M.Sc. Programme in Genomics and Bioinformatics (Full-time and Part-time)

School of Biomedical Sciences, Faculty of Medicine, CUHK

<For reference only>

GNBF5010 Introduction to Programming

Course description

This course introduces computer programming to students with no previous programming experience. Students learn the fundamentals of python programming and learn how to design, implement, test, debug, and document programs. They also learn how to solve problems using object-oriented programming methodology. Most of the examples and assignments will be related to biological questions in genomics and bioinformatics.

Learning outcomes

After finishing this course, students should be able to

a. Master key programming concepts such data types, variables, conditions, loops and functions.
b. Understand fundamental concepts in object-oriented programming and pattern matching.
c. Solve small to medium size programming tasks that arise in bioinformatics.
d. Write well-structured and maintainable programs in Python.

Topics

The topics include Introduction to computation and programming; Flow controls: conditional and iteration; Python functions; Files I/O; Lists, tuples and strings; Dictionaries and sets; Program design; algorithm complexity; recursion; Introduction to object-oriented programming; classes and inheritance; Program development with classes; Python packages; Biopython; Regular expressions; Working with databases in Python; UI and Web development in Python.

Assessment scheme

The assessment scheme includes project (15%), assignments (20%), midterm examination (25%) and final examination (40%).

GNBF5020 Introduction to Molecular Biology and Genetics

Course description

This course introduces students to the molecular mechanisms responsible for the transmission, expression and regulation of genetic information in prokaryotic and eukaryotic organisms. Students will also learn the basic concepts of genetics including population genetics, developmental genetics and evolutionary genetics.

Learning outcomes

After finishing this course, students should be able to

a. understand basic concepts in biomolecules and cell biology.
b. know how molecular biology can explain the transmission of genetic information.
c. correlate molecular biology concepts with genetic and phenotypic traits.

Topics

The topics include Introduction to Biomolecules; Basic Cell Biology; DNA and Chromatin Structure; DNA Replication, Repair and Recombination; Control of Gene Expression; Methods in Molecular Biology; Genomic Applications in Biomedical Research; Molecular Genetics of Mendelian Diseases; Molecular Genetics of Complex Diseases; Population Genetics; Evolutionary Genetics.

Assessment scheme

The assessment scheme includes assignments (30%), midterm examination (30%) and final examination (40%).

GNBF5030 Bio-computing and Statistics

Course description

This course covers several computational technologies in bioinformatics. First, students learn the fundamentals of Linux OS and shell and learn how to accustom themselves to the Linux computing environment for routine bioinformatics tasks. Students also learn how to run and install common bioinformatics tools from the command line. In the second half of this course, students learn the basic statistical methods for bioinformatics, and how to use R to conduct statistical tests and create graphs for bioinformatics questions. Hands-on practice is provided throughout the whole course, whereas a comprehensive genomics project enhances students' learning on the technologies above mentioned.

Learning outcomes

After finishing this course, students should be able to

a. accustom themselves to Linux computing environment.
b. acquire the usage of common bioinformatics tools.
c. employ common statistical methods for bioinformatics problems using R.

Topics

The topics include Introduction to Linux computational environment; Working with Linux (I); Common bioinformatics tools (I); Common bioinformatics tools (II); Common bioinformatics tools (III); Common bioinformatics tools (IV); High performance computing; Introduction to programming with R (I); Introduction to programming with R (II); Basic statistical methods for bioinformatics (I); Basic statistical methods for bioinformatics (II); Basic statistical methods for bioinformatics (III); Introduction to machine learning methods for bioinformatics.

Assessment scheme

The assessment scheme includes assignments (30%) and project (15%) and final examination (55%).

GNBF5040 Genomics: Basic Concepts and Applications

Course description

This course introduces the basic concepts of genomics. It covers the structure and organization of human genome, and the strategies that are used to map, sequence and analyse the genomes. Students learn how to make connections between genomic data and the relevant biological questions. They also learn how genomic sequence information is utilized biomedicine including pharmacogenomics, drug discovery, diagnostics and personalized medicine.

Learning outcomes

After finishing this course, students should be able to

a. acquire the basic concept of genomics.
b. learn the principle, strategies and limitations of genomic technology.
c. apply genomics to solve biological and biomedical questions.

Topics

The topics include Introduction to genomics; An overview of large scale genomic projects; Genomic sequencing and data analysis; Genome assembly: a key step towards comprehensive genomic maps; Workshop I; Functional annotation of genomes: gene, mutation, and SNP; Functional annotation of genomes: mutation profiling and cancer diagnosis; Functional annotation of genomes: transcriptional regulation; Functional annotation of genomes: transcriptome analysis; Functional annotation of genomes: noncoding RNA and single cell sequencing; Workshop II; Medical genomics

Assessment scheme

The assessment scheme includes assignments (40%) and final examination (60%).

GNBF5050 Theories and Algorithms in Bioinformatics

Course description

This course introduces the basic concepts underlying the theoretical basis of common bioinformatics algorithms. It covers the topics of sequence alignment, phylogeny, motif finding, assembly, metagenomics and machine learning. Students learn these topics by attending lectures, classroom activities, and getting hands-on experience through assignments.

Learning outcomes

After finishing this course, students should be able to

a. Describe the related biological problems in mathematical terms such that they can be solved by algorithms.
b. Appreciate the computational ideas underlying common bioinformatics algorithms and get familiar with the corresponding software to solve the problems.
c. List and explain the strengths and weaknesses of existing algorithms and interpret their results appropriately.
d. Develop the ability to read and understand scientific publications on bioinformatics in depth.

Topics

The topics include Sequence Alignment and searching (Theory); Sequence Alignment and searching (Application & Practice); Molecular phylogenetics (Theory); Molecular phylogenetics (Application & Practice); Motif finding and hidden Markov model (Theory); Motif finding and hidden Markov model (Application & Practice) Part I; Motif finding and hidden Markov model (Application & Practice) Part II; Mapping of next-generation sequencing data (Theory & Application); Assembly of next-generation sequencing data (Theory & Application); Metagenomics (Theory & Practice); Machine learning in Bioinformatics (Introduction & Practice); Student presentations.

Assessment scheme

The assessment scheme includes in-class exercise (5%), assignments (35%), midterm examination (20%) and final examination (40%).

GNBF5060 Systems Biology

Course description

This course introduces how systems biology combines molecular biology and genomics with physical chemistry and mathematical modeling to analyze and model biological systems. Students will learn a broad range of modeling methods relevant to systems and computational biology and apply them in several practical biological networks such as transcriptional regulatory networks, cell signaling networks, and metabolic networks.

Learning outcomes

After finishing this course, students should be able to

a. explain the importance of studying biological systems as a whole.
b. illustrate common methods of modeling biological systems.
c. simulate system dynamics that respond to input signals.
d. describe the roles and behavior of regulatory network motifs.
e. calculate biological network properties using graph theory.
f. reconstruct regulatory networks using high-throughput data.
g. apply appropriate methods to model and analyze specific biological systems.

Topics

The topics include Introduction to Systems Biology; Computational approaches for systems biology (I); Computational approaches for systems biology (II); Computational approaches for systems biology (III); Transcriptional networks and network motifs (I); Transcriptional networks and network motifs (II); Signal transduction networks; Metabolic networks; Network analysis in systems biology (I); Cytoscape workshop; Network analysis in systems biology (II); Network analysis in systems biology (III); Presentation.

Assessment scheme

The assessment scheme includes assignments (30%), literature discussion and presentation (15%), and final examination (55%).

GNBF5070 Genome Informatics

Course description

This course provides a comprehensive introduction to the field of genome informatics. Students will gain knowledge about various aspects of genomics studies, including reference genome studies, population genomic studies, and applications of genomics. The course covers both the fundamental concepts and the latest advancements in each of these categories. In addition to theoretical lectures, students will have the opportunity to engage in hands-on practice using relevant tools. This practical experience will enhance their understanding of genomics and bioinformatics, allowing them to apply their knowledge effectively.

Learning outcomes

Upon completion of this course, students will have achieved the following learning outcomes,

a. Understand the fundamental principles and pipelines involved in sequencing and genomic studies.
b. Stay updated with the latest advancements and progress in the field of genomic studies.
c. Acquire the skills to analyze second-generation sequencing data.
d. Gain proficiency in utilizing and applying various bioinformatics tools.
e. Develop the ability to independently conduct a genomic study.

Topics

The topics include Overview of genome informatics; Sequencing to obtain genome information; Genome assembly to construct reference genomes; Reference genome based studies; Hands-on study on reference genome assembly; Resequencing to identify genomic variations; Genomic variation based studies; Transcriptome studies; Hands-on study on resequencing analysis; Using genome sequencing as a tool for other research; Using genome sequencing as a tool for applications; Summary of genome informatics.

Assessment scheme

The assessment scheme includes assignments (45%) and final examination (55%).

GNBF6010 Research Project

Course description

Students are required to conduct a research project on a current topic in genomics and bioinformatics under the supervisors in the Chinese University of Hong Kong. This course will give students an insight into how research is carried out in the fields of bioinformatics and omics analysis with selected research techniques and data analysis approaches. It will give students the opportunity to develop and enhance their analytical and organizational skills through hands-on research and the opportunity to develop their ability to work independently. This course will also provide practice in the writing of project reports and the presentation of scientific findings.

Topics

Students are required to conduct a research project on a current topic in genomics and bioinformatics under the supervisors in the Chinese University of Hong Kong. Although there will be no lectures, students are expected to meet with supervisors and complete their research projects according to supervisors' suggestions and give out 15-minute oral presentation in the end of April and submit a research proposal and a final report in the beginning and the end of the Term 2 respectively.

Assessment scheme

The assessment scheme includes research performance (25%), proposal (15%), oral presentation (25%) and final report (35%).