

# BIOINFORMATICS (BI-GY)

## BI-GY 810X Bioinformatics Capstone (3-6 Credits)

*Typically offered Fall, Spring, and Summer terms*

This online course is providing students an opportunity to work in a public or private research or production environment. This may include labs at companies in the private sector or independent research institutes and foundations, within or outside of Tandon. Students apply their skills (such as Python, R, UNIX, and Next Generation Sequence Analysis) in a real-life environment. Students who enroll in this course will work under the advisement of a Tandon Online faculty member. At the end of the course the student has to submit a final report/paper. | Prerequisites: BI-GY 7663, BI-GY 7673, BI-GY 7653

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** Yes

## BI-GY 997X MS THESIS IN BIOINFORMATICS (3-9 Credits)

*Typically offered occasionally*

Original research, which serves as basis for master's degree. Minimum research registration requirements for the master's thesis: 12 units. Registration for research required each semester consecutively until students have completed adequate research projects and acceptable theses and have passed required oral examinations. Research credits registered for each semester realistically reflect time devoted to research. | Prerequisites for MS candidates: Degree status and consent of graduate adviser and thesis director.

**Grading:** Satisfactory/Unsatisfactory

**Repeatable for additional credit:** Yes

## BI-GY 7453 Algorithms and Data Structures for Bioinformatics (3 Credits)

*Typically offered Fall and Spring*

The online course is aimed at introducing the foundational ideas from computer science in designing and implementing bioinformatics algorithms. The goal of the underlying algorithms and data structures is to accurately abstract and model the biological problems and to devise provably correct procedures with efficient computational complexity bounds. The algorithms will be described in pseudo-codes in order to simplify the correctness and complexity analysis, but with sufficient details to enable the students implement them in any suitable software pipelines and hardware architectures. | Prerequisites: MA-UY 2314

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

## BI-GY 7513 Chemical Foundation for Bioinformatics (3 Credits)

This course intensively reviews those aspects of organic chemistry and biochemistry necessary to begin research in bioinformatics and to enter graduate courses in biology. Topics include covalent bonding, quantum mechanical basis of bond formation, three-dimensional structure of molecules, reaction mechanisms, catalysis, polymers, enzymes, thermodynamic and kinetic foundations, metabolic pathways, sequence and structure of macromolecules. This course extensively uses computer approaches to convey the essential computational and visual nature of material to be covered. | Prerequisites: General Chemistry, General Physics, Organic Chemistry and Calculus.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

## BI-GY 7523 Biological Foundation for Bioinformatics (3 Credits)

*Typically offered occasionally*

This course intensively reviews the aspects of biochemistry, molecular biology and cell biology necessary to begin research in bioinformatics and to enter graduate courses in biology. The areas covered include cell structure, intracellular sorting, cellular signaling (i.e., receptors), Cytoskelton, cell cycle, DNA replication, transcription and translation. This course extensively uses computer approaches to convey the essential computational and visual nature of the material to be covered. | Prerequisites: General Chemistry, General Physics, Organic Chemistry, Calculus or permission of instructor.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

## BI-GY 7533 Bioinformatics I: Sequence Analysis (3 Credits)

*Typically offered occasionally*

This course covers computer representations of nucleic acid and protein sequences; pairwise and multiple alignment methods; available databases of nucleic acid and protein sequences; database search methods; scoring functions for assessment of alignments; nucleic acid to protein sequence translation and codon usage; genomic organization and gene structure in prokaryotes and eukaryotes; introns and exons; prediction of open reading frames; alternative splicing; existing databases of mRNA, DNA protein and genomic information; and an overview of available programs and of Web resources.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

## BI-GY 7543 Proteomics for Bioinformatics (3 Credits)

*Typically offered Fall and Spring*

The online proteomics course contributes an application focused specialty class to the bioinformatics curriculum. It will be a tour-de-force of modern proteomics methods and analysis in the context of practical research and clinical applications. The course will teach fundamentals, applications, experiments and predictions in parallel. Thus, each week will include a mix of interactive approaches from background learning, to understanding experimental methodology pro and con, to software usage and sophisticated bioinformatics approaches to prediction. Limitations and complementary of prediction methods will be emphasized. It is desirable (but not required) for students to complete a Biochemistry course before taking this course. | Prerequisites: Bioinformatics I.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

## BI-GY 7553 Bioinformatics III: Functional Prediction (3 Credits)

*Typically offered occasionally*

The course covers functional classifications of proteins; prediction of function from sequence and structure; Orthologs and Paralogs; representations of biological pathways; available systems for the analysis of whole genomes and for human-assisted and automatic functional prediction. | Prerequisites: Bioinformatics II

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

**BI-GY 7563 CHEMOINFORMATICS (3 Credits)**

This course features a review of database theory; chemical structure representation; connection tables, line notations and structure diagrams; representations of chemical reactions; structure manipulation: graph theory, structure analysis: ring perception, structural fingerprints, symmetry perception, molecular modeling algorithms, genetic algorithms, simulated annealing, QSAR historical approaches, structural search of chemical databases, commercial chemical information databases, combinatorial chemistry and diversity assessment.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

**BI-GY 7573 Special Topics in "Informatics in Chemical and Biological Sciences" (3 Credits)**

*Typically offered occasionally*

This course covers special topics on various advanced or specialized topics in chemo- or bioinformatics that are presented at intervals.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** Yes

**BI-GY 7583 GUIDED STUDIES IN BIOINFORMATICS I (3 Credits)**

*Typically offered occasionally*

This research/case course can be handled in different ways at the faculty adviser's discretion. The course may involve a series of cases that are dissected and analyzed, or it may involve teaming students with industry personnel for proprietary or non-proprietary research projects. Generally, the student works under faculty supervision, but the course is intended to be largely self-directed within the guidelines established by the supervising faculty member. Master's degree candidates must submit an unbound copy of their report to adviser/s one week before the last day of classes. | Prerequisite: degree status.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

**BI-GY 7593 GUIDED STUDIES IN BIOINFORMATICS II (3 Credits)**

*Typically offered occasionally*

This research/case course can be handled in different ways at the faculty adviser's discretion. The course may involve a series of cases that are dissected and analyzed, or it may involve teaming students with industry personnel for proprietary or non-proprietary research projects. Generally, the student works under faculty supervision, but the course is intended to be largely self-directed within the guidelines established by the supervising faculty member. Master's degree candidates must submit an unbound copy of their report to adviser/s one week before the last day of classes. | Prerequisite: degree status.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

**BI-GY 7613 Introduction to Systems Biology (3 Credits)**

*Typically offered occasionally*

This course explains the functioning of basic circuit elements in transcription regulation, signal transduction and developmental networks of living cells, using simplified mathematical models. The course focuses on design principles and information processing in biological circuits. It discusses network motifs, modularity, robustness, evolutionary optimization and error minimization by kinetic proofreading in specific applications to bacterial chemotaxis, developmental patterning, neuronal circuits and immune recognition in several well-studied biological systems. | Prerequisites: Bioinformatics II

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

**BI-GY 7623 Systems Biology: -Omes and -Omics (3 Credits)**

*Typically offered occasionally*

This course summarizes knowledge in genomics, proteomics, transcriptomics, metabolomics and relative molecular technologies. Topics include an overview of technologies in functional genomics (DNA chip arrays); whole genome expression analysis (EST, MPSS, SAGE, arrays); proteome analysis technology (2D-electrophoresis, protein in situ digestion for mass spectrometric analysis, yeast 2-hybrid analysis. 2-D PAGE, MALDI-TOF spectroscopy); the principles of Nuclear Magnetic Resonance Spectroscopy and Mass Spectrometry technologies for metabolomics, including general principles, the strengths and weaknesses of each technique, the requirements for sample preparation and the options for the management of output data. This course explains how to exploit different -ome database resources for investigations via special practical tasks to lectures. Special attention is focused on nutrigenomics, a multidisciplinary science that uses genomics, transcriptomics and proteomics to study metabolic health. This relatively new area of metabolomics has the potential to contribute significantly to advances in nutrition and health. | Prerequisites: Bioinformatics II, Bioinformatics III

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

**BI-GY 7633 Transcriptomics (3 Credits)**

*Typically offered occasionally*

Screening of differential expression of genes using microarray technology builds the opportunities for personalized medicine converging soon to medical informatics and to our health care system. The course will start with a discussion of gene expression biology, presenting microarray platforms, design of experiments, and Affymetrix file structures and data storage. R programming is introduced for the preprocessing Affymetrix data for Image analysis, quality control and array normalization, log transformation and putting the data together. Bioconductor software will be dealt with data importing, filtering, annotation and analysis. Machine learning concepts and tools for statistical genomics will be addressed along with distance concept, cluster analysis, heat map and class discovery. Case studies link the methodology to biomolecular pathways, gene ontology, genome browsing and drug signatures.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

**BI-GY 7643 COMPUTATIONAL TOOLS PERL & BIOPERL (3 Credits)**

*Typically offered occasionally*

This course is designed to introduce students to the Perl programming language, its bioinformatics toolbox BioPerl and Unix commands for processing high throughput genomic and/or proteomic data. | Prerequisite: BI-GY 7573

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No

**BI-GY 7653 NEXT GENERATION SEQUENCE ANALYSIS FOR BIOINFORMATICS (3 Credits)***Typically offered Fall and Spring*

The online course is aimed at developing practical bioinformatics skills of next generation sequencing analysis. Students will be introduced to current best practices and in high-throughput sequence data analysis and they will have the opportunity to analyze real data in a high-performance Unix-based computing environment. Special attention will be given to understand the advantages, limitations, and assumptions of most widely bioinformatics methods and the challenges involved in the analysis of large scale datasets. Some of the topics that will be covered include, current sequencing platforms, data formats (FASTA, SAM, BAM, VCF), sequence alignment, sequence assembly, variant calling, RNA-seq analysis, and their biological applications. Students enroll into this course should have knowledge of Basic of programming, unix tools, and shell scripting.

**Grading:** Grad Poly Graded**Repeatable for additional credit:** No**BI-GY 7663 Problem Solving For Bioinformatics (3 Credits)***Typically offered Fall, Spring, and Summer terms*

This course will introduce students to programming in Bioinformatics. The focus will be on object oriented techniques of scripting. Cancer data will be used as examples throughout the course.

**Grading:** Grad Poly Graded**Repeatable for additional credit:** No**BI-GY 7673 Applied Biostatistics for Bioinformatics (3 Credits)***Typically offered Fall and Spring*

This online course will introduce the basics of statistics and its applications in various fields of biology. It will lean towards practical applications, allowing for an intuitive understanding of concepts and some rigor in the application of statistics. It will use R for all the programming exercises. The course will not be requiring a lot of programming, and the requisite skills will be introduced in the lectures. The problems, exercises and assignments will be drawn from real-life problems in research papers and books. The student should be able the initiate and solve problems in the field at the end of the course. Students enroll into this course should have knowledge of basics of programming, probability and statistics.

**Grading:** Grad Poly Graded**Repeatable for additional credit:** No**BI-GY 7683 Biology and Biotechnology for Bioinformatics (3 Credits)***Typically offered Fall and Spring*

The online course is aimed at introducing the key ideas from biology and biochemistry and how they are used in modern biotechnology. The goal of this course is to develop students' critical thinking and analytical reasoning skills in the specific context of biotechnology and its modern applications. This course will explore a plethora of technologies used in the fields of genetic engineering, forensics, agriculture, bioremediation and medicine in order to give the students a basic but fundamental experimental skill set which can be applied in conjunction with computational skills to solve biological problems in a scalable manner. Students enroll into this course should have knowledge of basic Sciences (Biology, Physics and Chemistry).

**Grading:** Grad Poly Graded**Repeatable for additional credit:** No**BI-GY 7693 Population Genetics and Evolutionary Biology for Bioinformatics (3 Credits)***Typically offered Spring*

The online course is aimed at introducing the key ideas from population genetics and how they are used to understand the interaction of basic evolutionary processes (e.g., including mutation, natural selection, genetic drift, inbreeding, recombination and gene flow) that determine the genetic composition and evolutionary trajectories of natural populations. The goal of this course is to develop students' critical thinking and analytical reasoning skills in the specific context of many mechanisms shaping genetic variations and within and between populations. This course will equip the students with mathematical and experimental skills to address public health issues.

**Grading:** Grad Poly Graded**Repeatable for additional credit:** No**BI-GY 7733 Translational Genomics and Computational Biology (3 Credits)***Typically offered Fall and Spring*

This online course will introduce will expose the students to different aspects of the data analysis and modeling activities that are expected of a Bioinformatician or a Computational Biologist. This course will offer a wide spectrum of examples of applications roughly divided in two broad parts: (a) data analysis in a "translational" settings and (b) more "computational" approaches to Biology pertaining the simulation of biological systems. This course will explore a different set of online resources that contain complex data models of data (e.g., cancer data from TCGA and ICGC); the data thus collected will be used to expose novel model reconstruction tools. Other online resources and related exchange formats will be explored in order to show how simulation of biological systems models (and the related problem of their parameter tuning) in its different forms has become more and more usable and an important tool for biomedicine. Students enroll into this course should have knowledge of basics of programming, undergraduate calculus, probability and statistics, introductory cell biology. | Pre-requisites: BI-GY 7673

**Grading:** Grad Poly Graded**Repeatable for additional credit:** No**Prerequisites:** BI-GY 7673.**BI-GY 7743 Machine Learning and Data Science for Bioinformatics (3 Credits)***Typically offered Fall and Spring*

This online course is aimed at developing practical machine learning and econometric (time series) skills with applications to biological data. The course will use examples from bioinformatics application areas throughout and will emphasize translational aspects.

**Grading:** Grad Poly Graded**Repeatable for additional credit:** No**BI-GY 7753 BIOINFORMATICS GUIDED STUDIES (3 Credits)***Typically offered Fall, Spring, and Summer terms*

This online course is providing students an opportunity to work in a public or private research laboratory outside of NYU Tandon. This may include labs at companies in the private sector or independent research institutes and foundations. Students will have the chance to apply skills (such as Python, R, UNIX) acquired in other online courses in a real-life environment. Students who enroll in this course will work under the advisement of a Tandon Online faculty member. At the end of the course the student has to submit a final report or paper. | Prerequisites: BI-GY 7663, BI-GY 7673 and BI-GY 7653

**Grading:** Grad Poly Graded**Repeatable for additional credit:** Yes

**BI-GY 7843 MOLECULAR MODELING AND SIMULATION (3 Credits)**

This course introduces principles and applications of modern molecular modeling and simulations methods, using commercial software packages on powerful computer workstations. Algorithms for visualizing and predicting structural and physical properties of molecules and molecular aggregates are taught, based on principles of quantum, classical and statistical mechanics, which are in a mathematically simplified form. Commercial software packages are applied to illustrative problems in physical chemistry, chemical engineering, biology and medicine | Prerequisites: Completion of core undergraduate courses in mathematics and science (grade C or better) in CM, CH, ME, EE, CS, PH or CE, or equivalent.

**Grading:** Grad Poly Graded

**Repeatable for additional credit:** No