MS	9 core credit hours and then 21 credit hours of electives, with 6 credit hours of work on thesis.	Intelligent systems, neural networks, bioinformatics, gene regulation
Iowa State University	Program in Bioinformatics and Computational Biology with multiple participating departments	MS, PhD	MS: 30 credits required with core and advanced requirements, PhD: 72 credits are required	Intelligent searching, data warehouses, analytical tools, high performance computing in genomics
Keck Graduate Institute of Applied Life Sciences	N/A	Professional Masters of Bioscience	Two academic years of work, with internship over the summer and master's paper	Recombinant protein expression, biomaterials, molecular computation
Marquette University/Medical College of Wisconsin	Mult. Depts.: Mathematics, Statistics and Biology et al. (MU), Bioinformatic and Biomedical Research (UWM)	MS	Thesis: 24 credit hours required plus thesis. Non-thesis: 36 credit hours. Core courses required for both options.	Development of systems to aid in the genomics, proteomic research.
Medical University of South Carolina	Department of Biometry and Epidemiology	PhD track	7 core courses with electives beyond that. Lab rotations strongly encouraged.	Computational science systems for analysis of biological data, protein interactions
Michigan Technical University	Department of Biological Sciences	BS	74 credits of bioinformatics work required.	Immunology, microbial toxicology, comparative genomics
Missouri Southern State University	Department of Computer Science	BS Concentration	81 required credits in CS and biology	N/A
New Jersey Institute of Technology	Department of Continuing Professional Education	Certificate	4 courses - 3 core, 1 elective	N/A
North Carolina State University	Program in Genomic Science	MS (non-thesis), PhD,	MS: 33 credit hours, core courses with oral exam, non-thesis degree. PhD: 72 credit hours and thesis.	Statistical genetics, molecular sequence analysis, genetic mapping

Northeastern University	Mult. Depts: Department of Biology's Program in Bioinformatics et al.	MS	32 credits required. Core courses with electives, internship required.	No information available on specific research interests
Northern Illinois University	Department of Biological Sciences	MS Specialization, Certification	30 credits required for MS with specialization, 16-17 required for certificate	Arabidopsis BLAST searches, enzyme rate studies, similarity matrices
Northwestern University	Multiple participating departments	MS	3 core courses, seminar sequence, five electives, 3 units of independent research with one quarter spent in an industrial setting, thesis required.	No information available on specific research interests
Ohio State University	Biophysics Program's Division of Computational Biology and Molecular Biophysics	PhD	Programs are highly individual and are worked out with your advisor. Thesis defense is required for completion of degree.	Assembly and function of protein complexes, neural networks, function of solute transporters.
Oregon Health & Sciences University	Department of Medical Informatics and Clinical Epidemiology	All degrees in Medical Informatics: MS (research) and MS (professional) currently available, PhD program beginning Fall 2004; Graduate Certificate	MS research: 60 credit hours required. MS professional: 52 credit hours. Six credit on-campus requirement. Certificate: Eight courses required.	Mapping human genes, impact of computers on health informatics
Ramapo College	School of Theoretical and Applied Science	BS	128 credits, 65 core credits with option for internship.	Client-server applications, peptide synthesis methodology
Rensselaer Polytechnic Institute	School of Science's Department of Applied Science and Biology	BS, MS in Applied Science w/Concentration in Bioinformatics, PhD in Biology w/Concentration in Bioinformatics	Additional credits for concentration in degrees.	Regulation of gene expression, protein folding and structure, data mining, molecular simulations
Rice	Department of	MS in Computer	14 courses required.	No information

University	Computer Science	Science w/ Concentration		available on specific research interests
Rochester Institute of Technology	Department of Biological Sciences	BS and MS (professional)	No specific information available.	No specific research mentioned.
Rockefeller University/ NYU Courant Institute	No information	PhD, or MD/PhD	No specific information available.	No information available on specific research interests
Rutgers University/ UMDNJ	Department of Molecular Computational Biology	PhD track	No set number of credits beyond core courses. Individual curriculums are determined upon admission	Protein expression and structural genes, DNA topology, evolutionary trees
St. Edward's University	School of Natural Sciences	BS	52 credits of core courses, with 13 elective credits required in bioinformatics	N/A
Stanford University	Department of Biomedical Informatics	MS (academic), MS (online professional), MS (coterminal), PhD; Certification	Projects required for MS, thesis for PhD, two years of residence and completion of appropriate courses.	Biomedical Informatics
Stevens Institute of Technology	Department of Chemistry	MS Chemical Biology w/concentration; Certificate	MS: 30 credits required; Certificate: 12 credits	N/A
University of Alabama at Birmingham	Department of Computer & Information Sciences	Specializations for MS, PhD	MS: 6 core credits, 9 elective, PhD: individualized training to be worked out with your advisor.	Medical informatics
University of Buffalo	College of Arts and Sciences	BS	N/A	No information available on specific research interests
University of California - Berkeley	UC Berkeley Extension - Continuing Education	Professional Sequence w/Certificate	4 courses in two possible sequences.	Genetic engineering, Perl, Data Mining
University of California – Davis	Department of Biomedical Engineering	MS and PhD in Biomedical Engineering with Track in Bioinformatics	MS: 32 credits, w/ 3 core courses, and thesis. PhD: 48 credits, w/ 4 core courses, and dissertation.	DNA mechanics, mathematical modeling of pathways
University of	School of	MS, PhD, both	Three core courses, plus	Data mining,

California - Irvine	Information and Computer Science	have research areas in Informatics in Biology or Medicine	at least 6 additional courses, and courses to satisfy a breadth requirement. Other core courses required for ICS school.	prediction of protein sequences, gene expression data analysis
University of California – Los Angeles	Mult. Depts: Biomathematics, Chemistry and Biochemistry, Statistics, Computer Science et al.	BS in Cybernetics w/Concentration in Bioinformatics, MS, PhD	Statistics, Genomics, Computational Biology, Research	Predicting membrane protein structure, analyses of genome evolution, microarrays
University of California – Riverside	Graduate Program in Genetics	PhD in Genetics with track in Genomics/Bioinformatics	N/A	Plant gene expression, environmental stress tolerance, population genetics
University of California – San Diego	Mult. Depts: Departments of Biology, Biomedical Sciences, Computer Science & Engineering, Mathematics et al.	BS, PhD, also PhD in Neuroinformatics	Biological Data and Analysis Tools, Sequence Analysis, Genomic Analysis, Statistics areas, three quarters of work required	Structure and evolution of proteins, enzymes, genomics
University of California – San Francisco	Graduate Program in Biological and Medical Informatics	MS – only for those getting a second health-related masters (or MS with PhD), and PhD	36 credits required for MS, projects required for both MS and PhD	Protein structures, computer imaging
University of California – Santa Cruz	Currently under Department of Computer Engineering – moving to Department of Biomolecular Engineering	BS, MS and PhD	Six core courses with three electives, optional internship, 52 credits for MS, 56 for PhD, Thesis required for both MS and PhD	Gene finding, RNA detection techniques, proteomics
University of Cincinnati	Department of Biomedical Engineering	MS and PhD in Biomedical Engineering with Track in Bioinformatics	148 credits required over 3 years of work, with thesis	Computational neuroscience, clinical applications of bioinformatics
University of	Department of	Analytical Health	90 credits total: 45 credit	Structure of proteins,

Colorado Health Sciences Center	Preventive Medicine and Biometrics, Section of Bioinformatics	Sciences/Bioinformatics PhD track	hours of course work and 45 credits of thesis work	computational biology, molecular neurobiology
University of Delaware	N/A	BS minor	15 credits and thesis required.	N/A
University of Idaho	Initiative for Bioinformatics and Evolutionary Studies	MS, PhD	Core courses, depth courses, lab rotation, seminars, teaching experience, and thesis required. MS: 32 credits, PhD: 78 credits.	No information available on specific research interests
University of Illinois at Chicago	Department of Bioengineering	MS, PhD	MS: 36 credits minimum in biochemistry, mathematics, bioengineering, etc., 96 credits for PhD.	Structural bioinformatics, computational biology, neural engineering
University of Maryland	Graduate School	MS Biotechnology Studies w/ Track	36 credits, 24 of core courses.	No information available on specific research interests
University of Massachusetts – Lowell	Department of Computer Science collaborating with Depts of Biology, Chemistry, Mathematics and the Medical School.	Degrees in specified areas available with Bio/Cheminformatics Option: BS, MS, PhD	BS: 120-124 credits depending on major, MS, PhD: 9 core credit hours, 12 credits of course pairs, 9 elective credits	Data mining, visualization of data, viral-host interactions, protein composition
University of Memphis	Department of Mathematical Science's Computer Science Division	MS Computer Science or Mathematical Sciences w/Concentration	With PhD: 30 credits, without: 33 credits required. Thesis required for both.	Computational biology and algorithms.
University of Michigan	2 tracks: Program in Biomedical Sciences in the Medical School, or directly to the Bioinformatics Program	MS, PhD	MS: 31 credits with internship required, non-thesis. PhD: 68 credits required with thesis and exam.	Tools for facilitating gene mapping, nanomolecular modeling, transcription mechanism study, etc.
University of Minnesota	Department of Computer Science and Engineering	MS minor, PhD minor	Minor requires core courses, 9 credits for master's, 15 credits for doctoral minor.	DNA repair mechanisms, quantitative genetics, biopolymers, etc.
University of Nebraska	Univ. NE Medical Center Department of Pathology and	MS in Pathology and Microbiology	MS: Eleven foundation biology, computational sciences courses, core	Cost benefit analysis for systems, computer literacy

	Microbiology w/ Department of Information Systems and Quantitative Analysis	with Special Track in Bioinformatics, PhD in Pathology and Microbiology with Special Track in Bioinformatics	biological sciences, computational sciences, electives and independent study. PhD: Similar requirements.	
University of North Carolina at Chapel Hill	School of Information and Library Science (MS), School of Pharmacy's Carolina Center for Genome Sciences (PhD)	MS Certificate of Specialization, PhD Certificate of Specialization	MS: 38 credits of required classes with research rotation. PhD: Two research rotations, one semester of teaching, core classes.	Structure and function relationships of proteins, computational protein design, statistical genetics
University of Pennsylvania	Department of Computational Biology	BS Biology, CS, or Mathematics w/Concentration, MS in Biotech w/Concentration, PhD in Genomics and Comp Biology	MS: 12 courses required. No information on PhD	Evolutionary population genetics, mathematical tools to map disease genes, multiple sequence alignments
University of Pittsburgh	Center for Biomedical Informatics	MS in Biomedical Informatics w/Concentration, PhD in Biomedical Informatics w/Concentration; Biomedical Informatics Certificate Program	MS: 44 credit hours, required core courses, electives, and thesis. PhD: 71 credit hours, core courses, electives, thesis, and significant research. Certificate: 15 credit hours	Biomolecular sequence-structure-function research, oncology informatics, medical simulations
University of Southern California	Department of Biological Sciences	PhD	60 credits and thesis.	Algorithm development, association mapping with SNPs, cancer genomics
University of South Florida	Health Sciences Center with other participating departments	MS	41 credits, with 9 core classes and a thesis.	No specific research mentioned.

University of Tennessee at Knoxville	Genomic Science and Technology Graduate School at UT-K w/ Oak Ridge National Laboratories	MS, PhD	MS: Similar requirements with thesis at end. PhD: 26 credits minimum, with thesis.	Microbial pathogenesis, mouse genomics, statistical methods of gene annotation.
University of Texas – Austin	Graduate Program in Cell and Molecular Biology	PhD track	Two semester core course required along with electives, and thesis.	Bioorganic chemistry, mouse genetics, apoptosis, cellular biosynthesis
University of Texas – El Paso	Department of Biological Sciences	Professional MS	2 year, non-thesis program. Core courses required.	Genome sequencing, bioluminescence, intelligent systems
University of the Sciences at Philadelphia	Program in Bioinformatics	BS, MS	22 credits core courses, electives beyond that.	No information available on specific research interests
University of Washington	Department of Medical Education and Biomedical Informatics	All degrees in Biomedical and Health Informatics, MS (research and applied), PhD awaiting approval; Certification only available for current students	MS Research: 60 credits minimum with thesis. MS Applied: 60 credits minimum with applied project.	Clinical informatics, genetic data integration, public health informatics, structural informatics
University of Wisconsin	MS in Computer Science with Bioinformatics Track	Department of Computer Science	N/A	No specific research mentioned
University of Wisconsin	Computation and Informatics in Biology and Medicine	Pre- and post-doctoral candidates	9 credits minimum.	Interdisciplinary research interests.
Vanderbilt University	Vanderbilt University Medical Center's Program in Biomedical Informatics	MS in Biomedical Informatics and PhD Concentration	MS: 27-40 credits required with thesis. PhD: 33-46 credits with teaching experience, and thesis.	Clinical terminology systems, medical informatics, machine learning
Virginia Polytechnic Institute	Program in Genetics, Bioinformatics, and Computational Biology	PhD in Genetics, Bioinformatics and Computational Biology	No specific information available.	Computational control, statistic analysis of microarrays, functional genomics

Wright State University	Department of Computer Science	BS in Computer Science or Biology w/Bioinformatics option	CS: 195 credit hours required. Biology: 200 credit hours required.	Protein binding interactions, data mining, molecular visualization
Yale University	Department of Molecular Biology and Biochemistry	PhD	Achieve competency in bioinformatics, biological sciences, and informatics.	Comparative genomics, data mining, macromolecules

Figure 2. Degree-granting Program in Bioinformatics in the United States as of February 2004. The columns give the university name (and link in online version), the hosting Department or School Unit, the degree granted, the requirements for completing the degree, and the primary research interests of faculty associated with the program, respectively.

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