DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-15): BIOINFORMATICS & ENVIRONMENT

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
DSE-EVS-15: BIOINFORMATICS & ENVIRONMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Introduce the principles of bioinformatics for environmental research
- Provide with hands-on experience of bioinformatics to analyze biological data for environmental research
- Enable to address the challenges and opportunities of using bioinformatics in environmental science
- Enable students to communicate effectively and professionally about bioinformatics research and its implications for environmental science.

Learning outcomes:

After the course, students will be able to

- Use bioinformatics to analyze biological data for environmental research
- Evaluate the quality of bioinformatics data and use it for environmental science
- Communicate effectively the use of bioinformatics for environmental protection
- Apply problem-solving skills to real-world bioinformatics and environmental research challenges
- Use environmental challenges as novel opportunities by applying bioinformatics for developing sustainable approaches for environmental protection

SYLLABUS OF DSE-EVS-15

Theory (02 Credits: 30 lectures)

UNIT – I Bioinformatics Basics (2 Weeks) (4 lectures)

Definition and Scope of Bioinformatics, Biological Data Types and Sources, Introduction to Computer Science and Mathematics for Bioinformatics, Overview of Bioinformatics Tools and Databases, Sequence Alignment and Assembly Algorithms, Phylogenetic Analysis and Molecular Evolution

UNIT – II Genomics and Transcriptomics (2½ Weeks) (5 lectures)
DNA Sequencing Technologies and Platforms, Genome Sequencing, Assembly, Annotation and Visualization, Comparative Genomics, Gene Expression Transcriptomics Analysis and Interpretation, and Epigenetics Analysis

UNIT – III Proteomics and Metabolomics (3 Weeks) (6 lectures)
Proteomics Technologies and Platforms, Protein Separation and Identification, Mass Spectrometry and Peptide Mapping, Protein-Protein Interactions and Complex Analysis, Metabolomics and Metabolic Pathway Analysis, Metabolite Profiling and Identification, Biomarker Discovery and Validation, Integration of Omics Data and Network Analysis

UNIT – IV Computational Biology and Biostatistics (1½ Weeks) (3 lectures)
Biostatistical Methods and Techniques, Hypothesis Testing and Model Selection, Regression Analysis and Linear Models, Machine Learning and Data Mining, Statistical Analysis of Biological Data

UNIT – V Systems Biology and Network Analysis (2 Weeks) (4 lectures)
Systems Biology Concepts and Approaches, Regulatory Networks and Pathways, Signaling Networks and Cell Communication, Metabolic Networks and Flux Balance Analysis, Network Visualization and Analysis

UNIT – VI Environmental Genomics and Metagenomics (4 Weeks) (8 lectures)
Environmental DNA: sampling, sequencing, and analysis; Metagenomics for: biodiversity assessment, community analysis, understand biogeochemistry, determine ecosystem functioning; and ascertain functional diversity

Bioinformatics Applications in: developing stress-tolerant crops, genomics for animal breeding, improving livestock health, management of aquaculture and fisheries, environmental monitoring, bioremediation, bioprospecting and conservation

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1-4. Familiarize with commonly used bioinformatics tools and databases, such as BLAST, ClustalW, NCBI, and UniProt
5-6. Sequence analysis and alignment of nucleotide and protein sequences and analyze their properties
1. Familarize with basics of genome annotation and comparative genomics using different software and tools
8-9. Analyze metagenomic data, identify and classify microbial communities, and explore their functional properties

10-11. Know dealing with RNA sequencing data for transcriptome analysis and explore gene expression patterns
12-13. Explore protein structure and function using different software and tools or learn basics of identification and quantification of metabolites, and exploration of metabolic pathways
14-15. Learn basic statistical techniques and perform data analysis on biological datasets, such as hypothesis testing and regression analysis,

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Bell, T., & Lilley, A. (2019). Environmental Proteomics: Methods and Protocols. Springer.
- Carvalho, R. (2019). Bioinformatics for Biologists. Wiley.
- Li, R. W. (2018). Environmental Metagenomics: Methods, Protocols, and Applications. Humana Press.
- Xia, X. (2019). Ecological Bioinformatics: The Role of Bioinformatics in Studying Ecology. Academic Press.
- Zhu, D. (2021). Environmental Bioinformatics. CRC Press.

Suggested readings

- Hirsch, A. (Ed.). (2020). Environmental DNA: A Practical Guide to Methods, Applications, and Data Analysis. Wiley.
- Liu, Z. (2020). Bioinformatics in Aquaculture: Principles and Methods. Academic Press.
- Karlovsky, P. (Ed.). (2019). Environmental Metabolomics: Methods and Protocols. Humana Press.
- Huang, X., & Madan, A. (2019). Environmental Bioinformatics. Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.