Bioinformatics and Systems Biology (MMD-896)

Credit Hours 3 (3-0)

Course Description

The course aims at providing an introduction to integrative systems biology, an approach that brings together diverse high throughput experiments and databases to gain new insights into biological processes or systems at molecular through physiological levels. These approaches rely on diverse high-throughput experimental techniques that generate heterogeneous data by assaying varying aspects of complex biological processes. The use of important methods in bioinformatics, is integral to study diverse complexities of a biological system. Computational approaches are necessary to provide an integrative view of these experimental results and enable data-driven knowledge discovery.

Bioinformatics is changing as high throughput biological data collection becomes more systems-oriented. The aim of the course is to give the students an introduction from basic to applied bioinformatic methods, including principles from systems biology, making the students capable of applying relevant methods to their research questions and problems.

Educational Objective

- To provide a coherent overview from basic to advance aspects of bioinformatics and integrative systems biology.
- To develop the computational and analytical understanding necessary as a platform for processing biological data.
- To learn the applications and implementation of computational tools, genome databases and software that can benefit students in the life sciences.
- To demonstrate applications and worked examples in the fields of bioinformatics and systems biology, integrating with student involvement through project work.

Course Outcomes

A student who has met the objectives of the course will be able to:

- Describe different high-throughput experimental techniques used in systems biology.
- Understand the function and behavior of frequent regulatory network motifs and use of systematic genome-wide data together with biological networks to evaluate cellular response or other phenomena.
- Design regulatory networks with a defined input/output function.
- Simulate the dynamics of regulatory circuits that respond to signals form the environment
- Determine the properties of kinetic models in biology.

Course Contents

1. Overview of Bioinformatics
2. The Biological Foundations of Bioinformatics
    - Nucleic acids and proteins
    - The storage of genetic information
3. The Global Biological databases
    - Primary databases: Nucleotide and Protein sequences databases
    - Secondary databases: Prosite, PRINTS, Pfam, Interpro
    - Genotype-phenotype databases: PhenomicDB
    - Molecular Structure Databases: Protein data bank, SCOP, CATH, PubChem
4. Basic concepts in systems biology
    - Network Properties of Biological Systems
    - Interactome Networks
    - Gene Regulatory Networks
    - Metabolic networks
    - Regulatory networks
    - Signaling networks
5. Graph Theory Properties of Cellular Networks

6. Boolean Models of Cellular Signaling Networks
7. Transcriptional Network Logic: The Systems Biology of Development
8. Spatial Organization of Subcellular Systems
9. Yeast and *Arabidopsis* as Model for Systems Biology
10. Protein Structures and Structure-Based Rational Drug Design
    - Protein structure, Transmembrane proteins and signal peptides
    - Analysis of Protein structure: Protein modelling, Determination of protein structure by High-through put methods.
11. Structure-Based Rational Drug Design
    - Docking example using DOCK and GOLD
    - Pharmacophore modelling and searches
    - Successes of structure-based rational drug design
12. Chemogenomic Profiling: Understanding the Cellular Response to Drug
13. Integrative Systems Biology: Implications for the Understanding of Human Disease
    - Data generation: Microarrays, Transcriptomics, Genotyping, Other Omic Disciplines
    - Data integration: Semantic Web Technologies
    - Modeling systems
14. Implications for understanding disease
    - Redefining Human Diseases
    - The Transition to Personalized Medicine
15. Applications of Systems Biology to Medicine

Recommended Books

1. Mukhopadhyay, C. S., Choudhary, R. K., & Iquebal, M. A. (2017). *Basic Applied Bioinformatics*. John Wiley & Sons.
2. Alon, U. (2019). *An introduction to systems biology: design principles of biological circuits*. CRC press.

3. Eils, R., & Kriete, A. (2013). *Computational Systems Biology: Chapter 1. Introducing Computational Systems Biology*. Elsevier Inc. Chapters.

Walhout, M., Vidal, M., & Dekker, J. (Eds.). (2012). *Handbook of systems biology: concepts and insights*. Academic Press