**BMI**

**Biomedical Informatics**

**BMI 501: Introduction to Biomedical Informatics**
This course introduces the unique characteristics of clinical and life science data and the methods for representation and transformation of biomedical data, information, and knowledge to improve human health. The course will provide an overview of basic concepts and will serve as a Launchpad into other more focused courses that explore the computational and analytics needs of BMI, as well as the clinical, research and translational applications of informatics. There will be three major themes: Information representation, management and sharing; biomedical data representation and management; standards, terminologies, and ontologies such as HL7, IHE, SNOMED, ICD-9; Privacy, confidentiality and data sharing. Clinical Informatics: Health care environment and processes; electronic health records and management; clinical decision making clinical information retrieval clinical natural language processing. Imaging informatics: radiological image modalities; DICOM and PACS systems; computer-aided diagnosis; digital pathology; analytical pathology imaging. This course will provide hand-on assignments for the participants to familiarize the concepts. Prerequisite: Graduate standing in BMI or permission of instructor.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 502: Life Sciences for Biomedical Informatics**
This course presents the fundamentals of human cell biology, biochemistry, genetics and cell/organ physiology. The biochemical and molecular bases of cell structure, energy metabolism, gene regulation, heredity, and development are discussed, as are the structure and function of cell membranes and the physiology of cell to cell signaling, cellular respiration, and homeostasis of organs and individuals. Can be used for credit toward masters or doctoral degree in BMI only with permission and NOT in addition to BMI 503. Can NOT be used for credit toward certificate in Biomedical Informatics.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 503: Computer Science for Biomedical Informatics**
This course presents the fundamentals of computer science and problem solving for computer programming. Students learn how computers store and manipulate data using programming languages and algorithms and how computers are controlled by operating systems and networked. Software engineering, data abstractions, and database management systems are described. Applications include computer graphics and artificial intelligence. A theory of computing is presented. Approaches to devising solutions to problem are discussed. Structured programming tools are presented including sequential and decision logic and loops. Data and file operations are explained including processing arrays, sorting, stacks, queues, linked lists, and binary trees. Object-oriented programming and sequential file applications are discussed. Can be used for credit toward masters or doctoral degree in BMI only with permission and NOT in addition to BMI 502. Can NOT be used for credit toward certificate in Biomedical Informatics.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 511: Translational Bioinformatics**
This course will provide students with an integrative computational toolbox at the intersection between Biomedical and Quantitative Sciences. Students will develop storage, analytic, and interpretive methods to optimize the transformation of large biomedical and genomic datasets, into proactive, predictive, preventive, and participatory health information. Applying a working knowledge of Computational Statistics in a Biomedical/Biomolecular context, students will gain the ability integrate those Computational Tools and Big Data resources in the Biomedical research enterprise as well as in the clinical workflow. Accordingly, this course will familiarize the participants with the data processing methodologies associated with a range of biological signals that spans from Biological sequences to Histology images, and from imaging medical records to Genome Wide Association Studies (GWAS) and gene prioritization.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 512: Clinical Informatics**
This course offers a comprehensive study of Clinical Informatics. It provides a holistic review of the health care delivery system both historically and presently. It presents Clinical Informatics and its legal and ethical issues, followed by an overview of Clinical Informatics. This includes data content and structures; nomenclatures and classification systems; quality, performance, utilization, and risk management; Clinical Informatics databases; and a review of statistics and research. Clinical informatics management principles and theories presented include change, project, and knowledge management. Aspects of human resources and financial management, including reimbursement methodologies are presented as these relate to Clinical Informatics.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 513: Imaging Informatics**
Imaging Informatics is a multidisciplinary field which intersects Clinical Informatics, medical physics, engineering, computer and information sciences. It touches concepts across the whole imaging chain, including image creation and acquisition, image distribution and management, image storage and retrieval, image processing, analysis and understanding, image visualization and interpretation. The goals of the course are to gain familiarity with the terminology, core concepts, and standard practices, understand the current state of the field and enable critical reading of the literature and to perform research. The course will cover both radiological imaging and pathology imaging. Topics include: radiological imaging modalities, DICOM standards, image management and PACS systems, image exchange and IHE, image processing techniques, content based image retrieval, structured reporting and annotations, image visualization, digital pathology and analytical pathology imaging. The course will also cover emerging technologies in Imaging Informatics.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 514: Imaging Informatics Analysis**
This course will give an overview of the analytical aspects of the Biomedical Imaging Informatics. Topics include image visualization, enhancement, processing and analysis, with focus on the applications in medical fields. It covers a broad spectrums of biomedical image analysis techniques: image enhancement, segmentation, registration, texture analysis, morphometry, and tractography. Their applications in diagnostic and therapeutic imaging will be extensively discussed. The course will also cover a wide range of image modalities: Magnetic resonance imaging (with its various subtypes), Computed tomography, Ultrasound, Positron emission tomography, Single-photon emission computed tomography, etc., with an emphasis on the interplay and fusion of multi-source information. The computation/analysis will be carried out using languages such as Matlab, C++, Python, Java, etc., based on well tested open sources algorithm packages such as the Insight Toolkit. Moreover, softwares more geared towards end-users, such as 3D Slicer, ImageJ, FreeSurfer, etc. will also be introduced.
**BMI 517: Current Research in Signaling Pathways, Biochemistry, and Tissue Morphology of Disease**

In this seminar course, students will explore current knowledge and lines of research inquiry for a disease of their choice, with respect to Signaling Pathways, Biochemistry, and Tissue Morphology. Students will learn to analyze and synthesize research literature for a particular disease topic and propose a testable hypothesis for a research project that would advance one or more lines of research inquiry for the disease. Students will provide feedback for other students; literature reviews.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 520: Data Analytics and Software Stacks**

This course will cover cutting-edge data analytic applications, infrastructure, and analytic methods. Students will have the opportunity to analyze real (de-identified) healthcare datasets and spatio-temporal and molecular datasets drawn from cancer research. Each class session will include discussions of applications, infrastructure, and algorithms. Students will present papers, and there will also be guest lectures from visiting experts. Students will attend lectures, present and critique papers, and work with a team of students on a substantial project throughout the semester. Students are expected to demonstrate a high level of independence, critical thinking, and initiative.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 530: Software Development in Biomedical Informatics**

This is an advanced topic in the BMI series, designed for participants with plans to develop Biomedical Informatics software applications. The BMI530 course is divided in two parts. The first part will provide an overview of approaches to software development in a Biomedical context, where reproducibility, governance and availability are particular concerns. The participants will be introduced, hands-on, to practices such as the use of version control services (such as GitHub), collaborative development models (such as agile programming, extreme programming, unit testing, continuous code review, pair programming etc) and software architectural patterns (such as Model-View-Controller, MVC, and Model-View-Adapter, MVA). The increasing reliance on Cloud Computing infrastructure and Web 3.0 technologies for both software development and deployment will be of particular attention. The increasing reliance on Big Data resources in Biomedicine, and the broadening use of Web Computing will be approached as part of the exercise of configuring class projects for the second part of the course. Accordingly, a particular focus will be put on the use of Representation State Transfer (REST) architectures and hands-on familiarization with REST APIs (Application Programming Interfaces). The second part of the course will put these concepts into practice through the development of small software projects. Groups of one to three people per project development team will be configured to develop software that solves problems brought to the class by the participants, preferably, but not necessarily, as contributions to manuscripts and/or funded research. Prerequisite: BMI 503 and programming experience, BMI 520, or permission by instructor (face-to-face meeting required).

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 531: Advanced Computer Science for Biomedical Informatics (Data Management for Biomedical Informatics)**

Data management is a key area of competency in biomedical informatics. This course will cover the concept of database design, data modeling, data management and analytical queries. Topics include relational models, conceptual modeling, relational database implementation, SQL queries, spatial database and GIS, XML databases, NoSQL databases, and big data platforms such as Apache Hadoop and Spark. It will also cover data management for electronic health records, and GIS for public health.

3 credits, May be repeated for credit.

**BMI 540: Statistical Methods in Biomedical Informatics**

Recent advances in high-throughput experimental technologies generate enormous amounts of data. In order to extract insights from such large-scale data sets, robust statistical models and efficient computation methods are indispensable. This course introduces probability and statistical modeling and analytical methods commonly used in biomedical-informatics. Basic probability theory will be briefly reviewed and the course will focus on the construction and solving of statistical modeling based on real biomedical data sets. The methods covered include maximum likelihood estimation, Bayesian inference, dynamic programming, Markov Models, Monte Carlo simulation, classification and clustering. Students will learn to use statistical programs and related resources locally and on the Internet, with an emphasis on the computational aspects of the statistical models in order to harness the ever-growing hardware power. Upon finishing the course, the students will master advanced applications of statistical computing in a wide range of biological and biomedical problems. PREREQUISITES: BMI 501; Basic knowledge in probability theory, algorithms and programming experience in R/MATLAB/C/C++ are expected. Knowledge in biology is a plus but not a must.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 541: Advanced Statistical Methods Informatics**

This course will introduce students to advance statistical methods in informatics. Students will be introduced to basics of optimization, control, information geometric techniques and trends. This class will be a continuation of BMI 540 and basic statistical methods and probability concepts will be reintroduced. Students learn basic ability to derive new models that can be applied to generalized informatics. Upon finishing this course, student will have master advanced application of how to utilize standard statistical knowledge coupled with ability to implement such algorithms.

3 credits, May be repeated for credit.

**BMI 550: Clinical Informatics Practice Patterns**

This course provides detailed information on Clinical Informatics in a variety of practice settings including hospitals, freestanding ambulatory care, managed care, dialysis, correctional facilities, long-term and acute mental health, substance abuse, developmental disabilities, long-term care, rehabilitation, home health, hospice, dental, veterinary, and consulting. The role of Clinical Informatics in each setting is described with respect to regulatory issues; documentation; reimbursement and funding; information management, including data flow, coding and classification, computer systems, and data set; quality improvement, utilization and risk management, and legal issues; the role of the Clinical Informatics professional, and changes and trends.

3 credits, Letter graded (A, A-, B+, etc.)

**BMI 551: Case Studies in Clinical Informatics**

This course presents cases based on real-life challenges in Clinical Informatics. Critical thinking is essential for the Clinical Informatics professional and case studies demand that students develop thought and...
action plans and then, in class, present and defend their choices. Each case exposes the student to a complex Clinical Informatics scenario, requiring the student to synthesize information and strategically solve problems using Clinical Informatics principals. Learning through the case method helps students to bridge the gap, from content knowledge for previous and/or current courses to on-the-job Clinical Informatics experience.

3 credits, Letter graded (A, A-, B+, etc.)

BMI 552: Quality Improvement Methods for Clinical Informatics

Teaches health care management professionals how to perform improvement projects and incorporate quantitative measurement into daily work routines to form the foundation for a quality improvement-oriented culture. Using Minitab software, provides strategies to gather and analyze the data needed to plan, implement, monitor, and evaluate health care quality improvement initiatives.

3 credits, Letter graded (A, A-, B+, etc.)

BMI 560: Personalized Medicine

This course is focused on the multidisciplinary research and clinical context associated with the development of personalized health care delivery solutions. It will place particular emphasis on assessing opportunities identified by translational and operational research of the clinical settings that define the practical utility of personalized medicine. Accordingly, the clinical decision support systems (CDS) will be developed for clinical pharmacogenomics, specifically those that establish pharmacotyping in drug prescription, will play a central role in this course. Its content will cover innovative drug formulations and nanotheranostics, molecular imaging and signatures, medical genomics, translational nanomedicine and informatics, stem cell therapy approaches, modeling and predictability of drug response, pharmacogenetics-guided drug prescription, pediatric drug dosing, pharmacovigilance and regulatory aspects, ethical and cost-effectiveness issues, pharmacogenomics knowledge bases, personal genome sequencing, molecular diagnostics, as well as information-based medicine.

3 credits, Letter graded (A, A-, B+, etc.)

BMI 590: Independent Study in Biomedical Informatics

Independent study in Biomedical Informatics. Must have the approval of the Research and Directed Study Committee of the Department of Biomedical Informatics prior to registration. Prerequisite: Graduate standing in BMI, or permission of instructor

1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 591: Independent Reading in Biomedical Informatics

Supplemental specialized readings in Biomedical Informatics for graduate students under faculty supervision. Must have the approval of the Research and Directed Study Committee of the Department of Biomedical Informatics prior to registration.

1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated 1 times FOR credit.

BMI 592: Biomedical Informatics Masters Pre-Candidates Seminar

This course is designed to expose students to current research and other topics in Biomedical Informatics. Speakers are invited from both on and off campus.

1 credit, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 595: Special Topics in Biomedical Informatics

Examination of special topics on artificial intelligence in Biomedical Informatics. We present and critique literature on artificial intelligence in biomedicine, including but not limited to machine learning, signal processing, and deep learning. The literature will span different fields of biomedical informatics such as imaging informatics, computational biology, clinical informatics etc. Students are required to review articles and connect the presented techniques to a bigger picture context within the different fields of biomedical informatics. Following the article presentation, the thoughts that the article provoked will be discussed together.

0-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 596: Special Problems in Biomedical Informatics

Examination of special problems in Biomedical Informatics, conducted jointly by graduate students and one or more members of the faculty.

1-6 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 598: M.S. Capstone Project in Biomedical Informatics

M.S. Independent Capstone project planning and project execution under the supervision of a Biomedical Informatics faculty member. Only open to M.S. students in Biomedical Informatics who will do a Capstone project. Credits earned from BMI 598 may not be used to fulfill requirements for students in Biomedical Informatics who will write an M.S. thesis and not do a Capstone project.

1-6 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 599: M.S. Research and Thesis in Biomedical Informatics

M.S. Research and Thesis project under the supervision of a Biomedical Informatics faculty member. Only open to M.S. students in Biomedical Informatics who will write an M.S. thesis. Credits earned from BMI 599 may not be used to fulfill requirements for students in Biomedical Informatics who will do a Capstone project and not write an M.S. thesis.

1-12 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 620: Advanced Topics in Clinical Informatics

The subject matter of each special topics course varies from semester to semester, depending on the interests of students and faculty. Advanced topics and specialized topics will be discussed, particularly those of current interest.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 622: Advanced Topics in Translational Bioinformatics

The subject matter of each special topics course varies from semester to semester, depending on the interests of students and faculty. Advanced topics and specialized topics will be discussed, particularly those of current interest.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated 1 times FOR credit.

BMI 625: Advanced Topics in Imaging Informatics

The subject matter of each special topics course varies from semester to semester, depending on the interests of students and faculty. Advanced topics and specialized topics will be discussed, particularly those of current interest.

3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 690: Independent Study in Biomedical Informatics

Independent study in Biomedical Informatics. Must have the approval of the Research and Directed Study Committee of the Department of Biomedical Informatics prior to registration.
BMI 691: Independent Reading in Biomedical Informatics
Supplementary specialized readings in Biomedical Informatics for graduate students under faculty supervision. Must have the approval of the Research and Directed Study Committee of the Department of Biomedical Informatics prior to registration.
1-3 credits, Letter graded (A, A-, B+, etc.)

BMI 692: Biomedical Informatics Candidates Seminar
This course is designed to expose students to current research and other topics in Biomedical Informatics. Speakers are invited from both on and off campus.
1 credit, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 695: Special Topics in Biomedical Informatics
Examination of special topics in Biomedical Informatics, by one or more members of the faculty.
1-3 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 696: Special Problems in BMI
Examination of special problems in Biomedical Informatics, conducted jointly by graduate students and one or more members of the faculty.
1-6 credits, Letter graded (A, A-, B+, etc.)

BMI 697: Practicum in Teaching I
An introduction to teaching Biomedical Informatics, including course design, learning theory, evaluation of teaching, and teaching with technology.
3 credits, Letter graded (A, A-, B+, etc.)

BMI 698: Practicum in Teaching II
Graduate students assist the faculty in teaching by conducting recitation or laboratory sections that supplement a lecture course.
3 credits, Letter graded (A, A-, B+, etc.)

BMI 699: Dissertation Research-On Campus
Independent research conducted on campus, in the United States, under the supervision of a Biomedical Informatics faculty member in support of the Ph.D. Dissertation. Permission to register requires the agreement of the faculty member to supervise the research. May be repeated.
1-12 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 700: Dissertation Research-Off Campus, Domestic
Independent research conducted off campus, outside the United States, under the supervision of a Biomedical Informatics faculty member in support of the Ph.D. Dissertation. Permission to register requires the agreement of the faculty member to supervise the research.
1-2 credits, Letter graded (A, A-, B+, etc.)
May be repeated 1 time FOR credit.

BMI 701: Dissertation Research-Off Campus, International
Independent research conducted off campus, outside the United States, under the supervision of a Biomedical Informatics faculty member in support of the Ph.D. Dissertation. Permission to register requires the agreement of the faculty member to supervise the research.
1-12 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.

BMI 800: Full-Time Summer Research
Independent research conducted off campus, in the United States, under the supervision of a Biomedical Informatics faculty member in support of the Ph.D. Dissertation. Permission to register requires the agreement of the faculty member to supervise the research. May be repeated.
0-12 credits, Letter graded (A, A-, B+, etc.)
May be repeated for credit.