

Bioinformatics / Clinical Informatics / Biostatistics Core (3 required)

BMI 576	Introduction to Bioinformatics	Algorithms for computational problems in molecular biology, such as genome sequencing and mapping, sequence alignment, modeling sequence classes and features, gene-expression data analysis, biological network inference, etc.
<i>One of the following three courses is required. BMI 573 is a new course that is specifically designed for CIBM trainees and will be offered starting in the Spring 2017 semester.</i>		
BMI 573	Health Informatics	Grounding in core concepts and theories, and fundamental methods necessary to the practice of health informatics, including: fundamentals of information and communication processes and the principles that shape them; interventions that can improve upon existing information and communication processes; methods and principles that allow such health care interventions to be designed; evaluating the impact of health information systems and informatics interventions on the way individuals or organizations work; health care policy as it relates to health information technology; data security and privacy.
Med/BMI 918	Health Informatics for Medical Students	Two-week, intensive elective of foundational and cutting-edge medical informatics topics arranged into twelve modules. Programming, Standards and Vocabulary, Knowledge Management, Errors and Clinical Decision Support, Electronic Health Records, Legal Issues in Medical Informatics, Human Factors and Evaluation, PDAs and Applications, Personal Health Records, Security and Encryption, Evidence-Based Medicine, Genomics and Digital Imaging.
BMI 773	Clinical Research Informatics	Topics in clinical research informatics including information management, process flow and security enforcement. Several visiting experts bring a realistic and practical bias to this course. Fundamentals of computing and correlative disciplines are presented; students learn basic information processing techniques. Systems architecture, databases, security, data modeling, data mining and systems integration are described. Realistic use-cases are then be presented for exercises and understanding evaluation.
Nursing 764	Nursing and Health Informatics	Identification of computer and information technologies to support nursing the diagnosis and treatment of human responses to health, illness, and developmental challenges. Examination of information systems used in clinical practice, information processing and nurses' roles in the evaluation of solutions. Ethical, legal and social issues related to informatics in patient care.
<i>One of the following two courses is required.</i>		
BMI/Stat 541	Introduction to Biostatistics	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 ratio. Biomedical applications used for each topic.
STAT 571	Statistical Methods for Bioscience I	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.

Biomedical Science Courses (2 required)

There are many options in this category. Specific biomedical sciences courses are selected for each trainee depending on his/her research focus. Some of the more commonly used classes are listed below.

Gen 466	General Genetics	Genetics in eukaryotes and prokaryotes. Includes Mendelian genetics, mapping, molecular genetics, genetic engineering, cytogenetics, quantitative genetics, and population genetics. Illustrative material includes viruses, bacteria, plants, fungi, insects, and humans.
PH 471	Introduction to Environmental Health	Impact of environmental problems on human health; biological hazards to human health from air and water pollution; radiation; pesticides; noise; problems related to food, occupation and environment of the work place; accidents. Physical and chemical factors involved.
Biochem 501	Intro. to Biochemistry	Chemistry, nutrition, and metabolism of biological systems.
Microbiol 528	Immunology	Development and functions of immune response in animals; a comprehensive study of experimental humoral and cellular immunity.
Genetics 565	Human Genetics	Principles, problems, and methods of human genetics. Surveys aspects of medical genetics, biochemical genetics, molecular genetics, cytogenetics, quantitative genetics, and variation as applied to humans.
Biochem 601	Protein Structure and Function	Protein structure and dynamics. Protein folding. Physical organic chemistry of enzymatic catalysis. Analysis of enzyme kinetics and receptor-ligand interactions. Enzymatic reaction mechanisms.
Biochem 602	Biochemical Mechanisms of Regulation in the Cell	Control of major cellular metabolic pathways of biosynthesis and degradation; signal transduction; membrane biogenesis and cell compartmentation; intracellular protein and lipid traffic.
Biochem 630	Cellular Signal Transduction	Comprehensive coverage of human hormones, growth factors and other mediators; emphasis on hormone action and biosynthesis and hormone-producing cells.
Genetics 626	Genomic Science	Provides knowledge of basics of genomic science and introduces students to cutting edge topics. Basics will be covered in both the physical and biological sciences.
PH 794	Biological Basis of Population Health	Covers the physiology, biology and biochemistry of selected disease processes deemed to be important to students of population health sciences by virtue of their clinical significance including incidence, mortality and morbidity.

Advanced Computer Sciences Courses (1 required)

There are many options in this category. Specific computer sciences courses are selected for each trainee depending on his/her research focus. Some of the more commonly used classes are listed below.

CS 524	Introduction to Optimization	Introduction to mathematical optimization from a modeling and solution perspective. Formulation of applications as discrete and continuous optimization problems and equilibrium models. Survey and appropriate usage of basic algorithms, data and software tools, including modeling languages and subroutine libraries.
CS 540	Introduction to Artificial Intelligence	Principles of knowledge-based search techniques; automatic deduction, knowledge representation using predicate logic, machine learning, probabilistic reasoning. Applications in tasks such as problem solving, data mining, game playing, natural language understanding, computer vision, speech recognition, and robotics.
CS 559	Computer Graphics	Survey of computer graphics. Image representation, formation, presentation, composition and manipulation. Modeling, transformation, and display of geometric objects in 2 and 3 dimensions. Representation of curves and surfaces. Rendering, animation, multi-media and visualization.

CS 564	Database Management Systems	What a database management system is; different data models currently used to structure the logical view of the database: relational, hierarchical, and network. Implementation techniques for database systems. File organization, query processing, concurrency control, rollback and recovery, integrity and consistency, and view implementation.
CS570	Introduction to Human-Computer Interaction	User-centered software design; (1) principles of and methods for understanding user needs, designing and prototyping interface solutions, and evaluating their usability, (2) their applications in designing web-based, mobile, and embodied interfaces through month long group projects.
CS 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.
CS 635	Tools and Environments for Optimization	Formulation and modeling of applications from computer sciences, operations research, business, science and engineering involving optimization and equilibrium models. Survey and appropriate usage of software tools for solving such problems, including modeling language use, automatic differentiation, subroutine libraries and web-based optimization tools and environments.
CS 642	Introduction to Information Security	The course covers a wide range of topics on information security, such as, cryptographic primitives, security protocols, system security, and emerging topics.
CS 760	Machine Learning	Computational approaches to learning including various machine learning paradigms, algorithms, and methodologies for evaluating learning systems. Methods covered include decision trees, instance-based learning, neural networks, support vector machines, ensemble methods, and probabilistic graphical models.
CS 766	Computer Vision	Fundamentals of image analysis and computer vision; image acquisition and geometry; image enhancement; recovery of physical scene characteristics; shape-from 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.

Advanced Electives in Biomedical Informatics and CS (1 required)

Trainees take an additional elective in biomedical informatics or computer science. Some of the courses in the former category are listed below. Courses in the latter category include those in the list above.

ISyE 517	Decision Making in Health Care	Introduction to the use of decision sciences in health-care. Conceptual understanding of medical decision making and its tools including decision trees, sensitivity analysis, Markov (decision) processes, and Monte Carlo simulations with examples from the current medical literature.
ISyE/BMI 617	Health Information Systems	Covers core concepts of health information systems. Major applications include clinical information systems, language and standards, decision support, image technology and digital libraries.
BMI 567	Medical Image Analysis	Presents introductory medical image processing and analysis techniques. Topics include medical imaging formats, segmentation, registration, image quantification, classification.
Biochem/BMI 606	Mathematical Methods for Structural Biology	Intended to 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.
Biochem/BMI 609	Mathematical Methods for Systems Biology	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.
BMI 767	Computational Methods for Medical Image Analysis	Study of computational techniques that facilitate automated analysis, manipulation, denoising, and improvement of large-scale and high resolution medical images. Design and implementation of methods from computer Vision and Machine Learning to efficiently process such image data to answer biologically and clinically meaningful scientific questions.
BMI / CS 776	Advanced Bioinformatics	Advanced course covering computational problems in molecular biology. The course will study algorithms for problems such as: modeling sequence classes and features, phylogenetic tree construction, gene-expression data protein and RNA structure prediction, and whole-genome analysis and comparisons.
CBE 782	Modeling Biological Systems	Literature survey of mathematical models in biology at the molecular and cellular levels; application of chemical kinetics and thermodynamics to biological systems; comparison of deterministic and stochastic strategies.

Computation and Informatics in Biology and Medicine Seminars (required each semester)

BMI 915 CS 915 Biochem 915	CIBM Seminar	Participants and outside speakers discuss current research in computation and informatics in biology and medicine. Required of all Computation and Informatics in Biology and Medicine Program Trainees.
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Responsible and Ethical Conduct of Research (1 required)

There are multiple options in this category. Prof. Pilar Ossorio will be developing a new course BMI 826 (to be offered in Fall 2016) on responsible and ethical conduct of research that will be specifically tailored for trainees in data science fields.

Biochem 701	Professional Responsibility	Training for the practical aspects of being a scientist. Will cover ethics, peer review, grant writing, science communication, career alternatives, paper writing, experimental design, research documentation, science funding, academic-private interface, scientific fraud, and more.
Nursing 802	Ethics and the Responsible Conduct of Research	Ethical issues in the design, conduct and reporting of research are examined in the context of the nature of the scientific endeavor, the structure of the research community, and professional and federal guidelines for supporting scientific integrity and controlling misconduct.
BMI 826	Responsible Conduct of Research for Data Scientists	This new course will cover all of the NIH required topics as well as many of the suggested ones for RCR training and will be tailored to the experiences and needs of data scientists. We expect this will be the RCR course most CIBM trainees will be taking.
Microbio/ Chem 901	Responsible Conduct of Research	Examination and discussion of key topic areas: conflicts of interest; academia and industry; mentor and mentee relationships; confidentiality, peer review and intellectual property; collaboration, authorship and publication; data management; personal, institutional and societal responsibilities; select agents.