ACADEMIC PROGRAM PROPOSAL

Truman State University

Professional Science Masters in *Bioscience Informatics*

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Professional Science Master's in *Bioscience Informatics*

Approved by Truman State University Graduate Council on November 17, 2010

Approved by Truman State University Faculty Senate on December 17, 2010

Approved by Truman State University Board of Governors on February 5, 2011

1. NEW PROGRAM PROPOSAL FORM – Form NP

A. Sponsoring Institution(s): Truman State University

B. Program Title: Professional Science Master's Program in *Bioscience Informatics*

C. Degree/Certificate: PSM

D. Options: N/A

E. Delivery Site(s): Truman State University

F. CIP Classification: 26.1199 (Biomathematics and Bioinformatics, Other)

G. Implementation Date: Fall 2011

H. Cooperative Partners: N/A

I. Expected Date of First Graduation: Spring 2013

AUTHORIZATION

Richard J. Coughtin/Interim Provost and Vice President for Academic Affairs, Truman State University

Name/Title of Institutional Officer

_____

Signature Date

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2. NEED

A. Student Demand

Below is the estimated enrollment each year for the first five years for full-time and part-time students. The projections are based on conversations with program directors at other schools. At Southern Illinois University-Edwardsville, for example, the Environmental Science and Management Professional Science Masters (PSM) Program enrolled two students in its first two years, and then increased capacity to 10 new, full-time students in the fifth and sixth year. At that point, most programs seem limited by resources and space. We believe based on the interest and enrollments in the undergraduate minors offered at Truman in related areas such as Mathematical Biology, Statistics, Business Administration, et. al., that we have a number of students who would enroll in a PSM in Bioscience Informatics.

STUDENT ENROLLMENT PROJECTIONS – Form SE

Year	**1**	**2**	**3**	**4**	**5**
Full Time	4	5	7	10	12
Part Time	0	3	5	7	9
Total	4	8	12	17	21

B. Market Demand

The goal of Truman's PSM in Bioscience Informatics is to educate and train a workforce with the skills required to fill the critical need for trained scientific workers in bioscience informatics. Truman is at the geographic center of the headquarters or major installations of three of the nation's largest agricultural biotechnology companies, Monsanto, Pioneer, and Bayer CropScience. *Despite this, there is not a single PSM program in any discipline in Missouri.*

As with all PSM programs, the proposed Bioscience Informatics Program will cater to individuals interested in pursuing an advanced degree in science and mathematics, growing professionally, and increasing their potential income in the business world. It is understood that PSMs are the wave of the future (as described in the '21st Century MBA' by Sheila Tobias; *Science News*, June 20, 2009) and thus this Program will serve as a catalyst and launch pad for the development of PSMs in a number of different industry areas. We have been working for over two years with several companies who are eager for Truman to develop PSMs in computational chemistry, secure computing, and medical informatics. The proposed Program will be marketed to two main groups: undergraduates nearing graduation and individuals with undergraduate degrees who are currently employed in the industry. Emphasis will also be placed on the development of online capabilities to reach potential students in remote locations.

Our industry partners in the bioscience sector report a growing need for individuals with the ability to design, develop, and manage bioengineered traits in commercial crops. Even in the current depressed economy, their demand

for our undergraduate Mathematical Biology Minor graduates has grown. Truman produced 18 graduates during the last five years, with some attending graduate schools, actuarial programs, or entering the workforce directly. Our students are recruited for both regular employment and internships and co-op programs. Significant to the current proposed PSM Program, there have been an increasing number of conversations recently with our industry partners about the need for interns and employees with more advanced technical skills. While our partners employ significant numbers of workers with traditional masters and doctoral degrees, they are increasingly interested in employees with the type of training that a PSM provides. They are not unusual in this regard as this is a national trend.

The State of Missouri has also emphasized the need to produce Science, Technology, Engineering and Mathematics (STEM) graduates by aligning curricular standards and practices across student attainment levels (e.g., regional P20 groups are now working in this capacity). This is evidenced by the recent MO STEM Summit hosted by Missouri Department of Elementary and Secondary Education (DESE). Much of the emphasis in Missouri is focused on workforce development. The proposed PSM Program can be seen as an extension of this effort in that it will train STEM graduates for success in additional and complimentary areas of concentration (e.g., business, ethics) that are important for stimulating the economic growth of the state. The proposed PSM Program also dovetails with the efforts of the Missouri Life Sciences Project because the curriculum brings together elements of experiences from the business and private sectors as well as higher education. Biotechnology, in particular, has been identified by the State as an area of need.

C. Societal Need

The rapid development of the global economy has increased pressure on the United States to improve its output of individuals with advanced degrees in STEM fields in order for the country to maintain its international competitiveness. However, it has been demonstrated that it is not enough to produce graduates with traditional Masters and PhD degrees. For today's graduates to help the United States maintain its competitive edge, they must both be knowledgeable in their primary field of study and possess a product-development mindset and the skills necessary to function productively in a fast-paced business environment. Professional Science Master's programs are key in producing such graduates. To support the ongoing emergence of PSMs, the national PSM Advisory Board recently recommended principles for program development and recognition. If the number of programs is an indication of need, then it is worth noting that there are now 230 programs in 106 institutions (http://www.sciencemasters.com).

D. Methodology used to determine “B” and “C” above.

The information in the sections above was compiled during conversations with industry partners, reading and evaluation of the literature pertaining to PSMs (see references below), attending the MO STEM Summit, attending Council of Graduate Schools (CGS) and PSM meetings, and studying several websites supporting the development of PSMs, including the CGS website (http://www.cgsnet.org/), the Science Master’s website (http://www.sciencemasters.com/),

the Missouri Life Sciences Project (http://www.missourilifesciences.org/index.php) and solicitations from the National Science Foundation (e.g., NSF 09-607).

Key References

National Research Council. *BIO 2010: Transforming Undergraduate Education for Future Research Biologists*. Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century. National Academy Press, Washington, DC, 2003.

Council of Graduate Schools. *Professional Master's Education.* Council of Graduate Schools, Washington, DC, 2006.

National Research Council. *Science Professionals: Master's Education for a Competitive World*. National Academy Press, Washington, DC, 2008.

3. DUPLICATION AND COLLABORATION

Truman's proposed Bioscience Informatics PSM Program is the first in Missouri to have been approved by the Council of Graduate Schools for PSM affiliation. There are no other PSM-affiliated programs in the State (http://www.sciencemasters.com/; verified December 2010), and hence no duplication of effort in that regard. In nearby locations in neighboring states, the University of Northern Iowa sponsors five PSMs (Applied Chemistry, Applied Physics, Biotechnology, Ecosystems Management, Industrial Mathematics) and Creighton University (Omaha, NE) offers a PSM in Bioscience Management. Southern Illinois University in Edwardsville, IL, also offers several PSMs, although none in Bioscience Informatics.

Non-PSM activities in Bioinformatics within the State include The University of Missouri Bioinformatics Consortium (UMBC), which supports collaborative research in bioinformatics and life sciences across the University of Missouri System. Missouri Southern State University offers an undergraduate degree in Bioinformatics. The UMKC School of Medicine offers an MS degree in Bioinformatics through the Department of Biomedical and Health Informatics. That program emphasizes clinical research applications, development and use of bioinformatics tools, and analysis of biological data. Each of these programs requires two years of science and statistics-based courses. A thesis option is also available.

4. PROGRAM STRUCTURE – Form PS

A. Total credits required for graduation: Thirty six hours of coursework (includes a 14-hour core plus 22 hours of approved electives). A minimum of 30 hours of coursework must be at the 500G level and higher (i.e., graduate level). Advanced science (STEM) courses account for 50% of the total degree credits.

B. Residency requirements, if any: Transfer of credit for any major coursework is determined on a case-by-case basis. Each course has specific course objectives that may or not be met in a similar course taught elsewhere, so students wishing to transfer course credit must supply documentation that the objectives associated with the course for which they are requesting credit were met. According to University policy, no more than six hours of transfer credit may be applied towards a Truman Master's degree.

C. General education: Students applying for the PSM must have completed an undergraduate degree. It is assumed that general education will have been met given this requirement.

D. Major (Core) requirements: Fourteen credit hours. The Bioscience Informatics PSM degree will have the same common core of courses that are required for all Truman State University Master of Science in Biology students. These courses provide a deep understanding of the scientific process and excellent skills in quantitative analysis and scientific communication. In the professional master's track, the thesis research component will be replaced by the internship research in a corporate setting. The core courses and their hours are:

Courses (specific courses OR distribution area and credits):

Biometry (BIOL 502G)	3 cr.
Scientific Discourse (BIOL 610G)	3 cr.
Graduate Seminar I (BIOL 606G)	1 cr.
Graduate Seminar II (BIOL 607G)	1 cr.
Graduate Internship (BIOL 6XXG)	6 cr.
	14 cr.

E. Free elective credits: Twenty two credit hours. These courses are divided into two skill groups, the science and technology group and the "plus" group. Science and technology courses provide knowledge in the biosciences, in the computational and quantitative sciences, and in interdisciplinary topics at the intersection of these two. Extradisciplinary "plus" courses provide competencies for students seeking employment in the corporate environment, specifically business management and leadership skills and ethics. Students are required to develop a learning plan in consultation with the PSM Committee, with courses selected from these clusters. The learning plan must contain at least one course from the Business Management and Leadership Cluster and one from the Ethics

Cluster. The list below is not intended to be exhaustive. Rather, it documents courses either already in existence or far enough in development that they will be ready for delivery by the commencement of the PSM Program.

Science and Technology Clusters

Agricultural Science: Principles of Plant Agriculture (AGSC 110), Advanced Topics in Agronomy (AGSC 416) and, Advanced Topics (BIOL 518G)
Biology: Plant Physiology (BIOL 405), Comparative Plant Morphology (BIOL 509G), Cell Physiology (BIOL 512G), Advanced Cell Biology (BIOL 530G), Molecular Genetics (BIOL 552G), Fundamental Processes in Biology I & II (BIOL 603G, BIOL 604G), Advanced Plant Physiology (BIOL 610G), Readings in Biology I & II (BIOL 644G, BIOL 645G), and, Biology Research (BIOL 649G).
Computer Science: Introduction to Computer Science I (CS 170), Software Engineering (CS 370), and, Database Systems (CS 430)
Mathematics and Statistics: Game Theory (MATH 335), Topics in Mathematical Modeling (MATH 530G), Statistical Quality Control (STAT 374), ANOVA and Experimental Design (STAT 375), Nonparametric Statistics/Sampling (STAT 376), Linear Regression/Time Series (STAT 378), Mathematical Probability and Statistics I & II (STAT 570G, STAT 571G)
Interdisciplinary: Introduction to Bioinformatics (BIOL 370/CS 325), Mathematical Biology (BIOL 345/MATH 345), and special topics courses offered as needed.

Plus Clusters

Business Management and Leadership: Business Database Management Systems (BSAD 522G), Leadership in Business Organizations (BSAD 655G), Organizational Behavior (BUS 625G), Project Management (BUS 612G), International Management (BUS 610G), Organizational Leadership (LDRS 601), and Decision Making and Strategic Leadership (LDRS 602)
Ethics: Cyberethics (CS 345), Ethical Issues in Sustainable Agriculture (AGSC 415), and, Ethical Implications of the Human Genome Project (JINS 353)

F. Requirements for thesis, internship, or other capstone experience: In the proposed PSM Program a student will undertake a research experience as part of an internship at an industry partner site. *Every student will be required to perform an internship*, and we have already had discussions with industry partners about the need for a research component in the internships they will offer our students. They are very comfortable with this, and indeed, strongly desire to have the students take charge of some specific aspect of their internship duties, transform it into a discrete, identifiable project, carry this project to completion, and give a presentation at the end of the experience.

The typical intern in our Program will work in the research information technology (IT) area of the company. The research IT organization supports the PhD scientists who are variously involved in biotechnology trait discovery and development, field trials, regulatory approval, marketing, deployment, and follow-up analysis. Vast amounts of business data are collected, stored, and mined during these processes. In addition, much of the discovery, development, and field trial phases involve mathematical modeling, bioinformatics, computational biology, data

mining, and statistical techniques, all requiring the support of the research IT organization.

A sample research experience might proceed as follows. A student is hired for a four-month internship in the research IT organization and is assigned to a team supporting the development of a new trait in field corn. The trait in question has been inserted into the genome of the parental stock, but crossings with landrace varieties yields evidence of unexpected linkage patterns of the new trait. Sequencing across several generations has resulted in a huge set of single nucleotide polymorphism (SNP) data that must be managed in order to understand the linkage pattern. The research IT group is asked to develop a new database for this SNP data and provide customized frontends to support the questions the research scientists are trying to answer. While a member of the team working jointly on this software development effort, our student is given personal responsibility for being team lead on one aspect of the development effort, namely, researching, designing, and developing the algorithm that will allow custom SNP-based multisequence alignments. General-purpose, multi-sequence, alignment algorithms are well understood and tools are universally available, but our team needs one that is customized to allow the user to manually anchor a specific set of SNPs across multiple sequences and then optimally align the rest of the sequences without violating those anchors.

Our student proposes this project to both her internship manager and to her faculty committee members in a written research proposal. It is approved, she does the work, writes a white paper on the results, and presents the results orally at the conclusion of her internship both onsite and in a colloquium series or other appropriate venue back on campus.

At this point, the evaluation of the research experience is identical to that of a traditional master's student, with the committee listening to the presentation, reading the paper, and ultimately passing or failing the student.

The standard model in which the research experience is an integral part of the internship experience has the benefit of most closely approximating the real working conditions of employment after graduation; however, for some students a different model may be employed. Our current undergraduates, especially those majoring in Biology or Agricultural Science, or those minoring in Mathematical Biology, are heavily involved in undergraduate research. A PSM Program student recruited from the ranks of Truman alumni might as an undergraduate already be involved in an ongoing traditional on-campus bioinformatics research project in a faculty member's lab or research group. In this case, if the faculty mentor is able to accommodate the student as a graduate researcher, and if the proposed research is an acceptable component of the proposed learning plan, the student will be allowed to complete the research component of the master's degree in this more traditional setting rather than onsite with an industry partner. In such a case, this research component would count for the appropriate number of credit hours on BIOL 649G (Biology Research) which would form part of the student’s learning plan. The student will still be required to do a full internship experience, but the research component will be independent.

G. Any unique features such as interdepartmental cooperation: N/A

5. FINANCIAL PROJECTIONS – Form FP

Expenditures

In this section and the following table, we address one-time and recurring expenditures related to the deployment of the proposed PSM in Bioscience Informatics. The faculty who will be teaching courses for the PSM Program are part of the established science, mathematics, and business units, so there are no additional one-time costs related to faculty recruitment. Other substantial start-up costs such as space and equipment are not an issue for the start-up and development of this Program. A new science building was completed in 2005 and has adequate labs, meeting spaces, and offices to support the Program. The School of Science and Mathematics has an annual equipment budget that supplies new equipment purchases and upgrades for departments, including all of those departments that support the Science and Technology Cluster of courses. The library recently underwent periodical subscription cost reductions of about 30%. While this reduced the number of periodical subscriptions, it also sharpened the focus of the journal subscriptions in the library. A list of periodicals in each academic unit is available on request. The list of periodicals is adequate to support the PSM Program, especially when additional sources of materials from Mobius and interlibrary loan are included in the analysis. The library continues its practice of taking book requests from faculty members, so it is possible to add new books to the library to support the PSM Program.

We plan a one-time expenditure of $5000 for a consulting fee the first year of the Program. We hope to leverage expertise from other Program Directors (coordinated through CGS) to ensure a smooth start-up for our Program.

The PSM Program contains several ongoing expenditures, as described in the table in Form FP. These expenditures include annual student recruitment efforts ($1,000), including brochure and poster printing, mailings, and phone calls or visits to industry partners; funds for a seminar series ($5,000); funds for the travel and lodging expenses for a PSM Oversight Committee; and funds for faculty stipends to develop online courses. The most expensive recurring costs are associated with a full-time staff member to support all aspects of the Program. This person would be housed in the School of Science and Mathematics and would report to the Dean of the School. The person's role in the deployment of the Program would be to organize student internships; contact and organize visits with industry partners; manage campus-wide support for the Program; organize meetings of the PSM Program oversight committee; manage Program assessment; maintain the Program website; and manage student applications, grievances, and other requests. We have scheduled this support staff member to begin work in the third year of the Program depending on enrollment. The timing of this hire ensures that the Program will be self-sustaining.

Revenue

The sole source of revenue for the Bioscience Informatics PSM Program is tuition and fees associated with student enrollment. The revenue estimates in the following table are the most conservative possible, and would underestimate revenue for the projected number of students (see the footnotes for additional details). The projected number of students is based on enrollment in other, similar PSMs in neighboring states (see Section 2.A. and Form SE).

6. PROGRAM CHARACTERISTICS AND PERFORMANCE GOALS – Form PG

A. Institution Name: Truman State University

B. Program Name: Professional Science Master's in Bioscience Informatics

C. Date: March 11, 2011

D. Student Preparation: Students accepted into the Bioscience Informatics PSM Program at Truman will have earned an undergraduate degree. The main focus of the PSM Program is to provide advanced science and mathematics courses, business management and leadership courses, ethics courses, and internship opportunities to admitted students. This will prepare these students to enter the workforce, progress in their careers, increase their salaries, and make useful contributions to the state of Missouri and the broader society.

E. Faculty Characteristics: Faculty assigned to teach in this Program will typically hold a terminal degree in their area of specialty. Further, faculty members who teach graduate courses at Truman are required to become an approved member of the graduate faculty. In order for this to take place, faculty members provide evidence of their scholarly activity, interest and participation in scholarly organizations transcending the local campus, willingness and ability to direct graduate work, and holding the terminal degree in their field. Truman State University has robust promotion and tenure requirements and personnel review structures that require faculty members to conduct themselves as teacher-scholars.

F. Enrollment Projections: The anticipated enrollment is detailed in Section 2.A. in Form SE on Page 5. The estimates are based on comparisons with similar programs in neighboring states, the enrollment in our current graduate programs, and our critical assessment of the local and regional workforce needs.

G. Student and Program Outcomes: Truman State University has a long and distinguished assessment program that resulted in national recognition in the mid-1980s and early 1990s. The commitment to assessment and student learning outcomes is extended to this Program. We have identified the following student outcomes:

1) Increased understanding and sensitivity to interdisciplinary issues.
2) The ability to communicate and work closely with business partners in relevant scientific fields.
3) Learned ability to understand, articulate, and apply business principles to science-related fields.
4) Increased analytical and synthesis skills.
5) Deeper understanding of the realities of running successful biotechnology and bioinformatics businesses in an increasingly complex global economy.
6) Increased ability and desire for entrepreneurial activities.
7) Increased workplace mobility (both vertically and laterally).
8) The ability to leverage personal skills, networks, and business partnerships to solve statewide and national issues in the biotechnology and bioinformatics sectors.
9) Increased earning potential.

Program outcomes are:

1) An increase in the number of graduates as described in Section 2A (Form SE) of this document.
2) Growth and maintenance of formal relationships with industry partners.
3) Increased contributions to statewide biotechnology and bioinformatics sectors, as measured by number of employees in these areas.
4) Further development of PSM programs at Truman and throughout the state of Missouri.
5) Growth in bioinformatics activities (projects, student interest) at Truman.
6) Increased visibility of Truman graduates throughout the state.

H. Program Accreditation

Although the Council of Graduate Schools supports and advocates for the development and deployment of PSMs, they do not provide accreditation services. Further, there is no accreditation body that specializes in accrediting PSMs. Information on program and University-wide accreditation at Truman is covered in Section 7.

I. Alumni and Employer Survey: The Career Center at Truman State University organizes the initial alumni and employer survey for graduates. After the first year, the responsibility for tracking alumni rests with the Office of Advancement. We will work with the Office of Advancement to develop a survey for each cohort of students. This survey will target the student and Program outcomes listed in Section 6G.

7. ACCREDITATION

Truman State University has been accredited since 1914 by the Higher Learning Commission (HLC) of the North Central Association of Colleges and Schools. Truman has maintained full accreditation for all of its programs through the years since then. Truman's next HLC accreditation review occurs during AY 2014-2015. For more information on the HLC or Truman State University accreditation status, please visit http://www.ncahigherlearningcommission.org or call (312) 263-0456.

Additionally every undergraduate and graduate at Truman receives a program review every five years. The Bioscience Informatics PSM Program will be reviewed at the end of its initial five years.

8. INSTITUTIONAL CHARACTERISTICS

Truman State University, Missouri's highly selective public liberal arts and sciences university, began September 2, 1867, when Joseph Baldwin opened the North Missouri Normal School and Commercial College. Truman bears a long history of name changes, each reflecting a new institutional mission. Most recently, in 1967, the Board of Regents recognized the institution's wider mission and acted to change the name first to Northeast Missouri State College, and then in 1972 to Northeast Missouri State University. Truman historically has welcomed change. To better serve the needs and actualize the potential of its students, the University has met challenges creatively but realistically. The signing of House Bill 196 on June 20, 1985, changed Truman's mission from an open enrollment, regional, multipurpose university to the statewide, public, liberal arts and sciences institution with highly selective admission requirements. Truman was chosen to assume this unique role because the institution had already begun moving away from a multipurpose curriculum toward a competitive liberal arts curriculum. The state's goal was to provide a public institution that could compete with the nation's finest undergraduate liberal arts colleges, and stem the flow of Missouri's best and brightest students to other states. In March 1993 Truman became Missouri's only public university opting to achieve the Missouri Coordinating Board for Higher Education's highly selective mission category. The University's name change to Truman State University on July 1, 1996, was part of the logical progression of its new mission.

Today, over 6,000 young men and women come to Truman annually to gain a high-quality, liberal arts and sciences education at an affordable price. Truman now offers 49 undergraduate and eight graduate degree programs, 47 minors, and several additional areas of specialized study. Each year, graduates seeking admission to graduate and professional schools around the world enjoy a very high acceptance rate. Typically over 50% move on to attend graduate and professional school, and over 48% move on to full-time employment.

Truman State University is a national leader in undergraduate mathematical biology education. (We use the term "mathematical biology" in a very broad sense, to include a range of quantitative and computational approaches applied to questions in the life sciences including agriculture.) Regional and national discussions on the role of the mathematical sciences in life science research and industry and the support of three NSF grants led to the establishment of an interdisciplinary mathematical biology major, Missouri's first mathematical biology minor, heavy involvement of undergraduates in interdisciplinary mathematical biology research, and an enviable record of graduate placement in academic master's and doctorate programs. A central component of the mathematical biology program has been the establishment of close collaborative ties with a number of industry and non-governmental organization partners who provide research, internships, practical and field trip experiences for our students. These include Monsanto, Cerner, the Donald Danforth Plant Science Center, Boeing, and Bayer CropScience.

Truman State University also has long-term institutional experience with masters-level education. Truman has the second oldest masters program of public universities schools in Missouri. Truman has four masters programs allied with the goals of professional masters programs, including a Master of Accountancy, a Master of Arts in Communication Disorders, a Master of Arts in Counseling, and the largest Master of Arts in Education Program in Missouri. In addition, we have a newly approved Master of Arts in

Leadership degree that will share some courses with the current proposal. Truman also has an existing thesis-based Master of Science degree in the Biology Department. The current goal of the Biology Graduate Program is to produce highly competitive students for recruitment into the nation's foremost institutions granting doctoral-level graduate and professional degrees. As such, the Biology MS Program is designed to provide students with practical training in biological research, expertise in communicating scientific information, and advanced knowledge within a chosen specialty area.

The proposed PSM Program seeks to build upon the strong foundation of our Mathematical Biology Program and our existing Biology Masters degree to create a PSM program for those students who wish to enter the workforce rather than pursue conventional academic graduate degrees. We envision a PSM program that marries biology, agricultural science, computer science, statistics, and mathematics, with a strong infusion of business management and communication skills, to create a high-quality, in-demand technical expertise in bioscience informatics.

A continuity of purpose is evident in the growth and changes of Truman. The University has consistently been committed to academic excellence and has espoused the belief that a strong education is the best means of preparing for a life of continuing personal growth and service. Moreover, Truman's historic mission to improve the preparation of teachers has prompted the University to be among the nation's leaders in making education more professional. Commitment, unity of purpose, and concentration on student learning – putting first things first – have brought Truman to its present statewide mission and academic excellence.