May 21, 2014

Paul M. DeLuca, Jr., Ph.D.
Provost and Vice Chancellor for Academic Affairs
150 Bascom Hall
- CAMPUS -

Subject: Seeking Full Proposal Approval
MS Degree Program in Biomedical Informatics Proposal

Dear Provost DeLuca:

On behalf of the School of Medicine and Public Health (SMPH), I wish to provide my personal endorsement of the full proposal - “Proposal for the MS Degree Program in Biomedical Informatics.”

The SMPH Academic Planning Council members unanimously approved this request on May 21, 2014. I have enclosed a copy of the request for your review.

We understand that the UAPC would appreciate being advised of any outstanding reviews a department has, particularly at such time they are submitting a new proposal also requiring review. With regard to the pending review of the Certificate Programs in Bioinformatics (both Graduate Certificate and Capstone Certificate), the SMPH has received a self-study document from the Department of Biostatistics and Medical Informatics and is in the process of appointing a review committee. We anticipate that this review will be completed during the summer of 2014, will be presented to the SMPH APC in the fall of 2014, and, upon approval, will then be submitted to the Provost’s Office.

Thank you for your consideration. If you require additional information, please do not hesitate to contact my office at kjlee@wisc.edu.

Sincerely,

Robert N. Golden, M.D.
Robert Turell Professor in Medical Leadership
Dean, School of Medicine and Public Health
Vice Chancellor for Medical Affairs
University of Wisconsin-Madison

Enclosure: Full Proposal: MS Degree Program in Biomedical Informatics

xc: Jocelyn Milner, Ph.D.; Director of Academic Planning and Analysis
Kelly Haslman; Graduate Executive Faculty Committee
Paul Rathouz, Ph.D.; Professor and Chair, Biostatistics and Medical Informatics
Mark Craven, Ph.D.; Biostatistics and Medical Informatics
Eneida Mendonca, M.D., Ph.D.; Biostatistics and Medical Informatics
Whitney Sweeney; Biostatistics and Medical Informatics
Tracy Cabot; SMPH Dean’s Office
April 1, 2014

Academic Planning Council  
School of Medicine and Public Health  
University of Wisconsin – Madison

Dear Colleagues:

Attached is the full proposal for a New MS Degree Program in Biomedical Informatics to be housed and administered by the Department of Biostatistics and Medical Informatics (BMI).

There is a clear need for scientists and clinical investigators in Biomedical Informatics. The new degree program that we are planning will be one step towards meeting this need. The curriculum we propose will provide a forum where both the typical clinical investigator and computer savvy scientist can pursue the training needed to contribute informatics expertise both to biomedical research and to clinical care and processes. The Department of Biostatistics and Medical Informatics has a strong, maturing, and expanding cadre of faculty who cover many specialized areas in the field including (but not limited to) medical imaging, genomics, and bioinformatics, clinical trials, applications of machine learning, natural language processing, clinical informatics, and population health informatics. A graduate degree program in Biomedical Informatics will capitalize on this strength, and greatly leverage it for myriad research programs in the School of Medicine & Public Health. We predict that it will also be greatly desirable to clinical faculty members and recruits as they look to expand their methodological research skills.

At a meeting of the BMI Departmental Faculty on March 7, 2014, 19 members were present and voted unanimously to advance the full proposal for a new MS degree program in Biomedical Informatics. One additional member who could not be present expressed strong support to me via email before the meeting. Among all those involved, the common sentiment is that the development of such a program is not only long-overdue, but essential to the growth of the Department.

We thank you in advance for your consideration.

Sincerely,

Paul J. Rathouz, PhD  
Professor and Chair  
Department of Biostatistics and Medical Informatics
Request for Authorization to Implement a MS Degree Program in Biomedical Informatics At UW Madison
Prepared by Department of Biostatistics and Medical Informatics At UW Madison

ABSTRACT

Biomedical informatics explores the effective uses of biomedical data, information and knowledge in biomedical research and in the delivery of health care. The proposed program focuses on key concepts and methodologies at the intersection of computer science, statistics, and the biomedical sciences. The program will allow specialization both in methodology and application area. Potential students include both those in data sciences and biomedical fields.

PROGRAM IDENTIFICATION

Institution Name
University of Wisconsin – Madison

Title of Proposed Program
Biomedical Informatics

Degree/Major Designation
Masters of Science-Biomedical Informatics

Mode of Delivery
Single institution; on-campus, face to face

Projected Enrollment By Year Five of the Program
An enrollment of 5 new students per year is anticipated, for a total of 20-25 in the first five years of the program, and 10 enrollees on average at any given time. Expansion in enrollment will be considered as the program evolves over time; perhaps up to 15-18 students at a given time as with similar programs at peer institutions (e.g., Columbia and the University of Utah).

Tuition Structure
Students enrolled in the program will pay standard graduate tuition according to the rates approved by the Board of Regents. For the current 2013-14 academic year, the residential tuition and segregated fees total $5928.80 per semester for a full-time student who is enrolled in 8-12 or more credits per term. Of this amount, $565.00 is attributable to segregated fees and the remainder is tuition.

Departmental or Functional Equivalent
The proposed program will reside within the Department of Biostatistics and Medical Informatics

College, School or Functional Equivalent
The proposed program will reside within the School of Medicine and Public Health

Proposed Date of Implementation
Fall 2014 for recruiting and applications; Fall 2015 for enrollment
INTRODUCTION

Biomedical informatics is the interdisciplinary field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving, and decision making, driven by efforts to improve human health. Biomedical informatics investigates and supports reasoning, modeling, simulation, experimentation, and translation across the spectrum from molecules to individuals to populations [1]. The field of Biomedical Informatics requires (i) understanding and application of key concepts and methodologies from computer science and statistics, (ii) knowledge of biological, biomedical, and population health concepts and problems, and (iii) insight into the central computational problems in biomedicine and how methods from computer science, statistics and engineering can be applied to address them.

Rationale and Relation to Mission

In 1997, at the request of and in pursuit of the mission of the School of Medicine, the Department of Biostatistics at UW-Madison became the Department of Biostatistics and Medical Informatics (BMI). With that change, the Department embarked on long-term mission to build and fully develop scholarly programs in biomedical informatics in the School of Medicine (since transformed to the School of Medicine and Public Health; SMPH). The programs were initially focused in the areas of bioinformatics and medical image analysis, with a strong methodological emphasis on machine learning. Activities in these areas were closely tied to the Department of Computer Sciences (CS), through which many current graduate students are trained. More recently, the focus of research in the Department has expanded to embrace clinical informatics and population/public health informatics. One key faculty member in this area has a joint appointment with the Department of Industrial and Systems Engineering (ISyE) and participates in teaching relevant courses in that department. The faculty have been enormously successful at establishing robust and rich research and teaching programs, and they are now in a position to lead a new graduate program. Additionally, with the emergence of new scientific contexts generated by the proliferation of electronic health records and the increasing pervasiveness of genomic technologies, new audiences for training in biomedical informatics have emerged.

At the University level, such a program is in broad support of the University's mission. Three points in particular are advanced by the proposed program (italicized text indicates quotes from the University mission statement):

1. Generate new knowledge through a broad array of scholarly, research and creative endeavors, which provide a foundation for dealing with the immediate and long-range needs of society.

   Owing to the onslaught of biomedical data from myriad sources and in myriad formats, to the need for rigorous and broadly applicable quantitative approaches to handing such data, and to the special role that quantitative sciences play as a unifying and integrating force in interdisciplinary science, programs in biomedical informatics will be instrumental in advancing biomedical research and practice in maximal service to the needs of society.

2. Achieve leadership in each discipline, strengthen interdisciplinary studies, and pioneer new fields of learning.

   As mentioned above, quantitative sciences can provide a unifying platform from which to view many disciplines within biomedical sciences. A program in biomedical informatics will advance the quality and rigor of many areas of biomedical sciences as well as strengthen the ties that bind together those areas at transdisciplinary nexuses.
3. Maintain a level of excellence and standards in all programs that will give them statewide, national and international significance.

As mentioned in the foregoing, the research and teaching program in biomedical informatics has over the past 16 years evolved from a nascent program to a nationally recognized research program. The Department has 34 faculty who can contribute to training in informatics, either through teaching or mentoring research. More than 20 students are currently training in biomedical informatics through existing programs with these faculty. Existing training in informatics through the Department of Biostatistics and Medical Informatics involves 10 courses, including seminars and workshops. Additional courses are currently in development. The Department currently has all of the elements for an effective program, but a cohesive system for recruiting and training new researchers and professionals in this area is lacking, a limitation that is now inhibiting the program's trajectory to full maturity. Indeed, because a key component of the Department's mission is to be a fully-elaborated scholarly home for biomedical informatics, and because there is a demonstrated need for graduate programs in this area, the Department would be abdicating its mission by not proposing, mounting, growing and maintaining such a program.

Need as Suggested by Current Student Demand

Audiences for training in biomedical informatics extend beyond the disciplines of computer sciences and industrial engineering to include individuals trained as clinicians and biomedical scientists. There are many individuals in these areas in need of training in biomedical informatics, but who do not have the interest in pursuing training in computer sciences and industrial and systems engineering, only then to have to bridge that work into the biomedical world.

In addition to the demonstrated need and demand for training in the area of biomedical informatics, there is an intense and growing need for graduate students to support the Department faculty's increasingly broad and complex research programs and activities. Recruiting students to an MS program will give the Department and the SMPH a stronger competitive position with respect to other major research universities that offer programs specifically in bioinformatics, computational biology, and/or biomedical informatics. Similarly, the Department’s ability to attract and retain faculty will be strengthened by having a MS-Biomedical Informatics.

At the level of the School of Medicine and Public Health, biomedical informatics has become a mission-critical focus. In the past several years, the use of electronic medical records in partner clinical organizations has become widespread. Recently, the School hired a Chief Research Information Officer to spearhead the development of a clinical data warehouse, among other pieces of computational infrastructure. As these resources grow, training in biomedical informatics will be increasingly critical to the School's interest in leveraging them. The Institute for Clinical and Translational Research (ICTR) at the University of Wisconsin has embraced biomedical informatics and has made its growth and development at the SMPH one of its central areas of emphasis. ICTR is highly supportive of a formal graduate program in biomedical informatics at UW-Madison. One potential audience for the proposed program includes junior clinical faculty and clinical fellows. Several such clinicians have already pursued MS degrees that have been advised by Department faculty, but carried out under the auspices of the Clinical Investigation graduate program. Another anticipated impact of the proposed degree program on the SMPH is that some graduates may end up being employed in research programs in the school. Indeed, there are currently two openings in the Department for just such individuals.

An additional benefit to SMPH faculty of graduate training in biomedical informatics is that it will make individuals who complete the program much better collaborators with faculty in biomedical
informatics. Here, there is a strong analogue to biostatistics: Often the greatest benefit of training in biostatistics directed at clinicians is not that they eventually do all of their study design and data analysis on their own, but that they become better collaborators with their biostatistical colleagues. This same phenomenon is expected to arise in the arena of biomedical informatics.

**Need as Suggested By Market Demand**

Nationwide, the biomedical research community is struggling to manage, share, analyze and fully exploit expanding quantities of data in the biomedical sciences. The need for a workforce capable of innovating, implementing and using methods from biomedical informatics is widely recognized. This demand has been driven by several factors:

- The proliferation of high-throughput biological experimental methodologies (e.g., next-generation sequencing, microarrays, SNP arrays, etc.) has transformed biology into a data-intensive science. It has become commonplace for biological studies to involve and rely on scientists and staff who are trained in bioinformatics.
- A similar pattern is emerging with state of the art medical and neuro-imaging studies.
- Incentives, such as those specified by the Health Information Technology for Economic and Clinical Health (HITECH) Act, are accelerating the adoption and broadening functionality of electronic health records and health care billing records, including application in the important area of comparative effectiveness research.
- Increasingly, biomedical studies and clinical decision-making are integrating and making inferences with varied types of data (genotypes, molecular profiles, images, electronic health records, and population-based data), which heightens the need for sophisticated computational methods.

The NIH has clearly identified biomedical informatics as an area of priority for increased training in order for clinical and translational research to proceed at a pace that takes advantage of the tremendous output of scientific and clinical data. In a recent report, the Data and Informatics Working Group of the NIH Director's Advisory Committee made a specific recommendation to "build capacity by training the work force in the relevant quantitative sciences such as bioinformatics, biomathematics, biostatistics and clinical informatics" [2]. Following this report, the NIH formally recognized the need to expand the quantitative sciences workforce and methodology through its "Big Data to Knowledge" (BD2K) initiative (http://bd2k.nih.gov) which has called for innovative new research and training programs focused on the management and analysis of biomedical data. Thus, there is a pressing need and a keen interest among translational researchers for such training.

Also acknowledging this new discipline and the need for a specialized workforce, the American Board of Medical Specialties has recently added Clinical Informatics as a certified subspecialty for physicians. The first certificates will be awarded this year. In addition, the Accreditation Council for Graduate Medical Education (ACGME) has also released draft requirements for Clinical Informatics fellowship subspecialty programs [3]. The fellowship program will be one of the requirements for physicians who want to take the subspecialty board exam. It is likely that fellows will be taking courses in the proposed program or completing the MS program in order to prepare for the board examination. There is substantial interest in receiving board certification. Over 400 physicians passed the board certification exam last year when it was first offered. This is only a small subset of those who are currently seeking training in informatics.
Emerging Knowledge and New Directions in Biomedical Informatics

As discussed above, biomedical informatics represents a new and expanding professional direction and has been embraced by national agencies, biomedical science research communities, and the medical profession. The biological sciences and medicine have become very data-rich fields in recent years with the burgeoning growth of new high-throughput biological experimentation technologies, including genome sequencing, and electronic health records. At the same time, these new sources and types of biomedical data are posing new challenging problems for research in the data sciences.

DESCRIPTION OF PROGRAM

General Structure of the Program

Institutional Program Array

The MS-Biomedical Informatics focuses on applications of quantitative and data science methodologies in biomedical science broadly construed, including bioinformatics, image analysis, and health and clinical informatics. Students will be trained in (i) key concepts and methodologies from computer science and statistics, (ii) biological, biomedical, and population health concepts and problems, and (iii) the central computational problems in biomedicine and how methods from computer science, statistics and engineering can be applied to address them. As such, the proposed program relates to, and is especially contrasted with, four existing programs on campus: Those in Biostatistics, in Industrial and Systems Engineering, in Clinical Investigation, and in Computer Sciences (CS).

MS and PhD named options in Biostatistics are provided through a close relationship between the Department of Biostatistics and Medical Informatics and the Department of Statistics. The proposed program will emphasize statistical reasoning but will not ask the students to pursue work in statistical theory or in development or application of modeling methods. Rather, it will emphasize approaches to biomedical sciences based more on data structures and algorithms from computer science. Hence, relative to (bio)statistics, the proposed program represents an alternative set of quantitative methodologies for contributing to and advancing biomedical science.

The relationship and contrast to Industrial and Systems Engineering lies along the axis running between the invention of new systems, processes and devices for clinical care to the development of new algorithms and computational approaches for biomedical and clinical research. The proposed program emphasizes the latter elements and the connections to research design. It also provides greater emphasis on bioinformatics and image analysis. The Department of Biostatistics and Medical Informatics has a strong relationship to the Department of Industrial and Systems Engineering, and as can be seen, the proposed curriculum includes shared courses with this department, courses for which both departments are full partners in staffing and maintaining.

The MS program in Clinical Investigation shares some overlap with the proposed program in intended audience and in its emphasis on quantitative research methodologies. It completely lacks a formal informatics component, however, and such material could only be taken in a limited way as a set of electives.

Finally, for most students, the MS program in Computer Sciences will not be sufficiently concentrated in the arenas of biomedical or clinical science to move them from basic interest and background knowledge to functional skills in biomedical or clinical informatics. For the typical clinician, a program is needed that builds on his/her existing clinical training and knowledge while at the same time
recognizing that the quantitative background going into the program may not be as strong as that of the
typical graduate student in computer science or a similar program. For the individual with a stronger
undergraduate background in computer sciences, a program is needed that provides appropriate
background in biomedical problems, processes and systems, so that technical and methodological
material is appropriately contextualized. The proposed program brings all these needs together to
provide clinicians, and those with undergraduate degrees in computer sciences and other similar areas,
with the training needed to contribute informatics expertise both to biomedical research and to clinical
care and processes. Having said that, the proposed program does include many elective courses in
Computer Sciences. Several of these are commonly taught by BMI faculty who have affiliate
appointments in the Department of Computer Sciences (CS), including CS 540, 760 and 766. Over time,
the balance of elective course offerings is expected to shift from Computer Sciences to BMI. Indeed,
most junior faculty members in BMI have developed their own new courses during their probationary
period; as such, continued growth is expected for course offerings in these areas as a result of ongoing
departmental faculty expansion in biomedical informatics.

The BMI Department also has two Certificate Programs in Bioinformatics (the Capstone and
Graduate Certificates). However, we do not expect the Certificate Programs and the MS Degree
program to compete for the same students. The Graduate Certificate is for students in other disciplines
who are looking to advance and document their training in bioinformatics. They are already enrolled in
other degree programs. As for Capstone students, some potential students—especially professional
research staff here at the UW—may be willing to take on the financial commitment and to invest the time
for a 12-credit certificate, but not a 30-credit MS degree. Thus, these will be largely separate pools of
students. Additionally, the Certificate Programs are more narrowly focused in one area of biomedical
informatics, namely bioinformatics, whereas the MS Program will allow students to cover the waterfront
in biomedical informatics as well as to gain depth in one or more of bioinformatics, (medical) imaging
informatics, clinical informatics, or population health informatics.

During the process of developing this proposal, the Department faculty have carefully considered the
interaction and synergy of the Certificate programs and the proposed MS program, and have given
deliberate consideration to discontinuing one or both of the Certificate programs. During the process of
completing the self-study portion (see Appendix A) of the regular program review for the Certificate
programs, faculty decided to keep both programs for a limited number of years before deciding to
discontinue them, and have committed to re-reviewing these programs internally in three years’ time.
The main reasons for not discontinuing these programs at this point in time, despite low enrollment are
threelfold: First, students who have completed the programs have found them uniquely valuable for their
ongoing professional activities. Second, little has been done to market these programs and yet have
attracted a regular albeit small stream of students into them. In fact, enrollment seems to be increasing.
Five students were admitted to the certificate programs during the spring of 2014. With additional
inquiries regarding the program, the programs are expected to grow. This will be especially true with the
proposed increase in marketing efforts. Third, and perhaps most importantly, the programs have
intensely growing relevance owing to the exponential growth over the past few years of biomedical data
produced by high-throughput biological experimentation. These innovations are creating a strong
demand for individuals trained at all levels in bioinformatics, and the certificate programs are poised to
meet that demand at one level.

In summary, the MS degree program in Biomedical Informatics will be a unique and innovative
option for students looking to improve their knowledge and skills in the field of biomedical informatics.
Students will learn the basics of statistics, but not delve into the methodology as in the Degree Options
in Biostatistics, and the curriculum is designed to provide much more comprehensive coverage of
informatics than the MS Degree in Clinical Investigation and the two Certificate Programs. The proposed
program will emphasize the development of new algorithms and computational approaches and their connections to research design whereas Industrial and Systems Engineering has more of a focus on the invention of new systems, processes and devices for clinical care. It will also provide a balanced coverage of functional skills in informatics and biomedical problems, unlike the MS degree in Computer Science. Thus, the proposed program will likely appeal to both clinicians as well as those trained in computational methods.

**Governance and Leadership Structure**

The program will be governed by a *steering committee* consisting of seven members who are broadly representative of BMI faculty, at least five of whom are tenure-homed in BMI, and all of whom are members of the program faculty (defined below). If the Department Chair is not one of the seven, s/he will serve in an *ex officio* and non-voting capacity. The members of the committee will be appointed by the Chair of the Department of Biostatistics and Medical Informatics, and will generally serve three-year renewable terms, with no limit of the number of terms served. Shorter terms are allowed, especially to maintain staggered rotation of members on and off the committee. The steering committee has the authority to create subcommittees and working committees including but not limited to admissions and curriculum committees. These subcommittees must be populated by program faculty but not necessarily by members of the steering committee.

The *program faculty* will automatically include all tenured and probationary faculty of BMI. Other faculty on campus may be nominated and appointed to the program faculty by the steering committee. The program faculty members will be appointed for three-year terms, renewable with no limit on number of terms. The steering committee will also be charged with establishing, reviewing and applying criteria for appointing and renewing program faculty.

The Steering Committee will be Chaired by a Director of Graduate Study for the program, and Co-Chaired by an Associate Director of Graduate Study for the program. These two individuals will be named by the Chair of the Department of Biostatistics and Medical Informatics and will serve three-year terms, renewable with no limit on number of terms. The Director and Associate Director will be supported by a graduate student services coordinator (SSC) already employed by the Department. The Director and Associate Director will have ultimate responsibility for the successful operation of the program, including recruiting, admissions, curricular evaluation and changes, evaluation of student progress, and evaluation of student outcomes upon and after completion of the program.

Founding Director and Associate Director of Graduate Study are Professor Mark Craven and Associate Professor Eneida Mendonça. The Department is fortunate to have an able, experienced and energetic Student Services Coordinator in Whitney Sweeney, who has been involved with every aspect of the proposed program development, and who will have capacity to support admissions, student advising, and student registration processes for the program at the targeted enrollment levels. Dr. Sweeney holds a PhD in Psychology including training in research methods, and is a former faculty member involved in teaching and training. Indeed, she is well-equipped to support these processes as she currently supports and coordinates two training grant programs and two summer programs. The summer programs each involve their own applications, admissions, curricular, and student tracking processes, which she coordinates annually and which, while smaller in scope for the students, involve much greater administrative overhead per unit of student work than will the proposed MS program. She will provide the necessary student services the program will need.
Other Programs in the University of Wisconsin System

The University of Wisconsin-Milwaukee is the only UW system campus that has a closely related program – a Master of Science in Health Care Informatics. This program focuses on the areas of systems analysis and design, database and project management, decision support, network design, and health care applications and procurement. This valuable and well-run program is designed for individuals who seek careers in health care systems implementation and delivery, managed care organizations, and health care system vendors. As distinct from the UW-Milwaukee program, the proposed program places greater emphasis on biomedical informatics as a body of research methodology which may or may not be clinical, and which embraces the imaging, public health, and bioinformatics aspects of the field.

The UW-Madison is among only 14 institutions in the country that currently have a National Library of Medicine-funded training grant for research graduate study in biomedical informatics. These awards are highly competitive and awarded only to exceptional programs in order to provide support for graduate students and postdoctoral fellows conducting research in the area. Other top programs in the nation also receiving such an award include: Columbia University, Harvard University, Ohio State University, Oregon Health & Sciences University, Rice University, Stanford University, University of California-San Diego, University of Colorado Anschutz Medical Campus, University of Pittsburgh, University of Utah, the University of Washington, Vanderbilt University, and Yale University. Some of these programs have a similar focus to the one proposed here; others are differentiated by having a more specific focus, such as bioinformatics or health informatics. The proposed program includes a large spectrum of informatics research: health/clinical informatics, population informatics, image analysis, and bioinformatics. The proposed program is somewhat unique in terms of geography as well. The UW Madison is the only NLM-funded program in the Midwest other than Ohio State University and the OSU program emphasis is on translational and clinical research informatics.

Collaborative Nature of the Program

The MS Degree Program in Biomedical Informatics is inherently collaborative due to its interdisciplinary nature. The program curriculum is a convergence of a number of different disciplines (Computer Science, Industrial and Systems Engineering, Biostatistics, Bioinformatics, and Health Informatics) and courses from those departments are included in the curriculum. In addition, research conducted within the field of informatics is also inherently collaborative. Most studies involve data evolving from research in fields of biology, biomedicine, and/or public health. Researchers in biomedical informatics bring to bear their expertise in computational and quantitative data methodology, and combine it with domain area knowledge to produce novel solutions to some of the most difficult problems in those domain areas.

Diversity

The Department of Biostatistics and Medical Informatics is committed to diversity in the curriculum, faculty, and students. In terms of the curriculum there is a specific set of elective courses to choose from that will cover the responsible conduct of research which will include discussions of how to deal with diverse populations in research settings. More clinically related issues in ethics and diversity will be covered in courses such as Health Informatics\(^1\) where students will learn about policies, regulations and ethics, including HIPAA. Other elective courses in the program, like Health Information Systems (ISyE/BMI 617) and Clinical Research Informatics (BMI 773) also offer lectures on the topics.

\(^1\) This course is currently being taught as a special topics course (BMI 826), while we complete the proposal process.
In the fields of Biostatistics and Biomedical informatics, it is difficult to recruit a truly diverse group of faculty. The primary faculty in the Department of Biostatistics and Medical Informatics is currently made up of fifteen males and seven females. Thirteen individuals are white, seven are Asian, one is Turkish and one is Brazilian. This issue is important to the Department and time and resources have been committed to the effort. During recent faculty searches posted advertisements were posted on specific diversity related websites including, but not limited to the Society for Chicanos and Native Americans in Science (SACNAS) and the Association for Women in Science. The Department also participates in the SMPH diversity hiring programs.

The Department also supports the recruitment of diverse student populations. Funds are contributed to partner departments (e.g., Statistics) and the Department sponsors two undergraduate summer programs. Significant funding is specifically contributed to the undergraduate summer research program in Computation Biology and Biostatistics. This mentor-based research program is designed to bring under-represented groups of students to campus to pursue research in fields at the nexus of biomedicine and quantitative methods. Although it is not officially in the title, there are students who participate every summer working with Department faculty on topics related to bioinformatics and biomedical informatics. Many of the students from this program have applied and joined current graduate programs in Biostatistics, Population Health, Industrial and Systems Engineering, and Computer Science. This pool of students will now have the opportunity to pursue a MS in Biomedical Informatics when the program opens. The hope is that this will prime the pump so that these same students will go on to careers in the field, increasing the number of under-represented individuals competing for jobs on campus.

**Program Objectives**

The MS degree program in Biomedical Informatics will take a broad view of what constitutes biomedical informatics in terms of the range and scale of biomedical problems being addressed, and also in terms of the quantitative and computational methodologies being covered. The proposed program adheres to national standards for graduate training in biomedical informatics established by the American Medical Informatics Association (AMIA). As such, the program has several objectives:

- Train all students in a common core curriculum covering the breadth of challenges, scales and methods in biomedical informatics.
- Offer students a curriculum covering the spectrum from analyzing molecular-level data to analyzing populations of individuals in pursuit of biomedical research and novel clinical processes. That is, it will encompass the subfields of bioinformatics, imaging informatics, translational bioinformatics, clinical informatics, clinical research informatics, public health informatics, and consumer health informatics.
- Offer students a curriculum featuring rigorous training in a range of informatics methods, including but not limited to: artificial intelligence (including computer vision, machine learning, natural language processing), databases, human-computer interaction, optimization, and security. This curriculum will surpass that of peer programs in terms of depth of training in computational and quantitative methodology.
- Impart to students a fundamental knowledge of, and competence in, computer science, statistics, and the biomedical sciences.
- Produce students who are professionals capable of independent thinking, of bringing novel strategies and new ideas to their professional work environment, and of becoming leaders in healthcare, academia and industry.
- Produce students possessing core competencies defined by the AMIA standards for MS level training in biomedical informatics.

The targeted student outcomes and proposed curriculum are designed to meet these program objectives.
Assessment of Program Objectives

As part of standard procedure at the UW Madison, all courses in the curriculum will be evaluated at the end of each semester. These evaluations provide information about the quality of the teaching and materials with which the students are presented.

The program will be reviewed annually by conducting student interviews and surveys to determine if the program is meeting the needs of the students. Data will be collected about student outcomes both during the program and post-graduation. A successful program will be one in which students are able to fulfill the requirements of the program, meeting the associated core competencies. Job placement, additional degrees and publication records will also be used as evidence of successful post-graduation outcomes. In addition, many students will ultimately decide to apply for national certification (e.g., via the American Medical Informatics Association). The proposed program is geared to help prepare students for these national exams.

Mostly, biomedical informatics is a field motivated by developing new insights and solutions for addressing human health and disease, in both clinical and basic science spaces. Recognizing the rapid change in the approaches to addressing these issues, the program will be continuously reassessed in terms of the competency areas. The Associate Director of the proposed program, Dr. Mendonça, currently is a member of the Education Committee of the American Medical Informatics Association which addresses curriculum and competency areas in biomedical informatics education. The proposed program will be assessed by comparing it with other similar programs and published recommendations by national and international institutions and professional/academic organizations (e.g., the American Medical Informatics Association). In addition, on a regular basis, redundancies and overlaps in the curriculum will be addressed and faculty will be surveyed about their views and perspectives on curriculum content and need for changes.

Student Learning Outcomes

The broad view used to create this MS degree program will allow students a significant amount of flexibility in the design of their curriculum. However, even with the diverse array of course sequences possible for each student, all graduates will be expected to achieve a certain set of standards. At the end of the program, all graduates completing this degree program will be able to:

- Understand, apply, and evaluate common informatics theories, methods, and tools related to biological and biomedical problems, health care and public health.
- Apply, adapt, and validate an existing approach to a specific biomedical and health problem.
- Produce solutions that address academic or industrial needs using informatics tools and knowledge.
- Evaluate the impact of biomedical informatics applications and interventions.
- Understand the challenges and limitations of technological solutions.
• Adhere to the professional and legal standards of conduct in biomedical informatics.
• Demonstrate scholarly oral and written presentations.

Assessment of Student Outcomes

1. Coursework: The curriculum has been designed to accomplish the outcomes outlined above. The students begin with the core courses building a basic foundation in biomedical informatics. Note that many outcomes are covered in more than one course, thereby helping to cement the concepts for the students. As students progress through the program, they can then focus their learning in a concentrated area of biomedical informatics thus adding depth to their knowledge. Provided the students perform well in their courses (i.e., achieve a grade of B or better), they will meet the outcomes listed above. The table below indicates which outcomes are covered by each of the core courses.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Introduction to Bioinformatics</th>
<th>Medical Image Analysis</th>
<th>Health Informatics</th>
<th>Introduction to Biostatistics</th>
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<tbody>
<tr>
<td>Understand, apply and evaluate common informatics theories methods, and tools related to biological and biomedical problems, health care and public health.</td>
<td>✓</td>
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<td>Apply, adapt, and validate an existing approach to a specific biomedical and health problem.</td>
<td>✓</td>
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<tr>
<td>Produce solutions that address academic or industrial needs using informatics tools and knowledge.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Evaluate the impact of biomedical informatics applications and interventions.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Understand the challenges and limitations of technological solutions.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Adhere to the professional and legal conduct standards of their field of study (e.g., clinical health informatics, bioinformatics, imaging informatics).</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Demonstrate scholarly oral and written presentations.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

2. Annual Committee Evaluations: At the end of each year that the student is in the program a committee will be created to meet, discuss, and evaluate student performance. The committee will evaluate the student’s coursework and progress on any other projects he/she is working on.

3. Final Presentations: Students pursuing the research track will complete a research project that will be presented during their final semester in the program. This project will be presented to a group of their peers and departmental faculty (seminar style). This project will be assessed by the student’s faculty advisor (unless otherwise specified) who will provide summary statements.

4. Indirect assessments: Students will be sent an annual questionnaire asking about the following:
   a. Job placement (or admission to other graduate programs)
b. Publication records

c. Certifications and licenses acquired

d. Other awards or honors of note

Program Curriculum

Prerequisites and Admission

Candidates for admission to the degree program are expected to have earned at least a bachelor’s degree. Although candidates who have a wide range of undergraduate backgrounds will be considered, it is expected that all admitted candidates will have demonstrated an aptitude for computer science and math. Specifically, most candidates for admission will have taken computer science courses covering fundamental programming skills, data structures, and algorithms (i.e. the equivalent of CS 302 and CS 367 at UW-Madison). Additionally, students will be expected to have completed at least two semesters of college calculus (i.e. the equivalent of Math 221 and Math 222 at UW-Madison). Candidates who do not meet these requirements, may still be considered for admission but they will be expected to address these deficiencies immediately upon entering the program².

Prospective students will supply the following materials in their admission package: the online Graduate School application, official transcripts from each higher-education institution attended, a statement of purpose, GRE or MCAT scores, three letters of recommendation, and an English proficiency test score for relevant students. Prospective students will be expected to meet the same standard as that of the graduate school (Minimum TOEFL requirement: 92 internet (iBT); 580 paper-based test (PBT) ; Minimum IELTS requirement: 7.0; Minimum MELAB requirement: 82).

It is anticipated that prospective students will come primarily from two or three different types of background. One such pool of prospective students are those who have completed an undergraduate degree in computer science, or a related area, and who now want to have a quantitative, biomedical emphasis in their graduate studies. A second pool of prospective students, are clinicians who want to prepare for a career that involves a heavy emphasis on biomedical informatics, either for research or clinical practice. A third potential pool of students includes those who have completed undergraduate degrees in the biological sciences, and want to prepare for a career in bioinformatics. Note that the prospective students in the latter two pools, although they may not have undergraduate degrees in a quantitative field, will need to demonstrate that they have sufficient preparation for a rigorous curriculum that includes a number of computer science and statistics courses.

Prospective students will be recruited through several mechanisms. First, the MS program will be prominently featured and fully described on the departmental web site. Additionally, other relevant web sites on campus (e.g., the site for the Institute for Clinical and Translational Research and the site for the Computation and Informatics in Biology and Medicine training program as well as the online Graduate Catalog and Graduate School Website) will include links to the program web pages. Second, the program will be listed in the relevant directories at the web portals of two professional organizations: the American Medical Informatics Association, and the International Society for Computational Biology. Third, announcements of the program will be sent to departments and colleagues nationwide that might be sources of strong, interested students.

Advising and Student Services

² Courses taken to address these deficiencies will not be allowed to count as their electives.
Each student in the degree program will have a faculty academic advisor and mentor who will be a key source of information regarding both academic and career advising. This advisor will be assigned in consultation with the student at the point of matriculation into the program. Advisors must be faculty within the degree program.

Seminars and other workshops will be also available to the students as they make the course selections and career choices. The Department is fortunate to have an able, experienced and energetic Student Services Coordinator in Whitney Sweeney; her qualifications and roles were described under “Governance and Leadership Structure”.

Coursework

The proposed program requires that students complete a total of 31 credits.

Core courses (12 credits – 3 credits each)

Students will start with four core courses designed to present the essential concepts in the field and provide a base level of knowledge.

1. Introduction to Bioinformatics (BMI 3576)
2. Medical Image Analysis (BMI, course being developed)
3. Health Informatics (BMI, course being developed)
4. Introduction to Biostatistics (BMI 541, 551, or 571)

Concentration Electives (6 credits – 3 credits each)

Importantly, in order to attain depth of knowledge and skills in biomedical informatics, each student will select electives in an area of concentration within biomedical informatics. These concentration areas might correspond to common subareas such as bioinformatics or imaging informatics. Alternatively, a concentration might represent a more specialized, not-so-well-defined area such as secondary analysis of clinical data. The student will select or define such an area with the advice and approval of the student’s academic advisor.

Courses of high relevance as concentration electives include, but are not limited to Advanced Bioinformatics (BMI 776), Statistical Methods for Molecular Biology (BMI 877), Computational Methods for Medical Image Analysis (BMI 767), Statistical Methods for Medical Image Analysis (BMI 768), Introduction to Health Systems Engineering (ISyE 417), and Health Information Systems (ISyE/BMI 617).

Computer science electives (6 credits – 3 credits each)

Students will further support their program with appropriate technical depth in Computer Sciences, as this discipline is foundational in Biomedical Informatics. They will select two courses as electives in Computer Sciences to be approved by the student’s academic advisor. Coursework of high relevance includes the following areas:

3 The Department of Biostatistics and Medical Informatics (BMI)
Track Electives (6-7 credits)

Our curriculum has two tracks\(^4\), Professional and Research, which have substantial overlap. The Professional track is intended for students who have an undergraduate degree in computer science, engineering, biology, or a health-related field, and are interested in a terminal MS degree that will equip them to work as a biomedical informatics professional in industry (e.g. Epic, DNASTar, etc.), a hospital, or a research lab. The Research track is aimed at students who have a professional degree in a clinical field, and are interested in doing research that has a significant biomedical informatics component.

**Professional Track: Biomedicine electives (6 credits)**

E.g. for a student concentrating their studies in bioinformatics, we would recommend courses such as General Genetics (Genetics 466) and Introduction to Human Biochemistry (Biomol Chem 314).

**Research Track: Research electives (7 credits)**

1. Responsible conduct of research and research ethics (Nursing 802, Surgical Sciences 812, or Pharm Sciences 800; 1 credit)
2. Research Project (3-6 credits)
3. Research-oriented elective (0-3 credits)

The curriculum is substantially the same for Professional and Research track students. The key distinction is the following: Professional students will be required to take the biomedicine electives, but not the research–oriented electives. The assumption here is that this cohort of students probably does not have a substantial background in biomedicine. The Research track students, on the other hand, will not be required to take the biomedical electives, but instead will take a course in the responsible conduct of research and research ethics (1 credit), conduct a mentored research project (3-6 credits), and optionally take another elective, such as additional course in statistical methodology if the research project is taken for only 3 credits.

Each student’s research project will be supervised by a program faculty member, and we expect that most projects will be conducted in collaboration with a clinician or biologist on campus. The goal of the research project experience is to enable the student to apply the knowledge they have learned in novel setting with the advice and guidance of a program faculty member. The prior experience of program faculty indicates that a 3-credit experience is sufficient to accomplish this goal. However, those students desiring a more in-depth research focus (e.g. those aiming to have a first-author publication as a result of their project) will take 6 credits of research. Program advisors will help students design and select the research experiences and courses they will need to accomplish their goals.

**Instruction in Ethical Issues Pertaining to Biomedical Informatics**
All students in the program will receive instruction covering the ethical issues that arise in managing and analyzing biomedical data. Several lectures in the core course, Health Informatics, will be devoted to this topic. Additionally, students in the Research Track will receive additional training in the ethical conduct of research by taking one of the appropriate courses on campus.

Projected Time to Degree

Most students should be able to complete the MS degree in two academic years (four fall/spring semesters). Core courses will be offered at least once per year. Because a number of the elective courses are offered through the Department of Computer Sciences and the Department of Industrial and Systems Engineering, the Department does not have complete control over the availability of elective courses. However, all of the most relevant elective courses are usually offered at least once per year. Moreover, because some of the faculty at times teach courses listed in both of these departments, the Department has some control over the availability of relevant Computer Sciences and Industrial and Systems Engineering courses. Therefore, substantial barriers to students being able to complete the degree program in a timely manner are not anticipated.

Program Faculty

For a list of the program faculty, please see Appendix B.

Resources and Fiscal Considerations

All faculty in BMI will be available to support the program when it is implemented. These 34 faculty members, including affiliates (see Appendix A) are in a position to teach courses in the curriculum and/or provide projects for students. BMI faculty also frequently teach some of the key elective courses (e.g., CS 540, 760, 766, and ISyE 617) that are "owned" by other departments (e.g., Computer Sciences or Industrial and Systems Engineering). Although the Department currently has sufficient staffing for the development and maintenance of this new graduate program and for the provision of student services, the administrative tasks entailed in this endeavor will be closely monitored so that the need for additional staffing can be identified. The Department is also in the process of expanding its available space in the Medical Sciences Center, and some of this newly available space will be dedicated to housing students in this program.

The faculty in BMI are well funded by NIH, NSF, DOD and other sources, awarded at least $21 million during 2010-12. Some of this funding may be available to newly enrolled students as stipends for Program Assistantships or Research Assistantships to help defray the cost of their participation in the program. Other sources of funding may also be available to the new students including teaching assistantships and clinical fellowships from sponsoring departments.

During the inaugural year of the program, enrollment will be small, with only a few newly enrolled students. Thus, enrollment will be easily accommodated by the current faculty and staff. Courses should also be of sufficient capacity to accommodate the newly enrolled students. Growth will be measured to match available resources.

Program Review Process

Institutional Review

Students meeting the prerequisites and most other students should be able to complete the program in two years. Some students who choose to bolster their background with additional courses may take one or two additional semesters.
According to the UW-Madison program review policy, the provost, in collaboration with the dean of the School of Medicine and Public Health, will initiate program review five years after the program is first implemented. Success and quality will be evaluated based on the program goals outlined in this proposal. Subsequently, the M.S. in Biomedical Informatics will be included in the 10-year review of the programs in the Department of Biostatistics and Medical Informatics, following standard UW-Madison program review guidelines that require that all programs be reviewed at least once every ten years.

Letters of Support
Please see Appendix C and D for letters of support
Appendix A
Program Review: Certificate Program in Bioinformatics
Self-Study Spring 2014

1. Program Description and Context – includes program requirements, mission, learning goals, and relationship with other units

Bioinformatics is the application of computational and statistical methods to molecular biology. In the realm of biological and medical science, bioinformatics is becoming a central discipline and is placing a new demand on the training of graduate students and other scientists in the biological and computer sciences. Currently, there are two certificate programs in Bioinformatics: The Graduate Certificate and the Capstone Certificate. Both were proposed and approved in 2000. Both programs involve the same admissions and course requirements.

The main distinction between the two programs is the audience. The educational objective of the Graduate Certificate Program in Bioinformatics is to provide added formal training to pre–doctoral graduate students to improve their fundamental skills in bioinformatics. The goal is to allow them to have enough basic knowledge to continue their own research and to collaborate with computer scientists specializing in bioinformatics methods. The Capstone Certificate program reaches a broader audience including people working in industry (e.g., DNASTar, Roche-Nimblegen) as well as UW postdoctoral fellows, researchers, and scientists.

When considered independently, both of these programs have had relatively low enrollment since they were approved in 2000 and implemented in 2001. In addition, a new MS degree program in Biomedical Informatics is being proposed. We felt it was time for the Department to assess our programs, considering a number of different factors (e.g., resources, audiences, shift in the scientific landscape with respect to training).

Since the approval of the certificate program, some important curricular changes have been made in the graduate school. One particularly relevant change is the removal of the minor requirement for PhD students. Students who utilize bioinformatics in their research can now use the Graduate Certificate Program formally or informally to fulfill this requirement. We considered discontinuing the Graduate Certificate Program and creating a PhD minor in bioinformatics. However, this would exclude MS students from participating if they were to find this program useful for their training. Thus, we feel that the Graduate Certificate Program has the potential to benefit many graduate students on campus. We will discuss our plans to increase enrollment in section number five (Student Enrollment).

The Capstone Certificate Program provides valued training for many postdoctoral students and other researchers. One student who currently works for Great Lakes Bioenergy Research Center commented:

So far, the job has mostly been database work, but I want to understand enough bioinformatics to take on more challenging/scientific projects if they become available. 576 gave me a background in the basic algorithms and problems of bioinformatics, and helped me to understand the methods and goals of the work the researchers here are doing. It was
also a nice update on the field of genetics, which has changed a lot since I took biology classes 20+ years ago.

Since the Capstone Certificate programs were approved in 2000, seven students have completed the programs and five are currently enrolled progressing successfully towards completion. Although until recently the certificate programs would technically be considered low enrollment, we feel that eliminating them would result in a potential loss in our ability to reach an important audience. Some potential students—especially professional research staff here at the UW—may be willing to take on the financial commitment and to invest the time for a 12-credit certificate, but not a 30-credit MS degree. In addition, we are seeing a rise in enrollment with minimal recruitment efforts.

Since both Certificate Programs provide necessary training in informatics to two key audiences, we have decided to continue both programs. However, given the issues we have with low enrollment, we would like to make two suggestions for strengthening the programs. First, we propose to collapse or combine the two programs into one larger program: The Certificate Program in Biomedical Informatics. Currently the two programs are treated as independent entities, in spite of the fact that they are essentially the same. Enrollment and Completion counts are considered separately. Our website even markets them as separate entities. We feel that considering them as one program for different audiences is more appropriate for enrollment and completion data collection. It is not uncommon for programs that have low enrollment to combine such programs into one entity; thereby, pooling efforts to increase enrollment and ultimately program completion numbers. Since both programs are essentially the same, except for the audience, considering them as one unit is appropriate. Second, we intend to increase marketing and recruitment efforts to further increase our enrollment. Combining the two programs will also facilitate our marketing efforts. (See section five, Student Enrollment, for additional details).

Curriculum

The Certificate in Bioinformatics consists of four courses—three required and one elective—for a total of 12 semester credits. We assume that, depending on the course and/or research load of the student, the curriculum requirements may be completed in 1–2 years. This certificate program may also serve as a distributed minor. One of the required courses consists of a choice between one of two Statistics courses, either of which will provide adequate background in statistical methods. Two bioinformatics courses are required (an introductory and advanced course). The fourth course is selected from a list of electives. The two bioinformatics courses must be taken in sequence, but the other two courses may be scheduled at any time in the student’s course sequence.

Basic Course Requirements

Either Biostatistics and Medical Informatics (BMI) 541 or Statistics 571: Statistical concepts are central to the methods and algorithms used in bioinformatics. Students are required to take one of two introductory statistics courses for graduate credits. Either course will give an adequate starting background.

BMI 541 – Introduction to Biostatistics – is designed for the biomedical researcher. Topics include: descriptive statistics, hypothesis testing, estimation, confidence intervals, t–tests, chi–squared tests, analysis of variance, linear regression, correlation, nonparametric tests, survival analysis and odds ratios. Biomedical applications are discussed for each topic.
Statistics 571 – Statistical Methods for Bioscience I – is a design course aimed at CALS graduate students. Topics include: descriptive statistics, distributions, one- and two-sample normal inference, power, one-way ANOVA, simple linear regression, categorical data, non-parametric methods; underlying assumptions and diagnostic work.

Both BMI 576 and 776 are required for this certificate program and should give the students a good foundation in the field of bioinformatics.

BMI 576 – Bioinformatics – is an introductory course in bioinformatics. Topics include: Algorithms for computational problems in molecular biology. The course will study algorithms for problems such as: pairwise and multiple sequence alignment, genome annotation, phylogenetic tree construction, gene-expression data analysis, and molecular network reconstruction and analysis.

BMI 776 – Advanced Bioinformatics -- is an advanced course covering computational problems in molecular biology. Topics include: algorithms for problems such as: modeling sequence classes and features, phylogenetic tree construction, gene-expression data analysis, protein and RNA structure prediction, and whole-genome assembly and alignment.

Elective Courses: In order to complete the 12 credits, students must select a fourth course from among the following.

Biochemistry 711/712 – Sequence Analysis: This is a two–part course beginning with a lecture/discussion group course (711) and finishing with a hands–on laboratory course (712), taught at actual computer terminals, designed to complement and reinforce the sequence analysis concepts presented in Biochemistry 711. This course gives students a practical background in using many available software packages such as DNASTAR for gene sequencing, etc. Students are provided with actual data and gain experience using software.

BMI 542 – Introduction to Clinical Trials I – Intended for biomedical researchers interested in the design and analysis of clinical trials. Topics include definition of hypotheses, measures of effectiveness, sample size, randomization, data collection and monitoring and issues in statistical analysis.

Computer Science 540 – Introduction to Artificial Intelligence – teaches principles of knowledge–based search techniques; automatic deduction; knowledge representation using predicate logic, semantic networks, connectionist networks, frames, rules; applications in problems solving, expert systems, game playing and natural language understanding.

Computer Science 545 – Natural Language and the Computer - The course covers basic techniques and tools in natural language processing: generative grammars, parsing, dictionary construction, semantic networks, generation of text from a knowledge base, natural language interfaces, and machine translation.

Computer Science 564 – Database Management Systems: Design and Implementation - What a database management system is; different data models currently used to structure the logical view of the database: relational, hierarchical, and network. Hands-on experience with relational and network-based database systems. Implementation techniques for database systems. File organization, query processing, concurrency control, rollback and recovery, integrity and consistency, and view implementation.
Computer Science 577 -- Introduction to Algorithms - Survey of important and useful algorithms for sorting, searching, pattern-matching, graph manipulation, geometry, and cryptography. Paradigms for algorithm design. Techniques for efficient implementation.

Computer Science 731 – Advanced Artificial Intelligence – Novel techniques within Bayesian Networks, Machine Learning and Data Mining, Planning and Computer Vision have proven useful for many real–world problems. This course will cover some of the most important recent algorithms from these areas and will illustrate their use with biomedical applications.

Computer Science 760 – Machine Learning. The intent of this course is to present a broad introduction to machine learning, including discussions of each of the major approaches currently being investigated. Class lectures will discuss general issues in machine learning, as well as present established algorithms. Computational approaches to learning, including: inductive inference, explanation–based learning, analogical learning, connectionism, and formal models, what it means to learn, algorithms for learning, comparison and evaluation of learning algorithms, cognitive modeling and relevant psychological results.

Computer Science 766 – Computer Vision – an introductory course to the basic concepts in computer vision including fundamentals of image analysis and computer vision, image acquisition and geometry, image enhancement, recovery of physical scene characteristics, shape–form techniques, segmentation and perceptual organization, representation and description of two–dimensional objects, shape analysis, texture analysis, goal–directed and model–based systems, parallel algorithms and special purpose architectures.

BMI 799 – Independent Study in Bioinformatics – Some students may find their needs are better met by an independent study with one of the faculty in the department, in collaboration with a biological faculty member. Independent study in another department may be substituted with prior approval.

Industrial Engineering 617 – Introduction to health information systems and health informatics. Major topics include clinical information systems, formal language and vocabularies, telemedicine, image technology and public health informatics. Lectures by local and national experts will be followed by instructor-facilitated discussion examining how industrial engineering tools and perspectives could improve the quality, efficiency and effectiveness of health information.

Mathematics 605 – Stochastic Methods for Biology - This course is intended to provide a rigorous foundation for stochastic modeling of biological systems. The mathematical emphasis is in stochastic analysis and simulation. Biological applications include epidemiological phenomena, biochemical reaction networks and population dynamics.

Mathematics 606 – Mathematical Methods for Structural Biology - This course will provide a rigorous foundation for mathematical modeling of biological structures. Mathematical techniques include ordinary and partial differential equations, 3D Fourier analysis and optimization. Biological applications include protein folding, molecular dynamics, implicit solvent electrostatics, and molecular interactions.

Mathematics 608 – Mathematical Methods for Continuum Modeling in Biology - This course is intended to provide a rigorous foundation for mathematical modeling of biological systems. The mathematical emphasis is on partial differential equations, particularly reaction-diffusion and transport equations. Biological applications include bacterial chemotaxis, spatio-temporal ecological dynamics, and cell-level reactions.
Mathematics 609 -- Mathematical Methods for Systems Biology - This course is intended to provide a rigorous foundation for mathematical modeling of biological systems. Mathematical techniques include dynamical systems and differential equations. Applications to biological pathways, including understanding of bistability within chemical reaction systems, are emphasized.

2. Demonstration of Need and Recruitment/Outreach – includes populations targeted, data to demonstrate need, and efforts to recruit/inform students

Nationwide, the biomedical research community is struggling to manage, share, analyze and fully exploit expanding quantities of data in the biomedical sciences. The need for a workforce capable of innovating, implementing and using methods from biomedical informatics is widely recognized. This demand has been driven by several factors. The proliferation of high-throughput biological experimental methodologies (next-generation sequencing, microarrays, SNP arrays, etc.) has transformed biology into a data-intensive science. It has become commonplace for biological studies to involve and rely on scientists and staff who are trained in bioinformatics. In addition, biomedical studies and clinical decision-making are integrating and making inferences with varied types of data (genotypes, molecular profiles, images, electronic health records, and population-based data), which heightens the need for sophisticated computational methods.

The NIH has clearly identified bioinformatics—and the areas of biomedical informatics and biostatistics—as high priorities for increased training in order for biological, clinical, and translational research to proceed at a pace that takes advantage of the tremendous output of scientific and clinical data. In a recent report, the Data and Informatics Working Group of the NIH Director's Advisory Committee made a specific recommendation to "build capacity by training the work force in the relevant quantitative sciences such as bioinformatics, biomathematics, biostatistics and clinical informatics" [2]. The NIH has formally recognized the need to expand the quantitative sciences workforce and methodology through its "Big Data to Knowledge" (BD2K) initiative (http://bd2k.nih.gov). Thus, there is a pressing need and a keen interest of translational researchers for such training.

There is a strong need for training in bioinformatics across disciplines. Students who have participated in the certificate program to this point have been pursuing graduate degrees in a diverse array of fields including: Dairy Science, Animal Science, Botany, Statistics, Genetics, Mathematics, Plant Pathology, Medical Physics, Chemistry and Computer Sciences. With the increase in focus on translational research in more clinical settings, we are also seeing interest grow among medical researchers and those more interested in clinical practice.

Up to this point, our efforts to inform or recruit students have been fairly minimal. Students typically learn about the certificate program via word of mouth or the departmental website. Efforts to improve visibility of and recruitment for the program are currently underway and will be described in greater detail under heading number five (Student Enrollment).

3. Program Administration and Resources – includes description of administrative and advising processes
The Graduate Certificate Program is currently governed by a committee of four faculty from within the Department of Biostatistics and Medical Informatics. These faculty positions rotate with other committee assignments, but are always filled with faculty who are knowledgeable about the field of informatics. Currently, our members are Dr. Sushmita Roy, Dr. Colin Dewey, Dr. Mark Craven, and Dr. Christina Kendziorski. This committee reviews applications, advises students, and determines if curricular updates are necessary. Dr. Whitney Sweeney provides administrative assistance for the program including (but not limited to) processing applications, monitoring student progress, and providing the necessary forms to the graduate school.

4. Faculty/Staff Participants – includes list of participating faculty, instructional staff, and Administrative staff with their role and department affiliation noted

Below is a list of faculty members in the Department of Biostatistics and Medical Informatics (BMI) as well as others contributing to the Graduate Certificate Program in Bioinformatics. Faculty will provide their expertise to student participants through their teaching and mentoring experiences. In addition, they will also provide relevant guidance and insight in curricular changes and updates. Whitney Sweeney will provide necessary administrative assistance.

<table>
<thead>
<tr>
<th>Department faculty</th>
<th>Affiliate faculty</th>
<th>Administrative Staff</th>
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<tbody>
<tr>
<td>Karl Broman</td>
<td>Patricia Brennan (Nursing and Industrial)</td>
<td>Whitney Sweeney</td>
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<tr>
<td></td>
<td></td>
<td>(Student Services Coordinator)</td>
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<tr>
<td>Richard Chappell</td>
<td>Joel Buchanan (Internal Medicine)</td>
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<tr>
<td>Moo Chung</td>
<td>Elizabeth Burnside (Radiology)</td>
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<tr>
<td>Michael Coen</td>
<td>Charles Dyer* (Computer Sciences)</td>
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<tr>
<td>Mark Craven</td>
<td>Daniel Gianola (Animal Sciences)</td>
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<tr>
<td>David DeMets</td>
<td>Mari Patla* (Population Health Sciences)</td>
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<tr>
<td>Colin Dewey</td>
<td>Jignesh Patel (Computer Sciences)</td>
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<td>Ron Gangnon</td>
<td>Guiltherme Rosa (Animal Sciences)</td>
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<td>Sunduz Keles</td>
<td>Jude Shavlik* (Computer Sciences)</td>
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<tr>
<td>Christina Kendziorski</td>
<td>Grace Wahba* (Statistics and Computer)</td>
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<tr>
<td>KyungMann Kim</td>
<td>Brian Yandell (Statistics)</td>
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<tr>
<td>Mary Lindstrom</td>
<td>Zhengjun Zhang (Statistics)</td>
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5. Student Enrollment – includes total number of students enrolled/declared in the program compared to program enrollment goals as well as average length of program completion

The Graduate and Capstone Certificate Programs in Bioinformatics were approved in 2000 and implemented in the fall of 2001. Enrollment and Completion data can be seen below for each program separately as well as combined. When the programs are considered independently, they would technically qualify as low enrollment (<5 students completing the programs in five years). However, if the two programs are considered together, as proposed above, then they only qualify as low enrollment during 2006-2011. Since 2011, seven students enrolled in our certificate programs. Three have already completed it and four are successfully near completion. Thus, more than five students are on track to complete the programs before the third five-year period has expired. An additional five students were accepted during Spring 2014 and will begin in the Fall 2014. At least two additional students have inquired about application for Fall 2014. If the two students who made recent inquiries enroll, then the total number of enrolled students would equal twelve.

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<tr>
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<th>Graduate Certificate</th>
<th>Capstone Certificate</th>
<th>Programs Combined</th>
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<tr>
<td></td>
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<tr>
<td>2011-current</td>
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<td>5</td>
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<tr>
<td>Total</td>
<td>10</td>
<td>10</td>
<td>12</td>
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We believe that our relatively low enrollment is due to minimal marketing and recruitment. In spite of this low enrollment, we believe there is a strong need and potential for this program. We know that there are students who are interested. In fact, an additional 12 students were identified who completed all/most of the certificate requirements but did not officially apply for the program. We strongly suspect that many of these students would have enrolled if they had known about the program. Additionally, in the past few years, the requirement for a PhD minor has been lifted and we would very much like to give this program a chance to
serve as a breadth requirement for students in programs who could benefit from increased quantitative methodology.

We plan to make a concerted effort to improve visibility of the program and strengthen our recruitment efforts starting over the summer and in fall of 2014. We are currently updating our website and the certificate program will hold a significantly more prominent place on the site. Also, one of our faculty members, Dr. Sushmita Roy, is leading an initiative to improve the visibility of bioinformatics and computational biology research on campus. This group is likely to create a campus-wide portal to advertise research and training opportunities in this area across UW. Additionally, we plan to send faculty and staff to visit all relevant departments (e.g., Biochemistry, Genetics) and businesses (e.g., DNAStar, Roche-Nimblegen) to promote our program during faculty and staff meetings as well as student gatherings.

We can especially reach out to directors of NIH-funded training programs. Our faculty are involved in several of these programs in various ways including: serving as trainers in the Genetics and Microbiology Training Program, and serving on the management committees of the Genome Sciences Training Program, and the Computation and Informatics in Biology and Medicine training program. We believe that many graduate advisors and dissertation directors—recognizing the need for this kind of training—will be enthusiastic about our program’s availability to their students and some will strongly encourage their students to enroll.

Given the numbers we currently have under minimal recruitment efforts, we are confident that our numbers will increase significantly with these new initiatives. We will test this over the next few years. As we take this program to various department faculties, we will also ask for feedback as to the potential utility for their students.

We will also ensure that students who are enrolled in BMI 576 are made aware of the certificate program, given that there is very high overlap between the students in this course and our target audience. We also have noted an impressive uptick in enrollment (threefold increase over the past two years) for a key course related to bioinformatics—CS 760—which BMI faculty often teach. We believe this uptick can be leveraged to increase program enrollment; and we will make special appeal to students in this course to consider the Graduate Certificate in Bioinformatics.

During the summer of 2016, we plan to conduct a smaller scale self-study to ascertain the success of our efforts. If there we do not see an increase in enrollment—or strong indications thereof—we will discontinue the program at that time.

6. Curricular Offerings and Enrollment Levels – includes courses actually offered or for which students received program credit, by semester and enrollment data for "core" (introductory) and/or "capstone" courses

The required courses have been consistently offered since the Graduate Certificate Program was implemented in 2001. Enrollment levels can be seen for each course over the years in the table below. Note that data is provided for Stat 572 due to the fact that this was one of the statistics options until recently (Spring 2014). A discussion of this curricular change can be found in section eight (Recommendations).
The list of electives is presented in section one (Program Description). There are fifteen possible electives at this time. All electives are offered on at least an annual basis. Thus, it is easy for certificate students to fulfill their final elective requirement.

### 7. Program Completion – number of certificates awarded annually (as recorded by the Office of the Registrar); and placement of “graduates” (if appropriate)

The average annual number of certificate participants completing the program is less than one (0.76). This low number is specifically due to issues with low enrollment. Of all of the students who enrolled in the program, 100% of the students from our records completed it. Thus, our completion record is very favorable. Our low enrollment issues were discussed under heading number five (Student Enrollment).

We do not currently collect data regarding student placement.

### 8. Recommendations – includes recommendation and proposals for curricular changes or administrative improvements

Our first priority is to increase the enrollment for this program. We have described our plan to do so in section five (Student Enrollment).

In addition, we have made one significant curricular change during the last year. This changed involved Stat 572, one of two possible required statistics courses. There is a prerequisite to this course (e.g., Stat 571) that most of our students had not taken. Thus, choosing to take Stat 572 ended up requiring a two-course sequence for many students. Student feedback indicated that this was burdensome and, thus, many students elected to take BMI 541. The faculty committee looked over the syllabus for Stat 571 and felt that it was sufficient and could be used instead of Stat 572. Thus, as of Spring 2014 our students can now select between BMI 541 and Stat 571. This will give them more flexibility in their offerings.

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5 BMI 541 was offered both fall and spring semester in 2004. Data in this table are only for the traditional fall offering. During the spring of 2004 there were 124 students who took this course.

6 Note: There may be slight discrepancies between our data and that at the graduate school. Records were recently updated and until those data are posted in the graduate school database, the numbers will not match.
As the program has grown, we have added a number of electives. We will continue to monitor the set of relevant courses on campus and add electives as is appropriate.

Finally, we recently consolidated all BMI educational program functions under Whitney Sweeney. Having one central educational administrator allows for better tracking of applicants and matriculants. It also allows for better promotion of the program to students in our other training programs (e.g., Biostatistics).

9. Assessment – includes the assessment plan and a summary of annually conducted assessment activities, including an analysis of the extent to which the program is meeting the specified goals. This assessment evidence should form the basis for any proposals for curricular changes

Up to this point, formal assessments of certificate program have not been conducted. The relatively small number of students who participated did so effectively and efficiently. They seemed pleased with the program and enjoyed the courses. As always, we will continue to keep track of the number of students participating and completing the program on an annual basis. Whitney Sweeney is now in a central position, which should facilitate this process. This data will help us track our enrollment status.

As we increase the program size, we see that more formal assessments may be needed. Thus, we will plan to conduct exit interviews with each student who completes the program, asking for feedback about the courses and other aspects of the program. In addition, we solicit feedback from other departments (e.g., faculty mentors) about the utility of our certificate program. We will use this information to guide decisions regarding curricular changes.

Further assessment plans are in section five (Student Enrollment).
Appendix B

Faculty Members in the Department of Biostatistics and Medical Informatics (BMI) as well as other contributors to the MS Degree program in Biomedical Informatics

<table>
<thead>
<tr>
<th>Department faculty</th>
<th>Affiliate faculty</th>
<th>Administrative Staff</th>
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<tbody>
<tr>
<td>Karl Broman</td>
<td>Patricia Brennan</td>
<td>Whitney Sweeney</td>
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<td>(Nursing and</td>
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<td>Industrial</td>
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<td>Engineering)</td>
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<td>Richard Chappell</td>
<td>Joel Buchanan</td>
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<td>(Internal Medicine)</td>
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<td>Moo Chung</td>
<td>Elizabeth Burnside</td>
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<td>(Radiology)</td>
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<td>Michael Coen</td>
<td>Charles Dyer*</td>
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<td>(Computer Sciences)</td>
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<td>Mark Craven</td>
<td>Daniel Gianola</td>
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<td>(Animal Sciences)</td>
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<td>David DeMets</td>
<td>Mari Palta*</td>
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<td>(Population Health</td>
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<td>Sciences)</td>
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<td>Colin Dewey</td>
<td>Jignesh Patel</td>
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<td>(Computer Sciences)</td>
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<td>Ron Gangnon</td>
<td>Guilherme Rosa</td>
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<td>(Animal Sciences)</td>
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<td>Sunduz Keles</td>
<td>Jude Shavlik*</td>
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<td>(Computer Sciences)</td>
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<td>Christina Kendziorski</td>
<td>Grace Wahba*</td>
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<td>KyungMann Kim</td>
<td>Brian Yandell</td>
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<td>(Statistics)</td>
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<td>Mary Lindstrom</td>
<td>Zhengjun Zhang</td>
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<td>Eneida Mendonca</td>
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<td>Michael Newton</td>
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<td>David Page</td>
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<td>Paul Rathouz</td>
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<td>Marjorie Rosenberg</td>
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<td>Sushmita Roy</td>
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<td>Vikas Singh</td>
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<td>Sijian Wang</td>
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<tr>
<td>Menggang Yu</td>
<td>*Denotes joint executive</td>
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<td>Yingqi Zhao</td>
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Appendix C: Letters of Support

Howard Bailey, MD
Interim Director, University of Wisconsin Carbone Cancer Center
Professor, Department of Medicine
UW Madison, School of Medicine and Public Health

Vicki M. Bier, PhD
Professor and Chair, ISyE
College of Engineering

Elizabeth Burnside, MD, MPH, MS
Associate Professor of Radiology
UW Madison, School of Medicine and Public Health

Marc K. Drezner, MD
Senior Associate Dean
Professor of Medicine
Executive Director, Institute for Clinical and Translational Research
UW Madison, School of Medicine and Public Health

Edward Jackson, PhD, FAAPM, FACR
Professor and Chair, Department of Medical Physics
UW Madison, School of Medicine and Public Health

Jeffery F. Naughton, PhD
Professor and Chair, Computer Sciences
College of Letters and Sciences

F. Javier Nieto, MD, MPH, PhD
Professor and Chair, Department of Population Health Sciences
UW Madison, School of Medicine and Public Health

Lloyd M. Smith, PhD
W.L. Hubbell Professor of Chemistry and
Director of the Genome Center of Wisconsin
College of Letters and Sciences

Maureen A. Smith, MD, PhD, MPH
Professor, Population Health Sciences
UW Madison, School of Medicine and Public Health

Brian Yandell, PhD
Professor and Chair, Statistics
College of Letters and Sciences
March 28, 2014

Paul Rathouz, PhD  
School of Medicine and Public Health  
Professor and Chair  
Department of Biostatistics and Medical Informatics  
4675, K6/446 Clinical Science Center  
600 Highland Ave  
Madison, WI 53792  

Dear Prof. Rathouz:

It is my pleasure to provide my enthusiastic support for the Department of Biostatistics and Medical Informatics to develop a MS degree program in Biomedical Informatics within the School of Medicine and Public Health.

For over two decades, the Biostatistics Shared Resource and Cancer Informatics Shared Resource provided by your department have contributed statistical and computing expertise to members of the UWCCC in the design, conduct, and analysis of laboratory, clinical and epidemiologic studies promoting high quality, innovative cancer research. As we all know, cancer research is becoming much more data intensive and our curricula need to change in turn. Data sets have become increasingly larger and more complex with “big data” resulting from genomic and imaging studies, as well as new order entry systems. It is crucial that we have programs that will train scientists and clinical investigators who have substantial expertise in biomedical informatics in order to handle these challenges. This is why I enthusiastically support the MS program in Biomedical Informatics that your department is developing. Your program will provide the much needed training for new scientists as well as help in the recruitment and professional development of our clinical investigators, including faculty and fellows in the UWCCC.

I wish you the very best and am happy to help in any way I can.

Sincerely,

Howard Bailey, MD  
Interim Director, University of Wisconsin  
Carbone Cancer Center  
Professor of Medicine  
UW School of Medicine and Public Health
Dear Professor Rathouz:

On behalf of the Department of Industrial and Systems Engineering (ISyE), I would like to extend our enthusiastic support for the plan to develop a MS degree program in biomedical informatics on campus. As you know, ISyE at the University of Wisconsin-Madison has a long and celebrated history in health-systems research. In fact, health-systems engineering is one of the four areas of focus for our department’s research and education programs. Our program focuses on developing innovative transportable solutions to critical healthcare problems while contributing to advancements in decision science, decision-support systems, and quality engineering. In addition, several of our faculty members have research interests that overlap with the field of medical informatics, and in fact one of them is a past president of the American Medical Informatics Association.

Over the years, the collaboration between ISyE and Medical Informatics has been strong and productive, and in fact a faculty member in Medical Informatics has been involved in teaching one of our courses (617, Health Information Systems). Therefore, I anticipate that our department will connect with the proposed program on biomedical informatics in several important ways. First, our courses in health systems will be relevant and valuable electives for those students in your program who choose to focus on clinical informatics. Second, our department has several faculty members with joint appointments in Medical Informatics (Professors Patti Brennan, Elizabeth Burnside, and Eneida Mendonca), who will be actively involved in shaping the proposed program and mentoring its students. Third, some of the proposed courses in your program are likely be of interest to graduate students in ISyE, making a degree program in biomedical informatics a timely addition to our educational offerings.

In short, my faculty strongly supports your proposed MS degree program, and believes that it will complement our existing graduate program. I wish you the best in your efforts, and look forward to collaborating on this endeavor as it evolves.

Sincerely,

Vicki M. Bier, PhD
Professor and Chair, ISyE
College of Engineering
University of Wisconsin - Madison
March 28, 2014

Paul Rathouz, PhD
School of Medicine and Public Health
Professor and Chair
Department of Biostatistics and Medical Informatics
4675, K6/446 Clinical Science Center
600 Highland Ave
Madison, WI 53792

Dear Prof. Rathouz:

I’m writing to provide my enthusiastic support for the MS degree program in Biomedical Informatics that you and the Department of Biostatistics and Medical Informatics have developed.

As you know, my research investigates the application of artificial intelligence methods to breast imaging in pursuit of improving the population based screening and diagnosis of breast cancer. This multidisciplinary research is facilitated by my own MS in Medical Informatics. Thus, I know full well the value of such a program. Further, through my appointment in the Department of Radiology, I work with many clinical investigators who would be eager to embark upon such training. Your program would be a real asset to the SMPH and would be useful for both recruitment for and professional development of many of our clinical investigators.

Thus, I am highly supportive and extremely enthusiastic about this initiative that you and your faculty have taken on. Please don’t hesitate to let me know how I can support this critically important initiative.

Sincerely,

Elizabeth Burnside, M.D., MPH, M.S.
Associate Professor of Radiology
Breast Imaging
March 29, 2014

Paul Rathouz, PhD  
School of Medicine and Public Health  
Professor and Chair  
Department of Biostatistics and Medical Informatics  
4675, K6/446 Clinical Science Center  
600 Highland Ave  
Madison, WI 53792  

Dear Prof. Rathouz:

On behalf of the Institute for Clinical and Translational Research (ICTR), I am pleased to provide my unqualified support to the Department of Biostatistics and Medical Informatics for the development of a degree program in Biomedical Informatics in the School of Medicine and Public Health.

The Department of Biostatistics and Medical Informatics has been a key partner with ICTR in research services and education programs, since the beginning of the Institute in 2007. In both of these areas of endeavor, informatics training has been identified as a pressing need and a keen interest of translational researchers. Moreover, the NIH has clearly identified biomedical informatics as an area of priority for increased training, in order for clinical and translational research to proceed at a pace that takes advantage of the tremendous output of scientific and clinical data. And finally, students in the short courses and the Graduate Programs in Clinical Investigation, offered by ICTR, have asked specifically for increased training in biomedical informatics.

It has also become evident, from our local experience and the comments rendered by the ICTR External Advisory Committee, that there is a real need to house a development degree program for biomedical informatics faculty in the future. Since biomedical informatics is such a mission critical focus for ICTR, the cultivation of new faculty is essential and will be facilitated by the program that you have outlined in your proposal for a degree program.

I am fully confident researchers will find a graduate degree in Biomedical Informatics an asset to their careers and to speeding the progress of translational research. I wish you the best in this endeavor and look forward to working with you to fulfill the new potential of the program.

Sincerely,

Marc K. Drezner, MD  
Senior Associate Dean  
School of Medicine and Public Health  
Executive Director  
Institute for Clinical and Translational Research  
Professor of Medicine
March 27, 2014

Paul Rathouz, PhD
Professor and Chair
Department of Biostatistics and Medical Informatics
School of Medicine and Public Health
4675, K6/446 Clinical Science Center
600 Highland Ave
Madison, WI 53792

Dear Prof. Rathouz:

I am delighted to learn you are moving forward with a full proposal for the MS degree program in Biomedical Informatics. As you know, I expressed support for the development of the program at the time you submitted the letter of intent in October 2013, and I remain fully supportive. While I am still a relatively new chair of the Department of Medical Physics, your department and your vision for its continued evolution have impressed me. Medical Physics already enjoys a strong interaction with Biostatistics and Medical Informatics, and I hope to continue and deepen collaborations in training and research involving medical imaging analysis.

Therefore, it is my pleasure to reiterate my support for your goal of developing a MS degree program in Biomedical Informatics. Indeed, it is a strategic point for the SMPH to further develop research in biomedical informatics, and I see the development of the MS degree in Biomedical Informatics as a natural continuation of the progress that your department has already enjoyed. Your proposed program will be an asset to the academic environment of the entire SMPH.

Thank you for the opportunity to comment on this endeavor, and I wish you the best as your program continues to expand.

Yours truly,

Edward Jackson, PhD, FAAPM, FACR
Professor and Chair
Department of Medical Physics
efjackson@wisc.edu
April 1, 2014

Paul Rathouz, PhD
School of Medicine and Public Health
Professor and Chair
Department of Biostatistics and Medical Informatics
4675, K6/446 Clinical Science Center
600 Highland Ave
Madison, WI 53792

Dear Dr. Rathouz:

On behalf of the Department of Computer Sciences, I am pleased to extend my full and enthusiastic support for the MS degree program in Biomedical Informatics developed by the Department of Biostatistics and Medical Informatics within the School of Medicine and Public Health.

Up to this point in time, students interested in studying informatics would apply to the Department of Computer Sciences and work with faculty who share that expertise. Many such faculty are members of the Department of Biostatistics and Medical Informatics. Our two departments have worked very well together to provide the needed training. However, as the field of informatics evolves and datasets become larger and increasingly more complex, the need for your own program is clear. A distinct degree in biomedical informatics is, indeed, a timely addition to our educational offerings and will nicely complement our existing programs in the Department of Computer Sciences. We certainly look forward to collaborating to you as your program evolves.

I wish you the best in your efforts and look forward to opportunities to collaborate with you in this program as it evolves. Please feel free to contact me if I can be of any assistance in the process.

Yours truly,

Jeffrey F. Naughton
John P. Morgridge Chair and Chair
Computer Sciences Department

Prof. Jeffrey F. Naughton
Computer Sciences Department University of Wisconsin-Madison 1210 W. Dayton Street Madison, Wisconsin 53706 Phone: 608-262-87375  Fax: 608-262-9777  E-mail: naughton@cs.wisc.edu  Web: http://www.cs.wisc.edu/~naughton
31 March 2014

Paul Rathouz, PhD  
Professor and Chair  
Department of Biostatistics and Medical Informatics  
School of Medicine and Public Health  
4675, K6/446 Clinical Science Center  
600 Highland Ave  
Madison, WI 53792

Dear Dr. Rathouz:

On behalf of the Department of Population Health Sciences, I am pleased to support the MS degree program in Biomedical Informatics developed by the Department of Biostatistics and Medical Informatics within the School of Medicine and Public Health.

Population Health Sciences is an interdisciplinary department with the goal of understanding, preserving, and improving the health of human populations and individuals. As part of this mission, it is critical that we can effectively manage and analyze the ever-increasing amounts of data emerging from resulting research. Thus, I think the MS degree will nicely complement our existing graduate programs in Population Health and Epidemiology.

Over the years, our Department has developed a close working relationship with the Department of Biostatistics and Medical Informatics. It has been delightful to watch BMI grow and evolve. Whereas the Medical Informatics portion of the department was once a nascent entity, it has become a nationally recognized research program. A distinct degree in biomedical informatics is not only long overdue, but it is a timely addition to our educational offerings.

I wish you the best in your efforts and look forward to the opportunities that will arise from such an endeavor.

Sincerely,

F. Javier Nieto, MD, MPH, PhD  
Professor and Chair  
Department of Population Health Sciences
March 31, 2014

Paul Rathouz, PhD  
School of Medicine and Public Health  
Professor and Chair  
Department of Biostatistics and Medical Informatics  
4675, K6/446 Clinical Science Center  
600 Highland Ave  
Madison, WI 53792

Dear Dr. Rathouz:

I am pleased to provide my support for the proposed MS degree program in Biomedical Informatics in the Department of Biostatistics and Medical Informatics.

As director of the Genome Center, I see the importance of Bioinformatics as a discipline on a day-to-day basis. It is crucial that we have academic programs to support and educate our genomic research, graduate and undergraduate teaching and pre- and post-doctoral training. Your MS degree program will be an important part of this. The Genome Center is widely connected across campus with over 17 participating departments, some of which will contribute to the electives that some of your participating students will take. This is one way our organizations can work together to help create the academic environment that we seek to enrich our work.

Please let me know if there is anything I can do to assist you as you move forward in this endeavor.

Yours truly,

Lloyd M. Smith, Ph.D.  
W.L. Hubbell Professor of Chemistry and  
Director of the Genome Center of Wisconsin  
University of Wisconsin-Madison
March 28, 2014

Paul Rathouz, PhD
School of Medicine and Public Health
Professor and Chair
Department of Biostatistics and Medical Informatics
4675, K6/446 Clinical Science Center
600 Highland Ave
Madison, WI 53792

Dear Prof. Rathouz:

I am happy to provide my strong support for the MS degree program in Biomedical Informatics that you and the Department of Biostatistics and Medical Informatics are developing.

The Department of Population Health Sciences and the Department of Biostatistics and Medical Informatics have a long cooperative relationship in terms of training students in statistics, informatics and epidemiology. Your outstanding faculty provide quality training for many students in our department. I have no doubt this quality training will continue with your new MS degree program, and I look forward to our continued collaborations.

The creation of this program is essential. Through my research and educational activities in the field of health services, the need for training in biomedical informatics is obvious. In addition, through my other roles within the SMPH – Director of the UW Health Innovation Program, Director of the Community Academic Partnerships core of the NIH-CTSA funded Institute for Clinical and Translational Research, and Associate Director for Population Sciences at the UW Carbone Cancer Center – it is easy to see the far reaching impact this program can have for scientists and clinical investigators on campus.

Your program sounds terrific, and I would be delighted to be involved in any way that would be helpful.

Yours truly,

Maureen A. Smith, MD, PhD, MPH
Professor
Departments of Population Health Sciences, Family Medicine, and Surgery
Date: 27 March 2014
To: Paul Rathouz, Chair, BMI
From: Brian S. Yandell, Chair
Re: Proposed MS in Biomedical Informatics

The Department of Statistics enthusiastically supports the proposal for an MS in Biomedical Informatics. The intended audience is substantially different from any present or proposed degree offered through the Department of Statistics. Further, the expected impact on statistics course offerings is likely to be slight, as these would come in under a wide array of elective courses in the research track.
Appendix D: Supporting Letters from Divisional APC Meetings

Ian M. Robertson, Dean
   College of Engineering

Sarah Pfatteicher, Associate Dean for Academic Affairs
   CALS

John Karl Scholz, Dean
   College of Letters and Sciences
December 17, 2013

Dr. Paul M. DeLuca, Jr., Provost
UW-Madison
150 Bascom Hall
Madison, WI 53706

Dear Dr. DeLuca:

At its meeting on Wednesday, Dec. 11, 2013, the College of Engineering’s Academic Planning Council voted unanimously to support the Notice of Intent to Plan an MS Degree Program in Biomedical Informatics. As this notice was very detailed, the College does not feel it necessary to review the full proposal when developed unless there are substantial changes from what was presented in this notice.

The Department of Industrial & Systems Engineering has been collaborating with the Department of Biostatistics & Medical Informatics for several years and enthusiastically supports the continued development of this program. Many of our courses in health systems will be of interest to students pursuing this degree and some of the proposed courses in the program may be of interest to our graduate students as well.

If you require additional information, please contact my office.

Sincerely,

Ian M. Robertson
Dean
To: GFEC, c/o Kelly Haslam  
UAPC, c/o Jocelyn Milner

From: Sarah Pfatteicher, Associate Dean for Academic Affairs

Re: Proposal for an MS in Biomedical Informatics

Date: 7 May 2014

Cc: Paul Rathouz, Chair, Dept of Biostatistics & Medical Informatics  
Whitney Sweeney, Dept of Biostatistics & Medical Informatics  
Laura VanToll, Academic Planner, CALS

On 5 May 2015, CALS Academic Planning Council had its first hearing of the proposal for an MS degree in Biomedical Informatics, presented by the Department of Biostatistics and Medical Informatics. As a matter of practice, CALS APC prefers to see such proposals twice in order to permit the council members to hear the presentation at the first meeting and then seek input from their constituents prior to voting at the second meeting. Given the fullness of agendas at the close of the semester, CALS APC will not be able to provide a vote on this proposal before the close of the current academic year.

That said, let me provide the following input, in case it should be useful to GFEC and/or UAPC deliberations in the next few weeks. The proposed program appears to have little effect on or interaction with the College of Agricultural and Life Sciences: just one course from CALS appears in the curriculum, and that as an elective. During the brief discussion at CALS APC, no significant questions or concerns arose to suggest that CALS should object to the proposed program; indeed, it was suggested that enhancing campus offerings in informatics would be desirable.

We appreciate being consulted on this proposal, but given these particulars, we consider CALS to be a peripheral player in the review and approval process. If GFEC were to opt to move ahead without awaiting a formal vote by CALS APC, we would not object. If GFEC prefers to receive a formal vote from the CALS APC, we will strive to provide such at the start of the fall semester.
18 April 2014

TO: Bob Golden, Dean, School of Medicine and Public Health
   Paul Rathouz, Chair, Biostatistics and Medical Informatics

FROM: John Karl Scholz, Dean

RE: Proposal to Implement MS-Biomedical Informatics (SMPH)

CC: Kelly Haslam, Assistant Dean, Academic Assessment and Funding, Grad School
    Elaine Klein, Assistant Dean for Academic Planning, L&S
    Jocelyn Milner, Associate Provost and Director, Academic Planning and Institutional Research
    Whitney Sweeney, BMI Training Program Coordinator

On April 15, 2014 the L&S Academic Planning Council considered the request for L&S support
concerning the proposal to implement a new MS-Biomedical Informatics, to be housed in the Department
of Biostatistics and Medical Informatics in the School of Medicine and Public Health. The L&S APC
concurred with the observations of our colleagues in the Departments of Statistics and in Computer
Sciences. Both of these L&S units enthusiastically supported the proposal. Increasing interest in this field,
and the growing complexity of it, both signal that the time has come to create this program. The council
approved unanimously a motion to support the creation of this program.

We wish you all the best as you move forward with it!
Department of Biostatistics and Medical Informatics
Faculty Meeting
March 7, 2014


Guests: Charlie Giese, Chris Lindstrom and Whitney Sweeney

1. Minutes of February 28, 2014 were approved with one change.

2. Announcements:
   - Charlie Giese, the new Biostatistics Program Manager, and Chris Lindstrom, Paul’s new Assistant, were introduced.
   - Annual reports for 2013 are due to Chris by Friday, March 14.
   - Get any remaining Cap Ex requests in.
   - Jim Anderson can’t make the regular seminar time in May so talk will be part of Grand Rounds on May 7.

3. Review of Self-Study for the Certificate Programs:
   - (Sweeney) Data has been collected for self study. Programs are low enrollment. Need more marketing for programs. Need to look at options and determine whether to continue with the certificates. Discussion. M. Lindstrom motioned to accept the Committee’s recommendation and forward the proposal on to the SMPH. K. Broman seconded. All in favor.

4. Master’s Degree in Biomedical Informatics:
   - (Sweeney) Notice of intent has been done. The full proposal enhances the notice of intent document. Discussion. R. Chappell mentioned that BMI 767 (Singh) should also be included. Committee motion (E. Mendonca) to accept full proposal and move forward. All in favor.

5. Hiring Update:
   - Working on an offer to Kay See Tan for the joint PHS/BMI position. Yajuan Si was notified that she is not the top candidate.
   - Another candidate, Alan Boyle, is coming in later this week for the joint BMI/MIR position. Get reviews of the other candidates in to Kathleen Wessels ASAP. Jian Peng will be coming for a second visit next Thursday and Friday. He was unable to meet with Ahlquist or Livny and will also meet with chemo informatics and protein researchers.
6. Affiliate Appointments for Academic Staff:
   - Jeannette Mumford was going to be appointed through BMI but Richie Davidson changed his mind. Joint departmental status would give her the same voting rights as our Scientists. Ismor Fischer’s affiliate appointment would recognize his continued teaching commitment to BMI. R. Chappell motioned to approve both affiliate appointments for a three-year period. K. Broman seconded. All in favor.
Appendix E

Program (Major) Name: ___MS Degree Program in Biomedical Informatics________________________

1. Minimum Graduate Residence Credit Requirement:
The Minimum Graduate Residence Credit Requirement requires at least 16 credits for master’s degrees, 24 credits for MFA/specialist certificates, and 32 credits for doctorate degrees. Programs may require a higher Graduate Residence Credit minimum. If you have different credit requirements for different tracks of students at the same degree level, please note that accordingly.

<table>
<thead>
<tr>
<th>Name of degree level and any applicable options/tracks</th>
<th>Residence Credit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.S. Degree in Biomedical Informatics</td>
<td>16 credits</td>
</tr>
</tbody>
</table>

2. Minimum Graduate Degree Credit Requirement:
The Minimum Graduate Degree Credit Requirement requires at least 30 credits for master’s degrees, 42 credits for MFA/specialist certificates, and 51 credits for doctorate degrees (may include master’s, minor, and dissertator credits). Programs may require a higher Graduate Degree Credit minimum. If you have different credit requirements for different tracks of students at the same degree level, please note that accordingly.

<table>
<thead>
<tr>
<th>Name of degree level and any applicable options/tracks</th>
<th>Degree Credit Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>M.S. Degree in Biomedical Informatics</td>
<td>30 or 31 credits</td>
</tr>
</tbody>
</table>

3. Minimum Graduate Course Work (50%) Requirement:
The Minimum Graduate Course Work Requirement states that at least 50% of credits applied toward the program’s graduate degree credit requirement must be with courses designed for graduate work. Graduate course work can include UW-Madison courses (including but not limited to online, thesis/research, independent study, and practicum/internship credits) that satisfy one of the following guidelines:
- numbered 700 and above;
- numbered 300-699 that are specifically designed for graduate students in a graduate program;
- numbered 300-699 that assess graduate students separately from undergraduate students; or
- numbered 300-699 that have a graduate student enrollment >50% in any given semester.

Programs may be more restrictive with how they define graduate-level work (than the above parameters). Please provide the program’s policy around this requirement. If you have different requirements for different tracks of students at the same degree level, please note that accordingly.

<table>
<thead>
<tr>
<th>Name of degree level and any applicable options/tracks</th>
<th>Graduate Course Work Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Degree Program in Biomedical Informatics</td>
<td>Half of degree course work (15 credits out of 30 total credits) must be completed in courses numbered 700 or higher or numbered 300-699 that are specifically designed for graduate students in a graduate program.</td>
</tr>
</tbody>
</table>
4. Prior Course Work Requirements:

The Prior Course Requirements state a student's program may decide to accept coursework completed outside of the student's graduate career at UW-Madison when those courses are rigorous and meet the expectations of graduate work for the degree. The chart below summarizes the policy and its intersection with other policies:

<table>
<thead>
<tr>
<th></th>
<th><strong>Prior Graduate Course Work from Other Institution(s)</strong></th>
<th><strong>Course Work from Undergraduate Career at UW-Madison</strong></th>
<th><strong>Transfer from University Special Student Career at UW-Madison</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Graduate Residence Credit Requirement</td>
<td>No</td>
<td>No</td>
<td>*Allowed up to 15 credits numbered 300 or above if difference in tuition is paid.</td>
</tr>
<tr>
<td>Minimum Graduate Degree Credit Requirement</td>
<td>*Allowed</td>
<td>*Allowed up to 7 credits numbered 300 or above</td>
<td></td>
</tr>
<tr>
<td>Minimum Graduate Course Work (50%) Requirement</td>
<td>*Allowed</td>
<td>*Allowed up to 7 credits numbered 700 or above</td>
<td>*Allowed up to 15 credits numbered 700 or above if difference in tuition is paid.</td>
</tr>
</tbody>
</table>

*Fulfillment of requirements is allowed only if approved by the student's graduate program up to any stated maximum.

** Course work earned five or more years prior to admission to a master’s degree or course work earned ten or more years prior to admission to a doctoral degree is not allowed to satisfy requirements.

Programs may be more restrictive regarding the type and number of prior course work credits that are allowed to fulfill requirements. Please provide the program's policy around this requirement. If you have different requirements for different tracks of students at the same degree level, please note that accordingly.

<table>
<thead>
<tr>
<th>Name of degree level and any applicable options/tracks</th>
<th>Prior Course Work Requirements: Grad Work Other Institutions; UW-Madison Undergraduate; and UW-Madison University Special</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Degree Program in Biomedical Informatics</td>
<td><strong>Grad Work Other Institutions:</strong> With program approval, students are allowed to count no more than 9 credits of graduate course work from other institutions. Course work earned five or more years prior to admission to a master’s degree or earned ten years or more prior to admission to a doctoral degree is not allowed to satisfy requirements.</td>
</tr>
<tr>
<td></td>
<td><strong>UW-Madison Undergraduate:</strong> With program approval, students are allowed up to 7 credits numbered 300 or above from a UW-Madison undergraduate degree are allowed to count toward the degree.</td>
</tr>
<tr>
<td></td>
<td><strong>UW-Madison University Special:</strong> With program approval and payment of the difference in tuition (between special and graduate tuition), students are allowed to count no more than 9 credits of course work numbered 300 or above taken as a UW-Madison special student. Course work earned five or more years prior to admission to a master’s degree or earned ten years or more prior to admission to a doctoral degree is not allowed to satisfy requirements.</td>
</tr>
</tbody>
</table>
5. Maximum Credits per Term:

The Maximum Credits per Term allows non-dissertation students to enroll for a maximum of 15 credits per term. Dissertators must continue to enroll in exactly 3 credits related to their dissertation. Programs may set a lower Maximum Credits per Term for non-dissertators through advising or program policy. Please provide the program’s policy around this requirement. If you have different requirements for different tracks of students at the same degree level, please note that accordingly.

<table>
<thead>
<tr>
<th>Name of degree level and any applicable options/tracks</th>
<th>Maximum Credits per Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Degree Program in Biomedical Informatics</td>
<td>12 credits (note this will need to be monitored and enforced locally)</td>
</tr>
</tbody>
</table>

6. Effective Dates:

The GFEC approved the following implementation effective date parameters:
- Any student entering or readmitted to a graduate program on or after Fall 2014 must adhere to the above requirements.
- Currently enrolled master’s students have the option to complete their degree under the prior policy requirements if they can complete all degree requirements and are awarded the degree before Fall 2016.
- Students enrolled in a MFA, specialist certificate, or doctoral degree prior to Fall 2014 have the option to complete their degree under the prior policy requirements.
- A student who chooses to discontinue their degree program for a semester or more will return under the new policy requirements.

Please provide the program’s policy around these parameters. If you have different requirements for different tracks of students at the same degree level, please note that accordingly.

<table>
<thead>
<tr>
<th>Name of degree level and any applicable options/tracks</th>
<th>Effective Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS Degree Program in Biomedical Informatics</td>
<td>New master’s students must adhere to new program requirements effective Fall 2014.</td>
</tr>
</tbody>
</table>

Communication Implementation:

Please check and insert any relevant notations to each of the following communication steps necessary for appropriate and full implementation of the new policies.

- [✓] We have or will notify prospective and incoming students about these new policy requirements so they can make informed decisions regarding enrollment.
- [✓] We have or will notify current students about these new policy requirements so they understand how they may or may not be impacted.
- [✓] We have or will update our Fall 2014 (or 2014-15) program handbook and website where appropriate with these new policy requirements prior to the start of the Fall 2014 term.
We will be ready to update the Graduate Catalog with these and any other program requirements during the update cycle set to occur between November 2013-April 2014. Please retain a copy of this form as a reference.

Notes: We are designing a new degree program that won't be implemented until Fall 2014. Thus, we will begin the program adhering to the new guidelines.