B.Sc. (Hons./ Hon.with Research) in

BIOINFORMATICS

REGULATIONS AND SYLLABI

(Effective from 2024 onwards)

Department of Bioinformatics

SCHOOL OF LIFE SCIENCES

PONDICHERRY UNIVERSITY

PUDUCHERRY

Pondicherry University
School of Life Sciences
Department of Bioinformatics

B.Sc. (Hons./ Hon.with Research) in Bioinformatics

Program Objectives

The main objective of the program is to train the students to learn an innovative and evolving field of Bioinformatics with a multi-disciplinary approach. Hands-on sessions will be provided to train the students in both computational and experimental labs.

Program Outcomes

On completion of this program, students will be able to:

- Gain understanding of the principles and concepts of both Biology along with Computer Science.
- To use and describe Bioinformatics data, information resource and also to use the software effectively from large databases.
- To know how bioinformatics methods can be used to relate sequence to structure and function.
- To develop problem-solving skills, new algorithms and analysis methods are learnt to address a range of biological questions.

Eligibility B.Sc. (Hons./ Hon.with Research) in Bioinformatics

Successful completion of higher secondary (+2/PUC) certificate or Equivalent stage of education with Physics, Chemistry and Mathematics / Biology / Computer Science

The minimum number of credits required to be earned by students of B.Sc. (Hons with research) in Bioinformatics

Sl.No.	Programme	Credits for Major Courses	Credits for minor Courses	Credits for Interdisciplinary Language Skill development Value added course, Summer Training, Research Project	Minimum credits required for award of degree
1	B.Sc. (Hons with research) in Bioinformatics	80	32	48	160

A candidate who has passed in all the courses and Project Work (if any) and accumulated not less than the minimum number of Credits prescribed shall be eligible to receive the Degree.

PONDICHERRY UNIVERSITY

School Of Life Sciences

Department Of Bioinformatics

LIST OF MAJOR COURSES FOR B.Sc. (Hons with Research) IN BIOINFORMATICS

(Academic Year 2024 onwards)

Course Code	Course Title	Credits
Semester I		
BINEP 101	Plant Science	4
	Total Credits	**4**
Semester II		
BINEP 102	Animal Science	4
	Total Credits	**4**
Semester III		
BINEP 131	Physical Sciences	4
BINEP 132	Biomolecules and Biological Databases	4
	Total Credits	**8**
Semester IV		
BINEP 141	Databases system	4
BINEP 142	Mathematical Sciences	4
BINEP 143	Programming Languages C & C++	4
	Total Credits	**12**
Semester V		
BINEP 151	Genomics & Proteomics	4
BINEP 152	Bio-sequence Analysis	4
BINEP 153	Fundamental of Molecular Biology	4
BINEP 154	Next Generation Sequencing	4
	Total Credits	**16**
Semester VI		
BINEP 161	Algorithm	4
BINEP 162	Systems Biology	4
BINEP 163	Structural Biology	4
BINEP 164	Python programming	4
	Total Credits	**16**
Semester VII		
BINEP 171	Molecular Modelling, Mechanics and simulations	4
BINEP 172	Data Science & Machine Learning	4
BINEP 173	Computer Aided drug design: Fundamentals & applications	4
BINEP 174	Bioethics & Research Methodology	4
	Total Credits	**16**
Semester VIII		
BINEP 181	Next Generation Sequencing Technology	4
	Total Credits	**4**
		80

PONDICHERRY UNIVERSITY

School of Life Sciences

Dept. Of Bioinformatics

LIST OF MINOR COURSES

(Academic Year 2024-2025 onwards)

Course Code	Course Title	Credits
Semester I		
BINEP-210	Introduction to Bioinformatics for Biologist	4
Semester II		
BINEP-220	Introduction to Computer	4
Semester III		
BINEP-230	Introduction to Bioinformatics for biologist	4
BINEP-231	Statistical Computing for Biological data	4
Semester IV		
BINEP-240	Plant Functional OMICS	4
Semester V		
BINEP-250	Unix and Microbial Genome Informatics	4
Semester VI		
BINEP-260	Spectroscopy in Biology	4
BINEP-261	Immuno-informatics	4
Semester VII		
BINEP-270	Microscopic Technique for Biological Samples	4
BINEP-271	Genetic Engineering & Applications	4
BINEP-272	Comparative genomics	4
Semester VIII		
BINEP-280	Drug Design, Discovery and Development	4

PONDICHERRY UNIVERSITY

School of Life Sciences

Dept. Of Bioinformatics

LIST OF MULTIDISCIPILNARY COURSES

(Academic Year 2024-2025 onwards)

Course Code	Course Title	Credits
Semester I		
BINEP-310	Concepts in Programming languages	3
Semester II		
BINEP-320	Introduction to Bioinformatics for non-biologist	3
Semester III		
BINEP-330	Fundamentals of Bioinformatics for non-biologist	3

PONDICHERRY UNIVERSITY

School of Life Sciences

Dept. Of Bioinformatics

LIST OF SKILL DEVELOPMENT COURSES

(Academic Year 2024-2025 onwards)

Course Code	Course Title	Credits
Semester I		
BINEP-410	Good laboratory practice	3
Semester II		
BINEP-420	Analytical Techniques	3
Semester III		
BINEP-430	Biophysical Techniques	3
BINEP-431	Introduction to R language	3

SEM-I

Major course-I

BINEP 101 – Plant Science

COURSE OBJECTIVES: Students will understand the evidences explaining the descendance of life forms, nomenclature rules and systemic classification. Help them understand the inheritance pattern and practical methodology for applying the mendelian genetics along with effect of mutation and crossing over influencing the process of linkage in determining the sexes and heritable diseases.

Total Credits: 4 Total: 60 Hrs.

Unit 1 10 hrs

Classification of the living organisms: Classification of organisms- Linnaeus and Whittaker's Five Kingdom classification. Systematic and binomial System of nomenclature. Salient features of animal (non-chordates up to phylum level and chordates up to class level) and plant (major groups; Angiosperms up to class level).

Unit 2 10 hrs

Structural organization of living forms: Morphology and anatomy of flowering plants; Anatomical arrangements of various organ systems- Skin structure and function, Digestive system, Respiratory system, Urinary and Reproductive system, Neuro and muscular system, Cardiovascular and lymphatic system. . Different types of cellular tissues-epithelium, connective tissue and extracellular matrix. Morphology and anatomy of monocot and dicot root, stem, leaf, inflorescence, flower, fruit and seeds

Unit 3 10 hrs

Cell biology and Physiology: Structure and functions of plant and animal cells- mitochondria, endoplasmic reticulum, ribosomes, Golgi, lysosomes, vacuoles, peroxisomes, and nucleus. Role of cell membranes in transport of water and minerals, food translocation and storage.

Unit 4 10 hrs

Developmental Biology: Basic concepts of development, gametogenesis, fertilization and early development, morphogenesis and organogenesis in animals and plants, programmed cell death, aging and senescence.

Unit 5 10 hrs

Genetics: Mendelian principles- Dominance, segregation, independent assortment; deviations from Mendelian ratio (gene interaction- incomplete dominance, co-dominance, multiple alleles). Sex determination in human beings: XX, XY; Linkage and crossing over (role of mutagens in chromosomal disorders with emphasis to human beings).

Unit 6 10 hrs

Ecology & Evolution: Habitat and niche, population growth curves, Ecosystems stability and species interactions; conservation methods (both in situ and ex situ); Origin of life, theories and evidences; Genetic drift, co-evolution, co-operation, speciation and Extinction.

Text Books:

1. Life: The Science of Biology, 10th Edition by David E. Sadava, David M. Hillis, H. Craig Heller and May Berenbaum-2012.
2. Comparative anatomy of vertebrates- S.K. Kulshrestha- Anmol Publications Pvt. Ltd, New Delhi.1999
3. Christopher D. Moyes and Patricia M. Schulte, Principles of Animal Physiology Pearson Press, 2007
4. Strachan T and Read A, Human Molecular Genetics. Garland Science, CRC Press, Florida, 2018
5. EkambaranathaAyyar and Ananthakrishnan TN.(1993).Manual of Zoology Vol – II, S. Viswanathan Pvt. Ltd. Chennai.
6. Futuyma, Douglas J. and Kirkpatrick, Mark (2017). "Evolutionary Biology". Evolution (Fourth ed.). Sunderland, Massachusetts: Sinauer Associates, Inc 18

Reference Books:

1. The Economy of Nature by Robert E. Ricklefs and Rick Relyea. Publisher- W. H. Freeman 6 th ed, 2008. 2. Genetics: A Conceptual Approach 6th ed by Benjamin A. Pierce-2017
2. Schoener, Thomas W. (2009). "Ecological Niche". In Simon A. Levin. The Princeton Guide to Ecology. Princeton: Princeton University Press
3. Lynch, Michael (May 15, 2007). "The frailty of adaptive hypotheses for the origins of organismal complexity". Proc. Natl. Acad. Sci. U.S.A. 104 (Suppl. 1): 8597–8604.
4. Zimmer, Carl (January 7, 2016). "Genetic Flip Helped Organisms Go From One Cell to Many". The New York Times. New York.

COURSE OUTCOME: The students will be able to explain the basics of biology, classification of the living organisms, nomenclature, Morphology and anatomy of different Biological systems existing on earth and also principles of genetics and evolution.

BINEP-210: Introduction to Bioinformatics for Biologist

Total hours: 75 hrs (3 credits for teaching and 1 credit for practical)

COURSE OBJECTIVES: *The main objective of this minor course is to introduce general concepts of Bioinformatics to the allied department students of Pondicherry University.*

Total Credits: 4 **Total: 75 Hrs.**

Unit 1 **9 hr**

Introduction: Aim and branches of Bioinformatics, Application of Bioinformatics, Role of internet and www in bioinformatics. Basic biomolecular concepts: Protein and amino acid, DNA & RNA, Sequence, structure and function. Forms of biological information, Types of Nucleotide Sequence:

Unit 2 **9 hr**

Bioinformatics Resources: NCBI, EBI, ExPASy, RCSB, DDBJ: The knowledge of databases and bioinformatics tools available at these resources, organization of databases: data contents, purpose and utility. **Open access bibliographic resources and literature databases:** PubMed, BioMed Central, Public Library of Sciences (PloS), CiteXplore.

Unit 3 **9 hr**

Sequence databases: Nucleic acid sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; **Structure Databases**: PDB, Alphafold, PubChem, ChemBank. **Sequence file formats:** Various file formats for bio-molecular sequences: GenBank, FASTA, MSF etc. **Protein and nucleic acid properties:** Proteomics tools at the ExPASy server and EMBOSS, Computation of various parameters.

Unit 4 **9 hr**

Sequence Analysis: Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues **Scoring matrices:** basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles.

Unit 5 **9 hr**

Sequence alignment: Measurement of sequence similarity; Similarity and homology. **Pairwise sequence alignment:** Basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and protein sequences and interpretation of results.

Unit 6 **30 hr**

Practical: Entrez and Literature Searches: (Pubmed, Pubmed central OMIM/OMIA and Citation macher). SRS of Biological Databases (Nucleotide/ Genome data bases, Protein Sequence Databases, Structure databases and protein pattern databases.)File Format conversion(FmtSeq, ReadSeq) Sequence analysis Dot plot, Pairwise alignment, Multiple sequence alignment. Software, GeneDoc Clustalw MEME. Visualization Tool. (Rasmol PyMol)

COURSE OUTCOME: Students will be trained how to use the bioinformatics databases and tools.

Text Books:

1. Bioinformatics by Jonathan Pevsner Indian Adaptation. Wiley 2023
2. Bioinformatics: Sequence and Genome Analysis by Mount D., Cold Spring Harbor Laboratory Press, New York. 2004
3. Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellellette, B.F., Wiley India Pvt Ltd. 2009

Multidisciplinary Course-1

BINEP-310: Concepts in Programming Languages

COURSE OBJECTIVES: *To introduce the computer programming concepts to students. This course suits for students with non-computer background*

Total Credits: 3 **Total: 45hrs**

Unit 1 **10h**

Basics of Computing principles: Concepts of Input and Output – Input devices – Output devices – Number systems – Binary, Octal, and hexadecimal systems – Boolean algebra (AND, OR, NOT and EXOR operations) – DeMorgan's theorem.

Unit 2 **10h**

Operating Systems: Concept of operating system – DOS, UNIX and LINUX – Types of processing – multiprogramming, multitasking, and multithread processing, Shell programming.

Unit 3 **5h**

Problem Solving Techniques: Basics of problem-solving techniques – Understanding the problem – Algorithm – Flowchart – coding.

Unit 4 **10h**

Classification of computer languages: Human and computer languages – Machine level language – Assembly level language – High level language – Assembler and compiler – compilation – basic principles of coding – Testing of a program – debugging – syntax and semantic errors.

Unit 5 **10h**

Concepts in computer programming: Role of decision making – illustration of 'if' – Concept of loops – importance of loops in programming – arrays and stacks – file handling – interface with internet.

Text Book:

1. Fundamentals of Computers, Second Edition (2019) by Reema Thareja, Oxford University Press.

Reference Book:

1. Operating System Concept, Ninth Edition (2018) by Abraham Silberschatz and Peter B. Galvin, Wiley.

COURSE OUTCOME: *The students will possess basic knowledge about programming languages. On successful completion of the course, the student will be able to self-learn most of the programming languages.*

Skill Development Courses-I

BINEP-410: Good Laboratory Practice

Total credit: 03 **Total: 45hrs**

Course objectives: The course is designed to impart essential and regulatory procedures of experimental and computational laboratories for the students from various disciplines. It aims to equip students with biosafety strategies and various bio-software.

- Regulatory Procedures:
- National and International regulations
- Regulations for recombinant DNA research
- Bio-safety emphasis on molecular and recombinant DNA techniques - Cloning Strategies and Tissue culture procedures for plant cells, animal and stem cells - Transgenic plants, animals, genetically modified organisms
- Software installation and un-installation
- Disk storage and formatting
- File handling in different operating system
- Linux Conda environment
- Cyber Forensics
- Data Handling in Cloud
- Data sharing and Confidentiality
- 3D-Visulization of biomolecules and molecular networks

References:

1. David A. Patterson and John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, 4th Edition, Elsevier, 2012.
2. Carl Hamacher, ZvonkoVranesic, SafwatZaky, NaraigManjikian, Computer Organization and Embedded Systems, McGraw-Hill Publishing, 2011
3. William Stallings, Computer Organization and Architecture: Designing for Performance, 8th Edition,Prentice Hall, 2006.

Course outcome: Students will be familiarized with international and national regulations of research and biosafety procedures.

SEM-II

Minor course-II

BINEP-220- Introduction to Computer

Total hours:75hrs (3 credits for tutorial 3X 15hrs and 1 credit for practical 15X2hrs= 45+30hrs)

Credits: 04

Course Objectives:

The course objectives are to make the student understand basics of computer, concepts of network system, system software, different operating system and computer applications in biological and medical sciences. This course also aims to equip students with fundamental of DOS commands, Linux file system, booting process, MS packages and familiarize with few computational tools and software.

Unit-1: 7h

Computer Organization: Evolution of Computers, Generation of Computers, Types of Computers: Analog Digital and Hybrid Computers, Classification of Computers. Limitation and Characteristics of Computers, Block Diagram of a Digital Computer, Computer number systems.

Unit 2: 8h

Internet and network Basics: Concept of internet, Applications of Internet, Web Technology, browsing software, Search Engines; Understanding URL; Domain name; IP Address, Introduction to Server and Client technology. Overview of computer networks: LAN and WAN, Networking Elements and services. Cyber Forensics.

Unit-3: 10h

System Software and computer Languages: Overview of System software, Software application, Different Types of System Software, operating system and its Types. Introduction to application software, Difference between Program and Packages. Generations of computer languages, types of computer Languages, Compiler and interpreter. Programming constructs, overview of Algorithm & flowchart.

Unit-4: 10h

Introduction to MS DOS and Unix shell: Introduction to MS DOS: Booting Process (DOS, Windows, Unix), Essential External DOS Commands. Overview of The UNIX Operating System, UNIX File System and File Handling, Introduction to Shell commands, Commands to maintain File attributes.

Unit-5: 10h

Applications of Computer: Computers in biological and medical Sciences: 3D visualization of molecules and biological network.

Unit-6: 30h

Practical- Computer Peripherals, Storage Devices, Booting Process (Windows, Unix), Elementary External DOS Commands, creating a Batch Files, copying and moving files and folders. Linux File System and Text Editing, File content manipulation, Introduction to environment variables and sample software installation, MS Office.

Text Books:

1. P. K. Sinha and P. Sinha (2002), "Foundations of Computing", First Edition, BPB Publication.
2. Dharmendra B. Kadia. 2010. Basic Knowledge of Computer. 1st Edition.
3. Peek Jerry. 2002. Learning the UNIX Operating System. O'Reilly Media, Inc, USA. ISBN: 9780596002619, 0596002610.

Reference books:

1. V. Rajaraman and Neeharika Adabala. 2015. Fundamentals of Computers. 6th Edition, PHI Learning Pvt. Ltd.
2. Tanenbaum, Computer Networks, Pearson Education, 5th Edition, 2013.David
3. A. Patterson and John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, 4th Edition, Elsevier, 2012.
4. Russell, S. and Norvig, P. Artificial Intelligence - A Modern Approach, 3rd edition, Prentice Hall.,2015

Course Outcome:

- Familiarity with computer hard ware and software system their importance in present world.
- The ability to explore the various computer components, operating systems, basic Linux commands and computing systems.
- The ability to learn and apply their knowledge of computers skill which is mandatory for bioinformatics.
- Utilize various computer application for multidisciplinary study.

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Multidisciplinary Course-II

BINEP-320: Introduction to Bioinformatics for Non-Biologist

COURSE OBJECTIVES: *The main objective of this minor course is to introduce general concepts of Bioinformatics to the allied department students of Pondicherry University.*

Total Credits: 3 **Total hours:45hrs**

Unit 1 **9h**

Introduction: Aim and branches of Bioinformatics, Application of Bioinformatics, Role of internet and www in bioinformatics. Basic biomolecular concepts: Protein and amino acid, DNA & RNA, Sequence, structure and function. Forms of biological information, Types of Nucleotide Sequence: Genomic DNA, Complementary DNA (cDNA), Recombinant DNA (rDNA), Expressed sequence tags (ESTs), Genomic survey sequences (GSSs). DNA sequencing methods: Basic and Automated DNA sequencing, DNA sequencing by capillary array and electrophoresis, Gene expression data.

Unit 2 **9h**

Bioinformatics Resources: NCBI, EBI, ExPASy, RCSB, DDBJ: The knowledge of databases and bioinformatics tools available at these resources, organization of databases: data contents, purpose and utility. **Open access bibliographic resources and literature databases:** PubMed, BioMed Central, Public Library of Sciences (PloS), CiteXplore.

Unit 3 **9h**

Sequence databases: Nucleic acid sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: Uniprot-KB: SWISS-PROT, TrEMBL, UniParc; **Structure Databases**: PDB, NDB, PubChem, ChemBank. **Sequence file formats:** Various file formats for bio-molecular sequences: GenBank, FASTA, GCG, MSF etc. **Protein and nucleic acid properties:** Proteomics tools at the ExPASy server, GCG utilities and EMBOSS, Computation of various parameters.

Unit 4 **9h**

Sequence Analysis: Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues and xenologues **Scoring matrices:** basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles.

Unit 5 **9h**

Sequence alignment: Measurement of sequence similarity; Similarity and homology.

Pairwise sequence alignment: Basic concepts of sequence alignment, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and protein sequences and interpretation of results.

Text Books:

1 Bioinformatics: Sequence and Genome Analysis by Mount D., Cold Spring Harbor Laboratory Press, New York. 2004

2. Bioinformatics- a Practical Guide to the Analysis of Genes and Proteins by Baxevanis, A.D. and Francis Ouellellette, B.F., Wiley India Pvt Ltd. 2009

Course Outcome: Students will understand the information available in Bioinformatics databases and their applications in research.

Skill development-II

BINEP-420: Analytical Techniques

3+1 Credit **Total hours: 60hr**

COURSE OBJECTIVES: *To understand the principles of physical sciences that form the basis of the techniques and instrumentation used in research field*.

Unit -1 **5h**

Buffers and their Preparations: Principle and procedure for buffers with examples of acetic acid-sodium acetate buffer and Phosphate buffer; pH meter principles, types of electrodes with their advantages and disadvantages, types of pH calibrations.

Unit-2 Cell disruption & Fractionation **5h**

Mechanical methods- bead mill, ultra sound, French press and high-pressure homogenizer; non-mechanical physical methods- thermolysis, decompression, osmotic shock; non-mechanical chemical and enzymatic methods- detergents, solvents and enzymes.

Unit-3 Centrifugation **5h**

Principle- sedimentation and filtration process; Types of centrifugation techniques- Density gradient centrifugation, Rate zonal centrifugation, Isopycnic or sedimentation equilibrium centrifugation, Differential centrifugation and Ultracentrifugation; Applications of Centrifugation.

Unit 4 **7h**

Chromatography: and spec, Principles, methodology and applications of chromatography using paper, thin layer, column (gel filtration, ion exchange, and affinity), gas and types of HPLC.

Unit -5 **8h**

Electrophoresis: Theory and types; moving boundary electrophoresis, zone electrophoresis, paper, cellulose acetate gel electrophoresis, Native PAGE, disc PAGE, Gradient PAGE, SDS PAGE, DNA agarose gel electrophoresis. Isoelectric focusing, Pulsed - field Electrophoresis, Capillary Electrophoresis.

Unit 6 **30h**

Practical: Preparation of solutions, buffers, and their standardization using pHmeter; procedures for cell ruptures and separation using high pressure homogenizers/ sonicators; separation of cell and their organelles by centrifugation and resolving through paper chromatography; nucleic acids /proteins separation by electrophoresis and blotting (demo).

Reference:

1. Jain, A., Jain, R., Jain, S. (2020). Preparation of Buffer Solution and Measurement of pH. In: Basic Techniques in Biochemistry, Microbiology and Molecular Biology. Springer Protocols Handbooks. Humana, New York, NY.
2. Harrison, S.T. L. (2011) Cell distruption. In: M. Moo-Young (Ed. in chief), Comprehensive Biotechnology, Volume 2, (2nd ed.) (pp. 619–639). Oxford: Elsevier.
3. Alberts B, Johnson A, Lewis J, Raff M, Roberts. Fractionation of Cells. Mol Biol Cell. New York: Garland Science. 4th Edi. 2002.
4. Boruah, Tridip. (2019). How to prepare different types of buffer solutions- An overview.

5. Tanford C, Reynolds J. Nature's robots: A history of proteins. Oxford University Press. 2001:303-305
6. Katoch, R. (2011). Cell Disruption and Fractionation. In: Analytical Techniques in Biochemistry and Molecular Biology. Springer, New York, NY.

Reading materials:

1. Brakke A, Myron K. Density Gradient Centrifugation: A new separation technique. J Am Chem Soc.
2. Oster G, Yamamoto M. Density Gradient Techniques. Chem Rev. 1963: 63(3):257-268.
3. Anders B (2022) Principle, Applications and Types of Centrifugation. J Mass Spectrom Purif Tech. 8:155
4. Middelberg A., (1995) Process-scale disruption of microorganisms; Biotechnology Advances, Vol. 13, No. 3, pp. 491-551; doi: 0734-9750(95)02007-P

Course Outcome: the learners will be familiarized with the basic instruments need to be explored for the experiments and would skill them with the buffer preparations etc.