KANNUR UNIVERSITY

(Abstract)

M.Sc Computational Biology Programme at Dept.of Biotechnology & Microbiology, Dr Janaki Ammal Campus, Palayad - Revised Scheme & Syllabus - Approved- Implemented w.e f 2023 admission- Orders Issued

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ACADEMIC C SECTION

ACAD C/ACAD C3/25199/2023 Dated: 15.12.2023

Read:-1. UO No ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
2. Circular No dated ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
3. Email dated 22/11/2023 from the Head, Dept.of Biotechnology & Microbiology, Dr Janaki Ammal Campus, Palayad
4. Minutes of the meeting of the Department Council dated 20/11/2023

ORDER

1.The revised Regulations for Post Graduate Programmes under Choice Based Credit and Semester System in the University Teaching Departments/ Schools were implemented w.e.f 2023 admissions vide paper read 1 above

2. As per paper read 2 above, Heads of all Teaching Departments were requested to submit the revised Syllabus in accordance with the approved Regulations along with a copy of the Department Council Minutes.

3. As per paper read 3 above, the Head, Dept. of Biotechnology & Microbiology, Dr Janaki Ammal Campus, Palayad submitted the Scheme and Syllabus of M.Sc Computational Biology Programme to be implemented in the University Teaching Department w.e.f 2023 admissions.

4. Department Council vide the paper read 4 above approved the aforementioned scheme and syllabus of M.Sc Computational Biology Programme to be implemented in the Dept. of Biotechnology & Microbiology, Dr Janaki Ammal Campus, Palayad of the University w.e.f.2023 admission.

5. The Vice Chancellor, after considering the matter in detail and in exercise of the powers of the Academic Council conferred under section 11(1), Chapter lll of Kannur University Act 1996, ***approved the revised Scheme & Syllabus of M.Sc Computational Biology Programme and accorded sanction to implement the same in the Dept.of Biotechnology & Microbiology, Dr Janaki Ammal Campus, Palayad with effect from 2023 admission, subject to reporting to the Academic Council.***

6.The revised Scheme and Syllabus of M.Sc Computational Biology Programme under CBCSS implemented in the Dept.of Biotechnology & Microbiology, Dr Janaki Ammal Campus, Palayad with effect from 2023 admission, is appended and uploaded in the University website (www.kannuruniversity.ac.in)

7. Orders are issued accordingly.

Sd/-
Narayanadas K
DEPUTY REGISTRAR (ACAD)
For REGISTRAR

To: 1. Head, Dept.of Biotechnology & Microbiology, Dr Janaki Ammal Campus, Palayad
2. Convenor, Curriculum Committee

Copy To: 1.PS to VC/ PA to PVC/ PA to R
2. Examination Branch (through PA to CE)
3. EP IV/ EXC I
4. Computer Programmer
5. Webmanager (to publish in the website)
6. SF/DF/FC

Forwarded / By Order
SECTION OFFICER

SCHEME AND SYLLABUS

M Sc COMPUTATIONAL BIOLOGY

2023 ADMISSION ONWARDS

DEPARTMENT OF BIOTECHNOLOGY AND MICROBIOLOGY

KANNUR UNIVERSITY

Scheme and Syllabus of M Sc Computational Biology Programme Under the Choice Based Credit Semester System with effect from 2023 Admission

About the Department

The Department of Biotechnology and Microbiology of Kannur University established in the year 2000 at Palayad, Thalassery offers M.Sc., Ph.D. and Post-doctoral programs in Biotechnology, Microbiology and Computational Biology. The Department is a Centre of Excellence in Biosciences, receiving research funds from state, national and international agencies. Our vision is to improve quality of life through research and molding future scientists and individuals who will be a workforce to make a better tomorrow.

MSc Programmes offered by the Department

M.Sc. Biotechnology	- 13 Seats
M.Sc. Microbiology	- 13 Seats
M.Sc. Computational Biology	- 12 Seats

Duration and other details of the programme

- Duration of the programme is 2 years
- The whole program is divided into four semesters (2 years)

Eligibility for the admission to M Sc Computational Biology Programme

1. The student is required to obtain at least 50% in his/her Bachelor's programme with not less than 50% marks in aggregate (excluding languages).
2. Bachelor’s degree in any branch of science/technology/medicine (with degrees such as BSc, BE, BTech, BPharm, MBBS, BDS, BVSc and BAMS)
3. The eligible subject areas include: Life sciences (Botany, Zoology, Genetics, Human Biology, General life sciences, Ecology, Environmental biology), Bioinformatics, Microbiology, Biotechnology, Chemistry, Physics, Mathematics, Computer science/Information technology, Statistics, any branch of engineering, Pharmaceutical sciences, Agriculture, Medicine, Dentistry, Horticulture, Forestry, and Veterinary sciences.
4. Those who are awaiting final year results of their bachelor’s degree also can apply, but they must fulfill the eligibility criteria before the admission.

5. Eligible relaxation in the percentage of marks will be given to candidates belonging to SC and ST.
6. Reservation policies of the University/State are followed for admission.

Admission procedure

Admissions are notified in national newspapers inviting applications for the M.Sc. programme offered by the Department.

All the eligible applicants must appear for a written entrance test. Questions will be focused on the fundamentals of biology, chemistry, physics, mathematics, and computer science, with equal weightage (20%) for each subject area. A rank list will be prepared based on the entrance test. The admission will be as per the rank in the list and reservation policies of the University/State.

M Sc Curriculum

The curriculum of the MSc Computational Biology programme offered by the Department closely follows the level and extent as conceived by the National Curricula Development Centers of UGC/DBT. The Choice Based Credit Semester System (CBCSS) provides an opportunity for the students to choose courses from the prescribed courses comprising core and elective courses. The evaluation of the courses will be through Continuous Evaluation (CE) and End Semester Examination (ESE). Grading system is followed to show the performances of the students in each course and Cumulative Grade Point Average (CGPA) is used to indicate the overall performance in the programme.

COURSES AND CREDITS

Definitions:

I. '**Academic Programme'** means the entire course of study including its programme structure, details of the course, evaluation methods etc. This will be carried out by teaching and evaluation process in the parent department / centre or jointly under more than one such Department/ Centre.
II. **'Course'** means is a subject that is part of an Academic Programme
III. **'Programme Structure'** includes the list of courses (Core, Elective, Open Elective) that forms an Academic Programme, which specifies the syllabus, credits, hours of teaching, evaluation process and examination schemes, the minimum credits required for successful completion of

the programme etc. prepared in conformity to University Rules and eligibility criteria for admission.

IV. **'Discipline Specific Core Course'** means a course that a student admitted to a particular programme must successfully complete compulsorily to receive the degree and that which cannot be substituted by any other course.

V. **'Discipline Specific Elective Course'** means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre.

VI. '**Value Addition Course'** means an elective course which is available from recognized online resources like Swayam/ MOOCS or offered by other departments within the frame work of the subject.

VII. **'Credit'** is the value assigned to a course which indicates the level of instruction; 1 lecture per week equals 1 Credit, 1 session (2 - 3 hours) of practical class per week equals 1 credit.

VIII. '**SGPA'** means Grade Point Average of the semester calculated for individual semester.

IX. **'CGPA'** is Cumulative Grade Points Average calculated for all courses completed by the students at the end of the programme. A formula for conversion of CGPA into percentage marks will be given in the mark sheet.

A minimum of 84 credits are mandatory for the successful completion of the programme. The detailed course / credit distribution among the semesters are given in the following pages. If the student does not earn the required credits by not appearing for the exam or due to other reasons, the course will have to be repeated along with the concurrent semester of the next batch after the approval by the Department Council.

PROJECT WORK

Students have to take up a research project of 5 months duration in the fourth semester for which they are encouraged to go to national research institutes. The students may also get opportunity to undergo 1-2 weeks training in industrial / research institutions in the field of applied biology.

EVALUATION

There shall be two modes of evaluation in all the semesters - Continuous Evaluation (CE) and End Semester Evaluation (ESE). For each course, the weightages for CE and ESE will be in the ratio 40:60.

Continuous Evaluation (CE): Continuous evaluation includes assignments, seminars, periodic written

examinations etc. for each course. Weightages for each component under continuous evaluation of theory and practical courses shall be as given below:

Theory		Practical	
Components	**% of weightage**	**Components**	**% of weightage**
Test papers	40%	Tests/viva	75%
Seminar presentations	40%	Record	25%
Assignment	20%	-	-

End Semester Evaluation (ESE): The ESE shall be made based on examinations for each course at the end of each semester conducted by Controller of Examinations, as per the rules and regulations of the CBCSS of the PG programme framed by the University. End Semester Evaluation of Theory courses shall be done by a written examination of 3 hour duration with Weightage 60. The question paper for the examination of Theory courses for the ESE shall contain three sections, each under different categories of revised Bloom's Taxonomy. The number of questions and its weightages shall be in a format given in the below table.

Section	**weightage**	**Number of questions to be answered**	**Number of questions in the question paper**	**Revised Bloom's Taxonomy level**
A	15	5 (3 weightage each)	6	L1- Remembering, L2 -Understanding
B	15	3 (5 weightage each)	5	L6 - Creating
C	30	3 (10 weightage each)	5	L3-Applying, L4 - Analyzing, L5 - Evaluating
Total	**60**	**11**	**16**	

For practical courses, the number of questions and its weightages shall be decided by the examiner at the time of examination depending on the nature of the course.

Evaluation of project work

The weightages for CE and ESE for Project /Dissertation work will be in the ratio of 40:60, with a total weightage of 100. The continuous evaluation of the project work shall be done by the research supervisor based on the performance of the student in the lab.

End semester evaluation of the project work shall be done by a board of examiners consisting of two experts (at least one external). Each candidate has to submit a copy of the Project Report approved by the project supervisor before the last date fixed by the department. The candidate has to present the project before the board of examiners which will be followed by a viva voce. The ESE of the project will be based on the dissertation (weightage 20), its presentation (weightage 20) and viva voce (weightage 20).

ATTENDANCE

The minimum attendance required for each course in a semester shall be 60% of the total number of classes conducted for the course. Only those who secure the minimum attendance requirement in the semester will be allowed to register for the End Semester Examination.

TENURE

A student must complete the entire program within four years from the date of registration.

Program Specific Outcomes (PSOs):

On successful completion of the M.Sc. Computational Biology program the students will be able to

PSO1: Explain the structure, function and regulation of different cells.

PSO2: Explain the function of genes, heredity, flow of genetic information.

PSO3: Create and manage databases.

PSO4: Analyze large biological data sets.

PSO5: Proficiency in Computational Genomics and Proteomics data analysis using various tools relevant to Computational Biology.

PSO6: Conceptual understanding of systems biology that integrates parameter.

PSO7: Estimation, dynamic and constraint-based modelling of biological networks in the system.

PSO8: Concepts and skills in molecular biology to understand the biological process at the molecular level essential for Computational Biology

PSO9: Equip with the knowledge and skills required to apply genetic engineering techniques to a range of applications.

PSO10: Understand Mathematical concepts and apply skills relevant to Computational Biology.

PSO11: Develop skills to analyse bio sequence data.

PSO12: Gain practical knowledge for website design.

PSO13: Get programming language knowledge for industry.

PSO14: Knowledge in the field of machine learning.

Courses offered in the M.Sc. Computational Biology Programme
Total credits - 84

Semester I

Courses: DSC -6 (Theory -3, Practical - 3), DSE - 3
(*Students must choose 3 out of 4 DSE*)
Credits: DSC - 13, DSE - 9, Total = 22

Sl. No	Course Code	Title of the course	Contact hours /week			Weightage			Credits
			L	T/S	P	ESE	CE	Total	
Discipline Specific Core (DSC)									
1	MSCPB01DSC01	Fundamentals of Cell Biology and Genetics	3	2		60	40	100	3
2	MSCPB01DSC02	Basics of Computing and Java Programming	3	2		60	40	100	3
3	MSCPB01DSC03	Biological Database Management Systems	3	2		60	40	100	3
4	MSCPB01DSC04	Practical 1: Cell Biology and Genetics			2	60	40	100	1
5	MSCPB01DSC05	Practical 2: Programming lab I – Basic Computing and Java Programming			4	60	40	100	2
6	MSCPB01DSC06	Practical 3: Biological Database Management Systems			2	60	40	100	1
Discipline Specific Elective (DSE) (3/4)									
7	MSCPB01DSE01	Biochemistry[#1]	3	2		60	40	100	3
8	MSCPB01DSE02	Mathematics for Biology[#2]	3	2		60	40	100	3
9	MSCPB01DSE03	Biostatistics	3	2		60	40	100	3
10	MSCPB01DSE04	Biophysical Techniques	3	2		60	40	100	3
		Total Credits Required							**22**

[#1]Students with no life science background are expected to choose this as one of electives

[#2]Students with no mathematical/physical science background are expected to choose this as one of the electives

Semester II

Courses: DSC -6 (Theory - 3, Practical - 3), DSE -1, AEC - 2
(*Students must choose 1 out of 3 DSE*)
Credits: DSC - 15, DSE -3, AEC – 4, Total = 22

Sl. No	Course Code	Title of the course	Contact hours /week			Weightage			Credits
			L	T/S	P	ESE	CE	Total	
Discipline Specific Core (DSC)									
11	MSCPB02DSC07	Computational Genomics and Proteomics	3	2		60	40	100	3
12	MSCPB02DSC08	Python Programming	3	2		60	40	100	3
13	MSCPB02DSC09	R Programming	3	2		60	40	100	3
14	MSCPB02DSC10	Practical 4: Computational Genomics and Proteomics			4	60	40	100	2
15	MSCPB02DSC11	Practical 5: Programming lab II- Python Programming			4	60	40	100	2
16	MSCPB02DSC12	Practical 6: Programming lab III- R Programming			4	60	40	100	2
Discipline Specific Elective (DSE) (1/3)									
17	MSCPB02DSE05	Biophysics	3	2		60	40	100	3
18	MSCPB02DSE06	Fundamentals of Molecular Biology and Recombinant DNA Technology	3	2		60	40	100	3
19	MSCPB02DSE07	Food Microbiology	3	2		60	40	100	3
Ability Enhancement Course (For students from other departments)									
20	MSCPB02AEC01	Introduction to Biological Databases	3	2		60	40	100	2
21	MSCPB02AEC02	Bioethics and Biosafety	3	2		60	40	100	2
		Course offered by other departments	2			60	40	100	2
		Course offered by other departments	2			60	40	100	2
Value Addition Course (An approved **MOOC** course may be opted instead of Value Addition Course)									
22	MSCPB02VAC01	Science Writing and Communication	2	2		60	40	100	2
	Total Credits Required								**22**

The credits earned from the Value Addition Course or MOOC course will not be taken for the computation of CGPA. But, successful completion of the course is necessary for getting the degree.

Semester III

Courses: DSC - 7 (Theory - 4, Practical - 3), DSE -1
(Students must choose 1 out of 3 DSE and MDC)
Credits: DSC - 17, DSE -3, MDC - 4, Total = 24

Sl. No	Course Code	Title of the course	Contact hours /week			Weightage			Credits
			L	T/S	P	ESE	CE	Total	
Discipline Specific Core (DSC)									
23	MSCPB03DSC13	Introduction to Big Data Biology	3	2		60	40	100	3
24	MSCPB03DSC14	Computational Systems Biology	3	2		60	40	100	3
25	MSCPB03DSC15	Cheminformatics and Computer Aided Drug Designing	3	2		60	40	100	3
26	MSCPB03DSC16	Advanced Algorithms in Computational Biology	3	2		60	40	100	3
27	MSCPB03DSC17	Practical 7: Cheminformatics and Computer Aided Drug Designing			4	60	40	100	2
28	MSCPB03DSC18	Practical 8: Computational Systems Biology			2	60	40	100	1
29	MSCPB03DSC19	Practical 9: Big Data Biology			4	60	40	100	2
Discipline Specific Elective (DSE) (1/3)									
30	MSCPB03DSE08	Introduction to Machine Learning	3	2		60	40	100	3
31	MSCPB03DSE09	Environmental Microbiology	3	2		60	40	100	3
32	MSCPB03DSE10	Biotechnology in Medicine, Health, Agriculture and Environment	3	2		60	40	100	3
Multi-Disciplinary Courses (For students from other departments)									
33	MSCPB03MDC01	Basics of Biotechnology	4	2		60	40	100	4
		Course offered by other departments	4			60	40	100	4
	Total Credits Required								**24**

Semester IV
Courses: DSC - 1, DSE - 2
(*Students must choose 2 out of 3 DSE)*
Credits: DSC - 12, DSE - 4, Total = 16

Sl. No	Course Code	Title of the course	Contact hours /week			Weightage			Credits
			L	T/S	P	ESE	CE	Total	
Discipline Specific Core (DSC)									
34	MSCPB04DSC20	Research and Dissertation[#3]		5	25	60	40	100	12
Discipline Specific Elective (DSE) (2/3)									
35	MSCPB04DSE11	Introduction to Parallel and Cloud Computing	3	2		60	40	100	2
36	MSCPB04DSE12	Ethics, Patency and Intellectual Property Rights	3	2		60	40	100	2
37	MSCPB04DSE13	Enzymology	3	2		60	40	100	2
	Total Credits Required								**16**

[#3]The continuous evaluation of the project work shall be done by the research supervisor based on the performance of the student in the lab. The end semester evaluation consists of a presentation and a viva voce based on the project work conducted.

SEMESTER I

(Total Credits Required:22)

Semester	Type of course	Course Code	Course Name
I	**Core**	**MSCPB01DSC01**	**Fundamentals of Cell Biology and Genetics**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course "Fundamentals of Cell Biology and Genetics" is designed to provide the students an understanding about the mechanisms that define and regulate the function of cells and organisms. The course also explains the transmission and variation of inherited characteristics in the organisms, particularly at the level of chromosomes and DNA

COURSE OBJECTIVES:

- To understand the molecular nature and functioning of the cell components and how they interact with the external environment.
- To understand the mechanism of cell replication
- To understand the molecular basis of heredity
- To understand the genetic variations in population

COURSE OUTCOMES:

At the end of the course, the student will be able to-

CO1	Explain the basic architecture of prokaryotic and eukaryotic cells and cellular components
CO2	Explain the mechanism that define and regulate the function of cells and organisms
CO3	Explain the mechanisms of inheritance in eukaryotes and prokaryotes.
CO4	Explain the concept of chromosomes, genes, and genomes

M Sc Computational Biology Syllabus - Kannur University (2023 onwards)

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Biology of cells: cell as a unit of life; cell types - bacteria, viruses, eukaryotic; basic structure and composition of prokaryotic and eukaryotic (animal and plant) cells. 1.2 Overview of cell organelles: Mitochondria; chloroplasts; endoplasmic reticulum; Golgi; ribosomes; lysosomes and peroxisomes; plant vacuoles; nucleus and nucleolus. 1.3 An overview of extracellular matrix and cytoskeleton.	**11 hrs**
Module 2	2.1 Organization of chromatin: nucleosomes; higher order folding of chromatin. 2.2 Genes and chromosomes: gene and chromosome as a unit of inheritance; chemical nature of genes - organization of genes in prokaryotic and eukaryotic DNA. 2.3 Gene expression: central dogma; types of RNA molecules and their roles; overview of control of gene expression in bacteria and eukaryotes; overview of DNA replication - initiation, elongation, termination. Cell division: overview of different phases in mitosis and meiosis. Overview of cell death.	**11 hrs**
Module 3	3.1 Physical basis of heredity: introduction; concepts and theories of Mendelian genetics. 3.2 Concept of gene: alleles; multiple alleles; gene interactions; epistasis; pleiotropy. 3.3 Chromosome theory of inheritance: linkage, crossing over and chromosome maps. Maternal effects and cytoplasmic inheritance (overview only). 3.4 Gene mutations: somatic versus germinal mutations; types; mutation and cancer. Genomes: overview of prokaryotic and eukaryotic genomes.	**12 hrs**
Module 4	4.1 Introduction: Darwin's theory of evolution. 4.2 An overview of genetic variation in populations: gene pools; allele frequencies; Hardy - Weinberg equilibrium; genetic drift; gene flow; protein and DNA sequence polymorphism- analysis of DNA length polymorphism, analysis of single nucleotide polymorphisms. 4.3 Overview of genetic basis of diseases: single gene disorders; chromosomal disorders; mitochondrial disorders; epigenetics; cancer.	**11 hrs**

LEARNING RESOURCES

1. Molecular Cell Biology (8th edition) by Gerald Karp, Wiley, 2015
2. Molecular Biology of The Cell (6th edition) by Alberts, Garland Science, 2014
3. Molecular Cell Biology (8th edition) by Lodish, W.H. Freeman, 2016
4. Genes XI by Benjamin Lewin, Jones and Bartlett Learning, 2014
5. Molecular Biology of the Gene (7th edition) by Watson Pearson India, 2017.
6. Genetics (3rd edition) by M W Strickberger, Deakin University, 2008
7. Genetics (4th edition) by Veer Bala Rastogi, Medtech, 2018
8. Principles of Genetics (7th edition) by Simmons and Snustad, John Wiley & Sons Inc, 2015
9. Basic Genetics by R F. Weaver, P W. Hedrick, Wm. C. Brown Publishers, 1995.
10. An Introduction to genetic Analysis (12th edition) by Anthony J. F. Griffiths, John Doebley, et al., WH Freeman, 2020

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Differentiate between prokaryotic and eukaryotic cells. (3 marks)
2. Explain the organization of chromatin. (3 marks)
3. Differentiate between somatic and germinal mutations. (5 marks)
4. Explain any two diseases caused by chromosomal disorders. (5 marks)
5. Discuss the roles of different RNA molecules in eukaryotes. (10 marks)

Semester	Type of course	Course Code	Course Name
I	**Core**	**MSCPB01DSC02**	**Basics of Computing and Java Programming**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The 'Basic Computing and Java Programming' course is designed to introduce students to fundamental concepts of computing and develop their skills in Java programming. The course is suitable for beginners with little to no programming experience and aims to provide a solid foundation in both computer science principles and object-oriented programing. The course will provide basics of computer architecture, UNIX, shell scripting and Java programming. By the end of the course, students will have a solid understanding of the core principles of computing and will learn the theoretical aspects of design, develop, and debug basic Java applications, laying the foundation for further studies in computer science or software development.

COURSE OBJECTIVES:

- To understand the concepts of components and memory of computer.
- To design an interactive webpage using basic HTML tags.
- To work with shell scripting in Linux architecture.
- Understand the fundamentals of object-oriented programming features in java.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Possess knowledge in computer components and types of software.
CO2	Solve number conversions in different bases and also, learn to distinguish different network devices.
CO3	Use Linux/UNIX commands to manage file systems and shell scripting to solve problems.

CO4	Understand fundamentals of object-oriented programming in Java, including handling file operations, defining classes, invoking methods, using class libraries, etc.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1. Need of computers in biology: new approaches in data collection and data analysis. 1.2. Definition of computer. Software Vs hardware: types of software; system software and application software. 1.3. Components of computer: input devices; output devices; memory unit- primary and secondary memory. 1.4. Overview of generations and classification: workstation; super computer. Operation of processors. 1.5. Number systems and conversions: binary, octal, decimal, hexadecimal.	**12hrs**
Module 2	2.1. UNIX/ Linux: introduction; components of Linux; Linux architecture. 2.2. Types of shell; Bourne shell, korn shell, c shell. 2.3. Listing files and directories: masking permissions; directory permissions. 2.4. Essential UNIX commands. 2.5. Vi editors. 2.6. Shell programming: shell variables; keywords; positional parameters;Taking decisions: if-then-fi, if-then-else-fi, nested if-elses. The loop control structures: while, until, for loop.Case control structure. 2.7.File handling in shell: cp, create, rename, listing, file manipulation.	**10hrs**
Module 3	3.1 Developing a program: program development cycle; algorithm; flowchart; program control structures; programming languages; assembler; compiler; interpreter; syntax, source code;object code; executable file; file extensions. 3.2 Introduction to Java: features of Java; compilation of Java programs; Java development kit; virtual machine; byte code. 3.3 Data types: int; long; char; boolean. 3.4 Operators: arithmetic; relational; bit wise assignment; operator precedence; type conversion. 3.5 Arrays: 1D and 2D arrays.	**13hrs**

	3.6 Control statements and loops: if; switch; while; do while; for.	
Module 4	4.1 Working with Java classes: methods and classes; method definition; user defined classes; user defined methods; class declaration; class definition; class instances; invoking methods; constructors. 4.2 Inheritance: simple; multiple; multilevel; interfaces. 4.3 Overriding and overloading. 4.4 Exception handling: try; catch; final; finally; finalize; multiple catch. 4.5 File handling: create; read; write operations.	**10 hrs**

LEARNING RESOURCES

1. Gurvinder Singh, Rachhpal Singh. A Textbook on Windows Based Computer Courses,

   2019, Kalyani Publishers,Jalandhar.
2. Rachhpal Singh, Mamta Verma, Sonia Mahindru. A Textbook of Scripting Language and Web Designing, 2007, Kalyani Publishers, Jalandhar.
3. Norton's P. Introduction to Computing. 7th Edition 2017, McGraw Hill Education, New Delhi.
4. Sinha P.K. Fundamental of Computers. 8th Edition2021, BPB Publication, New Delhi.
5. HTML &CSS: The complete Reference (5th Ed.), 2010, Thomas A. Powell.
6. HTML: Beginners Guide to HTML to Master Your Web Designing, 2019, Josh Steven
7. Java: The complete Reference. (7thEd.) by Herbert Schildt, 2012, TMH.
8. K. Arnold, J. Gosling, D. Holmes; The Java Programming Language; Addison Wesley, 4th edition, 2005.
9. Anonymous; Core and Advanced Java Black Book; Dreamtech Press, 2016.
10. UNIX Shell programming by Kanetkar, Yashavant P, New Delhi: BPB Publications 1996.
11. https://www.tutorialspoint.com

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations.

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Discuss the hardware components in computer. (3 Marks)
2. Explain MICR and OCR. (3 Marks)
3. Describe UNIX architecture. (5 Marks)
4. What are the control statements in Java? (5 Marks)
5. Explain the object-oriented nature of Java. (10 Marks)

Semester	Type of Course	Course Code	Course Name
I	**Core**	**MSCPB01DSC03**	**Biological Database Management Systems**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course Biological Database Management Systems is designed to offer students with the essentials of databases for storing and managing the vast amount of data. The course is also focused on the creation and manipulation of databases.

COURSE OBJECTIVES:

- To understand basics theory and practice of database management systems
- To understand relational model in database management systems and the concept of normalization
- To provide an overview of SQL and create databases
- To understand different biological databases

COURSE OUTCOMES:

At the end of the course, the student will be able to -

CO1	Explain the database management systems and different data models
CO2	Explain the concept of relational model and different normal forms.
CO3	Explain SQL for storing, manipulating and retrieving data
CO4	Create databases based on needs and to retrieve data from the databases created
CO5	Acquire information from different biological databases

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Introduction to databases: traditional file system; data and need for information; purpose of database. View of data: data models; data abstraction; instances and schemas. 1.2 Database languages: DDL; DML; database users and administrators. Classification of database systems: data storage - overview of physical storage media, RAID; storage manager; query processor and transaction management. 1.3 Database architecture. Database design: overview of the design process; entity relationship model- basic concepts, entity, attributes, relationships, ER diagrams, cardinality.	**10 hrs**
Module 2	2.1 Introduction to relational model: basic concepts; relations; tuples; domain; atomic domain; null value keys; integrity constraints. 2.2 Relational database schemas: schema diagrams; reducing ER diagrams to relational schemas. Relational database design- features of good relational designs 2.3 Introduction to relational algebra; normalization concepts- need of normalization; functional dependency theory; normal forms; decomposition using functional dependencies; algorithms for decomposition; decomposition using multivalued dependencies; more normal forms.	**11 hrs**
Module 3	3.1 Structured query language: overview of the SQL language; SQL data definition; SQL data types; basic structure of SQL queries; additional basic operations- set operations, null values, aggregate functions, nested subqueries; modification	**11 hrs**

	of the database. 3.2 Advances SQL: joint expressions; views; integrity constraints; authorization; triggers; advanced aggregation features.	
Module 4	4.1 Biological databases: primary, secondary and composite databases; types of biological data. 4.2 Protein sequence databases: Uniprot; Trembl; PIR; Prosite; Pfam. Nucleotide sequence databases: GenBank; EMBL; DDBJ. Genome databases. Secondary and composite databases: MMDB; CATH; SCOP; BRENDA; ProDom; Blocks. Structure database: PDB; NDB; EMDB. Literature databases: PubMed; PMC; PLOS; BioMed Central. Metabolic database: KEGG; EST databases; SNP databases. 4.3 Database file formats: GenBank; FASTA; ALN/ClustalW2; FASTQ; PDB; PIR. Information retrieval from biological databases: Entrez; DBGET; LinkDB; SRS. Biological database management: Introduction to Biological Data Integration.	**13 hrs**

LEARNING RESOURCES

1. Database System Concepts (6th edition) by Henry F. Korth, Abraham Silberschatz, S. Sudarshan, Tata Mac-Graw Hill, 2009.
2. An Introduction to Database Systems (8th edition) by C.J. Date, Addison-Wesley, 2004
3. Introduction to Database Systems, Itl Education Solutions Limited, Pearson Education, 2010
4. Introduction to Database Management Systems by Atul Kahate, Pearson Education India, 2006
5. Bioinformatics: Databases and Algorithms by N. Gautham; Alpha Science, 2006
6. Bioinformatics Sequence and Genome Analysis (2nd edition) by D. W. Mount; Cold Spring Laboratory Press, 2004
7. Structural Bioinformatics: An Algorithmic Approach by F. J Burkowski; CRC Press, 2008
8. Introduction to Bioinformatics (5th edition) by A. M Lesk, Oxford University Press, 2019
9. BLAST by J. Bedell, I. Korf and M. Yandell; O'Reilly Press, 2003
10. Bioinformatics Vol. 1, Data, sequence analysis & evolution (2nd edition) by J. M. Keith; Humana Press, 2017 .

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations.

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. What are the advantages of DBMS over traditional file systems? (3 marks)
2. Explain relational data model (3 marks)
3. Write an algorithm for BCNF decomposition. (5 marks)
4. Describe different data types used in SQL (5 marks)
5. Discuss the unique features of GenBank (10 marks)

Semester	Type of course	Course Code	Course Name
I	**Core**	**MSCPB01DSC04**	**Practical 1: Cell Biology and Genetics**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	2	1	-	30	30	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The laboratory-based course in “Cell Biology and Genetics” combines the theoretical knowledge gained and provide hands-on experiments to understand the basic nature of the cell and explore various techniques used to study cellular contents. The course is also focused on cell division and the isolation process of DNA from various sources

COURSE OBJECTIVES:

- To explore mechanisms of cellular biology using techniques and model systems.

- To understand the mechanism of cell division and DNA isolation techniques from various sources .
- Interpret progeny data from genetic crosses and predict inheritance mechanisms.

COURSE OUTCOMES:

At the end of the course, the student will be able to-

CO1	Isolate Mitochondria and Chloroplast from cells
CO2	Quantify nucleic acids
CO3	Identify chromosomal aberrations using karyotyping
CO4	Design histological methodology for differentiating cellular proteins, carbohydrates, and nucleic acids
CO5	Isolate DNA and quantify it
CO6	Observe and identify cell division stages in mitosis and meiosis
CO7	Solve problems based on genetic crosses and predict the inheritance mechanisms

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

(The laboratory work will consist of any 8-10 experiments from the following list)

1. Cell Fractionation: chloroplast: differential centrifugation.
2. Cell Fractionation: mitochondria: differential centrifugation
3. Estimation of nucleic acid by spectrophotometric method
4. Determination of melting temperature of DNA
5. Study of Barr Body (Buccal smear).
6. Karyotyping.
7. Study of Cellular Carbohydrates (Periodic Acid- Schiff)
8. Study of Cellular Nucleic Acid (Methyl Green Pyronin)
9. Study of Chromosomal DNA (Feulgen Reaction)
10. Study of Cellular Nucleic Acids and Proteins (Hematoxylin Eosin)

11. Determination of melting temperature of DNA
12. Mitosis- Cell preparation and identification of the different stages
13. Meiosis - Cell preparation and identification of the different stages

LEARNING RESOURCES

1. Current protocols in Cell biology- March 2019- Wiley
2. Biology I: Introduction to Cell and Molecular Biology Lab Guidebook Alexander N Urquhart and Emily K Meredith Simple Book Publishing (pressbooks.pub) 2022
3. Laboratory investigations in Cell and Molecular Biology (4th Ed) Allyn A Bregman 2002 Wiley
4. Cell Biology A Laboratory Handbook 3rd Edition Elsevier Inc 2006
5. Cell and Molecular Biology Lab Manual David A Thompson 2009
6. Practical Handbook of Genetics by Vikas Pali, Kalyani, 2016
7. Protocols for Nucleic Acid Analysis by Nonradioactive Probes, edited by Peter G. Isaac, Methods in Molecular Biology Vol. 28., Human Press, 1994
8. Essential Practical Handbook of Cell Biology & Genetics, Biometry & Microbiology: A Laboratory Manual by Debarati Das, Academic Publishers, 2017

TEACHING LEARNING STRATEGIES

- Laboratory experiments
- Solve mathematical problems based on genetic crosses

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60 %
Continuous Evaluation	40 %

Semester	Type of course	Course Code	Course Name
I	**Core**	**MSCPB01DSC05**	**Practical 2: Programming Lab I - Basic Computing and Java Programming**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	4	2	-	60	60	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The laboratory course on 'Basic Computing and Java Programming' provides essential knowledge of UNIX architecture, UNIX commands, shell scripting etc. This course engages students with little or no programming experience to learn object-oriented programing. Students are introduced to object-oriented programming concepts, terminology, syntax, and the steps required to develop basic Java programs. Hand-on training will also be provided in HTML and web designing.

COURSE OBJECTIVES:

- To work on UNIX OS, UNIX commands and File system.
- To write programs for solving real world problems using java collection frame work.
- To expose students to the basic tools and applications used in Web publishing.

COURSE OUTCOMES:

At the end of the course, the student will be able to-

CO1	Use various UNIX commands on a standard UNIX/LINUX operating system.
CO2	Acquire the skills needed to develop Linux shell programs and, make effective use of a wide range of standard Linux programming and development tools.
CO3	Write, compile, run, and test simple object-oriented Java programs
CO4	Create web pages using HTML and Cascading Style Sheets.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

1. Basic Unix commands
2. Shell scripting – essential commands and file handling operations
3. Java programming:
    i. Simple java programs to demonstrate decision making, and loops.
    ii. Handling of arrays and working with matrices.
    iii. Working with classes and objects in java.
    iv. Use of constructors and demonstration of overloading of constructors.
    v. Demonstration of simple, multiple and multilevel inheritances.
    vi. Exception handling mechanism
    vii. Reading and writing files.
4. Exercises on HTML:
    i. Design a simple web page using basic tags
    ii. Tables in web page.
    iii. Frame set in web page.
    iv. Cascading Style Sheets.
    v. Design simple registration form using all form tags
    vi. Design simple page using hyperlink

LEARNING RESOURCES

1. Learning the Bash Shell Unix Shell Programming, Cameron Newham. O'Reilly Media,2005
2. Shell Scripting Recipes A Problem-Solution Approach, Chris Johnson. Apress,2015
3. Learning Linux Shell Scripting, Ganesh Sanjiv Naik. 2015
4. Linux Shell Scripting Cookbook, Shantanu Tushar. 2013
5. Java Projects -Learn the Fundamentals of Java 11 Programming by Building Industry Grade Practical Projects, 2nd Edition, Peter Verhas. 2018
6. Introduction to Java Programming, K. Somasundaram. 2014
7. Java -A Beginner's Tutorial, Updated for Java SE 8, Budi Kurniawan. 2015

8. HTML and CSS -Design and Build Websites, Jon Duckett. 2011
9. HTML & CSS: The Complete Reference, Fifth Edition Thomas A. Powell. 2010
10. HTML and CSS Design and Build Websites by Jon Duckett, Wiley, 2014

TEACHING LEARNING STRATEGIES

- Laboratory exercises, Assignments, Record evolution

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Semester	Type of Course	Course Code	Course Name
I	**Core**	**MSCPB01DSC06**	**Practical 3: Biological Database Management Systems**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	2	1	-	30	30	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The practical course on “Biological Database Management Systems” is designed to train the students to familiarize with the sequence and structural data of nucleic acids and proteins. Also, the course is intended to excavate information from different biological databases based on needs. The course is also focused on the creation and manipulation of databases using SQL.

COURSE OBJECTIVES:

- To familiarize with different biological databases

- To retrieve data from different biological databases
- To understand different literature databases
- To provide an overview of SQL and create databases

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Retrieve sequence information from NCBI from given ID
CO2	Retrieve protein sequence and structure information from UniProt, PDB
CO3	Retrieve sequence information of proteins from SWISSPROT
CO4	Search and retrieval of biomedical and life sciences articles from different databases
CO5	Create databases based on needs and to retrieve data from the databases created

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

(The laboratory work will consist of any 6-8 experiments from the following list)

1. Make a list of biological databases for DNA and protein by browsing search engines.
2. Visit NCBI, EMBL, and DDBJ. Explore them, list out the salient features of these databases.
3. Retrieve the gene sequences by exploring and querying the nucleic acid database GenBank.
4. Retrieve the protein sequences by exploring and querying the protein databases UNIPROT
5. Explore and retrieve protein structure from the database PDB
6. Explore the databases CATH and SCOP.
7. Browse and explore the metabolic pathway database KEGG
8. Find the chromosomal location of gene sequence and basic experiments in NCBI map viewer.
9. Create and connect databases with MySQL/PosGreSQL.
    a. Creating tables, dropping tables, adding data to tables, join tables
    b. Primary and foreign keys, operators, grouping
    c. Data retrieval - nested subqueries

d. Modification of the database

10. Literature mining using PubMed database.

LEARNING RESOURCES

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins by AD Baxevanis, John Wiley & Sons, Second edition, 2004.
2. A cell biologists' guide to modeling and bioinformatics by R. M. Holmes; Wiley Interscience, 2007
3. Practical PostgreSQL by J D. Drake, J C. Worsley, O'Reilly Media, Inc. 2002
4. MySQL Workbench: Data Modeling & Development by Michael McLaughlin, Oracle Press, 2013

TEACHING LEARNING STRATEGIES

- Laboratory exercises, Assignments, Record evaluation

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60 %
Continuous Evaluation	40 %

Semester	Type of Course	Course Code	Course Name
I	**Elective**	**MSCPB01DSE01**	**Biochemistry**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

Biochemistry, involves the study of the chemical reactions and composition of living cells, the organization of biomolecules within the cell, and the structure and function of these biological molecules. The biological macromolecules which this course focuses on are proteins, polysaccharides, and nucleic acids and other biologically important molecules. The overall goal of this course is for the student to get a basic idea of biochemical concepts and techniques which will be essential for the future scientific endeavors.

COURSE OBJECTIVES:

- To understand structure and function of biological macromolecules.
- To understand chemical changes taking place in the living cells.
- To understand transport across biological membranes.
- To understand the role of small molecules in the biological system.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Explain the chemical components of living system
CO2	Demonstrate structure of the basic building blocks of life

CO3	Explain the function and dispersal of the basic building blocks of life
CO4	Elucidate the role of small molecules in the biological system

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Introduction to Biochemistry: Molecular logic of living system, biological macromolecules. 1.2 Membranes: Structure and functions of different membranes and their composition. 1.3 Membrane proteins & transport: Passive transport, co-transport, anti-port, active transport, secondary active transport, pumps and channels and their significance. 1.4 Importance of Biochemistry in contemporary medicine and its perspectives.	**11 hrs**
Module 2	2.1 Carbohydrates: Definition and classification, Structure, conformation and functions of monosaccharides, disaccharides, polysaccharides. Starch, glycogen, dextrin, cellulose. 2.2 Glycoconjugates: Amino sugars, Glycoproteins, Glycolipids, Mucopolysaccharides. 2.3 Lipids: Definition and classification, structure, function, physical and chemical properties – Fatty acids, Fats, Waxes, Phospholipids, Sphingolipids, Cerebrosides, Gangliosides. 2.4 Lipid derivatives: Sterols, lipoproteins. Eicosanoids - Formation of prostaglandins; prostacyclin and thromboxane, Saponification number, acid number and iodine number of fats.	**12 hrs**
Module 3	3.1 Proteins: Properties of peptides and proteins, amino acids, their properties, and different classification. Essential and non-essential amino acids, 3.2 Structure of peptides and proteins: Primary structure, structures of higher order and their meaning for the function of peptides and proteins. Protein - protein interaction. 3.3 Nucleic acids: Definition and classification, bases, nucleosides, nucleotides	**11 hrs**

	3.4 Nucleic acid's structure: Structure of DNA, RN, function, physical and chemical properties, different types of base pairing.	
Module 4	4.1 Vitamins: chemistry, source, and functions of water soluble and fat-soluble vitamins. Role of vitamins as cofactors. 4.2 Minerals: Source and functions of macro elements and trace elements 4.3 Hormones: Chemistry, synthesis, and functions of various plant & animal hormones 4.4 Molecules of Biological Importance: Pigments (Plant & Animal), pheromones and neurotransmitters	**11 hrs**

LEARNING RESOURCES

1. Lehninger's Principle of Biochemistry. Nelson L D and M M Cox.
2. Biochemistry. Jeremy M. Berg John and Tymoczko Lubert Stryer.
3. Biochemistry with Clinical Correlation. Thomas M Devlin. Wiley- Liss
4. Biochemistry. Donald Voet, Judith G Voet, Charlottewpratt. John Wiley
5. Biochemistry. JeoffreryZubay. Wm C Brown Pub.
6. Biochemistry. Mathews CK and KE.van Holde. Benjamin Cumming Pub.
7. Biochemistry. Vol 1&2 David Metzler

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes

1. Explain biological macromolecules and their functions
2. Identify the applications of biochemistry in contemporary medicine and agriculture
3. Classify biological membrane lipids and explain its structure
4. Evaluate clinical relevance of eicosanoids in biological system
5. *Discuss the molecular logic of life.*

Semester	Type of Course	Course Code	Course Name
I	**Elective**	**MSCPB01DSE02**	**Mathematics for Biology**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course "Mathematics for Biology" is designed to provide students with a solid foundation in mathematical concepts relevant to the field of biology. The course aims to enable students to apply mathematical reasoning and problem-solving skills to biological phenomena and systems. The course will equip the students with basics mathematical concepts that help them to critically analyze biological problems through mathematics and develop mathematical models to describe biological phenomena.

COURSE OBJECTIVES:

- To understand the basics concepts in mathematics
- To introduce basic algebra and calculus
- To understand the concept of vector algebra
- To introduce integral transforms and numerical analysis in applied mathematics

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Explain coordinate systems, set theory, functions, limits, continuity and

	derivatives
CO2	Explain and demonstrate the application of derivatives, integrals and differential equations
CO3	Explain and demonstrate the use of scalars, vectors and matrices
CO4	Explain different numerical methods and integral transforms

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Cartesian and polar coordinate systems: Equations of standard objects in plane and space – line, circle,plane, sphere; equations of rays and circles in polar forms. 1.2 Basics of Set theory, combinatorics and Functions: Set theory - sets, elements, operations between sets, finite and countable sets. 1.3 Combinatorics- factorials, permutations and combinations, binomial coefficients. 1.4 Functions- domain and range of functions, plotting of functions; types of functions – linear, polynomial, exponential, logarithmic, trigonometric functions; basic properties and operations on functions, inverse of a function. 1.5 Calculus - concept of limit and continuity, evaluation of limits of polynomials and rational functions, continuous functions, the intermediate value theorem.	**10 hrs**
Module 2	2.1 Derivatives of functions: basic concept of derivatives- definition and examples of derivatives, derivatives of standard functions; applications of derivatives - derivative as rate of change of quantities - the velocity, graphical treatment of derivative - the slope of a curve, local/globalmaxima and minima of functions, mean value theorem for derivatives. 2.2 Integrals of functions**:** definite and indefinite integrals– definition, graphical treatment of integrals – area under a curve, integration of standard functions, rules of integration including integration by parts.	**11 hrs**

	2.3 Differential equations: first order differential equations- solutionof differential equations, variable separable method, linear differential equations, applications of differential equations in biology; second order linear differential equations linear, homogeneous differential equations with constant coefficients, their solution using auxiliary equations.	
Module 3	3.1 Vector Algebra: introduction to scalars and vectors – scalars and vectors, vector addition and scalar multiplication, magnitude and direction of a vector, unit vector, vector representation in cartesian coordinates; product of vectors and vector valued functions - dot product and cross product of vectors, vector and scalar triple products, scalar valued and vector valued functions. 3.2 Matrix algebra: basic concepts of matrices - definition of matrices, types of matrices, matrix operations - matrix addition, subtraction, scalar multiplications, matrix multiplication, transpose and inverse (an overview); matrices as linear transformations - system of simultaneous linear equations, matrix representations of linear systems, solution of homogeneous and non-homogeneous systems of linear equations, eigenvalues and eigenvectors of a matrix and their properties.	**12 hrs**
Module 4	4.1 Numerical methods: solution of nonlinear equations- Newton's method for solving equations of the form f(x)=0; numerical differentiation and integration-numerical differentiation, numerical integration– Trapezoidal and Simpson's rules; numerical solution of Ordinary Differential Equations- Euler method for solving first order ordinary differential equations, Runge Kutta method (second order only) 4.2 Laplace and Fourier Transforms: Laplace transforms– definition, Laplace transforms of elementary functions, properties of Laplace transforms, existence of Laplace transform- sufficient conditions, convolution of Laplace transforms, inverse Laplace transforms of simple functions (basic functions only); Fourier series- Fourier Series representation of functions at continuous points.	**12 hrs**

LEARNING RESOURCES

1. Advanced Engineering Mathematics: Erwin Kreyszig 10 edn. Wiley
2. Higher Engineering Mathematics: 42 Edn, B. S. Grewal, Khanna Publishers
3. A Textbook of Engineering Mathematics Paperback – 10th edition by N.P. BaliThomas' Calculus, 14thEdition, Pearsonby George B. Thomasand Joel Hass

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Solve the simultaneous linear equations:2x+ 3y= 8, 3x+ 2y= 7 (3 Marks)

2. Find the global minima of the function $f(x)=x^2- 4x$ in the interval [0,5] (3 Marks)

3. Use the rules of differentiation to find the derivative of each of the following:
   (i)$y=3x^5$ (ii) $y=14x^2$ (iii) $f(x)=60$ (5 Marks)

4. A square has vertices (1,1), (-1,1), (-1,-1), (1,-1). Find the linear transformation,
   a. which shift the square to 3 points to left and 2 points above.
   b. which rotate the square anticlockwise into an angle of 90 degrees. (5 Marks)

5. Solve the following integral

$$\int_1^5 \frac{1}{x-7}dx$$

using Simpson's rule with 10 subintervals. (10 Marks)

M Sc Computational Biology Syllabus - Kannur University (2023 onwards)

Semester	Type of course	Course Code	Course Name
I	**Elective**	**MSCPB01DSE03**	**Biostatistics**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course 'Biostatistics' provides an introduction to the fundamental concepts and methods of statistical analysis in biology, which are essential for analyzing and interpreting data in the field of life sciences. Students will gain a solid foundation in statistical techniques used to design studies, collect data, and draw meaningful conclusions in various life science research settings. The course will also emphasis on applying biostatistical methods to real-world biological problems and critically evaluating scientific literature. By the end of this course, students will have a strong understanding of the key concepts and tools in biostatistics, enabling them to analyze and interpret data in life science research, and make evidence-based decisions in healthcare and public health settings.

COURSE OBJECTIVES:

- To understand data collection, data types and data presentations.
- To understand the concepts of averages and dispersion of measurement values.
- To understand the concept of probability and probability distributions.
- To understand the method of testing statistical hypotheses.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Differentiate between different sampling techniques
CO2	Make graphical/diagrammatic representation of given statistical data.
CO3	Calculate measures of central tendencies and measures of dispersion of a given data
CO4	Conduct regression and correlation analysis on the given data set and make inference of the data.
CO5	Explain different probability distributions
CO6	Test hypothesis using normal, students-t, chi square and F distributions.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Collection, classification and diagrammatic representation of statistical data: Variables and constants, Different types of numerical data. 1.2 Collection of data, Sampling techniques: Random sampling, Stratified random sampling. 1.3 Classification and tabulation of data, frequency distribution. 1.4 Graphical/diagrammatic representation of data: line charts, Bar charts, Pie-chart, Histograms, frequency polygons, ogives.	**11hrs**
Module 2	2.1 Measures of central tendency: Arithmetic mean, Median, Mode, Geometric and Harmonic mean. 2.2 Measures of dispersion: Range, Inter-quartile range, Variance and Standard Deviation, coefficient of variation. 2.3 Correlation and Regression: Relation between two variables, scatter diagram, definition of correlations, Pearson's correlation coefficient, Spearman Rank correlation coefficient. 2.4 Definition of regression: regression lines. Fitting lines using method of least squares.	**13hrs**
Module 3	3.1 Probability: Permutation and combination, types of events, Definition of probability, addition and multiplication theorems of probability. 3.2 Probability distributions: Binomial, Poisson and Normal distributions. 3.3 Skewness and Kurtosis: Definitions, Karl Pearsons coefficients	**10 hrs**

	of Skewness and Kurtosis, moments.	
Module 4	4.1 Normal distribution and statistical inference: Central Limit Theorem, Concept of confidence interval: Estimation, confidence limit, level of significance, standard error. 4.2 Statistical hypotheses: Tests of significance of means, difference between two means and proportion. Student's t-distribution and testing of hypothesis for small samples. 4.3 Chi-square distribution, Chi-squared tests for independence and for goodness of fit, F-distribution and Analysis of variance.	**11 hrs**

LEARNING RESOURCES

1. Probability and Statistical Inference-Hogg R. V. Tanis E. A., Prentice Hall, New Jersey, 2001
2. Experimental Design Data Analysis for Biologists-Quinn G. P. & Keough M. J. Cambridge University Press, 2002
3. Biostatistical analysis -4th edition, Zar, J.H. Pearson Education, 2013
4. Fundamentals of Biostatistics –P. Hanmanth Rao and K. Janardhan, I.K. International Publishing House, New Delhi, 2011
5. Introduction to Biostatistics and Research Methods-P.S.S. Sundar Rao and J. Richard, PHI learning Pvt Ltd, New Delhi, 2012
6. Principles and Practice of Biostatistics. B. Antonisamy, Prasanna S. Premkumar, Solomon Christopher, Elsevier India, 2017

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. How does population differ from sample? (3 marks)
2. Illustrate geometric and harmonic mean with suitable examples. (5 marks)
3. Identify three different properties of linear correlation coefficient. (3 marks)
4. Explain multiplication theorem of probability with suitable examples. (5 marks)
5. Describe how central limit theorem plays a crucial role in inferential statistics. (10 marks)

Semester	Type of course	Course Code	Course Name
I	**Elective**	**MSCPB01DSE04**	**Biophysical Techniques**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course "Biophysical Techniques" was designed to deliver the basic principles and applications of some of the essential laboratory techniques used in the field of Biology. It will give the students a foundation for learning other courses in the programme.

COURSE OBJECTIVES:

- Understand basic principles of biomolecular separation techniques.
- Understand basic principles of spectroscopic and crystallographic techniques for characterization of biological molecules.
- Understand basic principles and applications of histochemical and immunotechniques.
- Understand basic principles and applications of radioactivity based analytical techniques.
- Understand basic principles some analytical techniques to study the intermolecular interactions

COURSE OUTCOMES:

On successful completion of the course, students will be able to

CO1	Explain working principles and applications of biomolecular separation techniques such as chromatography, electrophoresis.
CO2	Explain the working principle and applications of centrifugation and

	density gradient sedimentation.
CO3	Explain the principles of UV, visible, IR, ORD, CD, NMR, Mass spectroscopy
CO4	Explain the principle and applications of x-ray crystallography
CO5	Explain histochemical and immunotechniques such as ELISA
CO6	Explain fluorescent techniques such as FRET and FISH
CO7	Explain the principle and applications of techniques such as autoradiography, RIA, SPR, ITC and DSC

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.5 Chromatography: Partition coefficient, relative mobility, retention time. Basic principles and applications of chromatographic techniques such as paper, TLC, size exclusion, ion exchange, affinity, GLC, HPLC and HPTLC. Types of columns 1.6 Electrophoresis: Basic principles and application. types of electrophoresis, PAGE, SDS-PAGE, Isoelectric focusing, 2D Gel Electrophoresis, Capillary electrophoresis, PFGE 1.7 Basic principles and applications of centrifugation and density gradient sedimentation: RCF, sedimentation coefficient.	**11**
Module 2	2.5 Colorimetry and spectrophotometry: Absorption and emission spectrum, Beer-Lambert law. 2.6 ORD, CD, UV/visible, IR, Raman and NMR spectroscopies. 2.7 Mass spectrometry and its applications: different methods of ionization and its detection. 2.8 Single crystal X-ray crystallography: basic principles, crystallization techniques, data collection and structure solution.	**13**
Module 3	3.4 Histochemical and immunotechniques: Antibody generation, detection of molecules using ELISA, western blot, immunoprecipitation. Patch clamp techniques. 3.5 Fluorescence and fluorometry, FRET, BRET, Immunofluorescence microscopy, in situ localization by techniques such as FISH and GISH. Flow cytometry.	**10**
Module 4	4.4 Radioactive decay, radioisotopes normally used in biology. 4.5 Basic principle of Geiger-Muller and scintillation counters.	**11**

	4.6 Radiotracer techniques, Radioimmunoassay. Autoradiography 4.7 Surface Plasmon Resonance spectroscopy. 4.8 Isothermal Titration Calorimetry. 4.9 Differential Scanning Calorimetry.	

LEARNING RESOURCES

1. Physical Biochemistry: Principles and Applications, 2nd Edition- David Sheehan, 2013, Wiley
2. Principles and Techniques of Biophysics, N. Arumugam and V. Kumaresan, Saras Publication
3. Practical Techniques in Molecular Biotechnology, Bal Ram Singh and Raj Kumar, (2022), Cambridge University Press
4. Fundamentals Of Molecular Spectroscopy, P.S. Sindhu, (2011) New Age International Publishers
5. Spectroscopy for the Biological Sciences, Gordon G. Hammes (2005), Wiley

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Compare applications of paper chromatography with TLC. (3 marks)
2. What physical properties of molecules determine the speed and direction of their movement in gel electrophoresis? (3 marks)
3. You have been given a mixture of two proteins with same molecular weight but different pI values. Propose a chromatographic method to separate the proteins and explain the principle. (5 marks)
4. UV-Visible spectra of solutions tend to consists of a few broad peaks while the IR spectra of the same solutions give sharp peaks. Explain. (5 marks)
5. Discuss the applications fluorescence spectroscopy in the study of protein folding? (10

marks)

SEMESTER II
(Total Credits Required – 22)

Semester	Type of Course	Course Code	Course Name
II	**Core**	**MSCPB02DSC07**	**Computational Genomics and Proteomics**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course 'Computational Genomics and Proteomics' is designed to provide students with knowledge in omics analysis. This course offers a concise overview of technologies and computational applications used in omics studies. The course provides a detailed understanding about the principles, concepts and importance of various techniques in genomic and proteomic research.

COURSE OBJECTIVES:

- To understand the history of genome projects and the concept of sequence alignments.
- To understand multiple sequence alignment and protein prediction from DNA sequences
- To learn the concept of transcriptome, functional genomics and pharmacogenomics.
- To understand molecular phylogeny and various proteomics techniques.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Explain the basic concepts of sequence alignment and its application.
CO2	Explain multiple sequence alignment, its applications and can predict protein structures using different methods.
CO3	Articulate different approaches to analyse transcriptomics data, genome annotation and pharmacogenomics.
CO4	Explain molecular phylogeny, phylogenetic analysis and protein profiling methods.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Genomics: history; genome projects; sequence assembly; sequence submission and accuracy; sequence formats. 1.2 Applications of dynamic programming in computational biology: basic concepts of sequence alignment; local alignment - Smith and Waterman algorithm; global alignment - Needleman and Wunsch Algorithm. 1.3 Methods of alignment - dot plot, scoring alignment, gap penalty. 1.4 Substitution matrices: PAM and BLOSUM series.	**10 hrs**
Module 2	2.9 Multiple sequence alignment (MSA): the need for MSA; uses and practical Strategies of MSA; five main approaches of MSA - exact methods, progressive alignment, iterative approaches, consistency based, structure-based methods. 2.10 Algorithm of CLUSTALW; pileup and its applications. 2.11 Concept of dendogram and its interpretation; use of HMM-based Algorithm for MSA (e.g., SAM method); applications of MSA in Genome sequencing. 2.12 Protein structure prediction: Chou Fasman method; GOR method; threading; homology modelling; ab initio prediction.	**11 hrs**
	3.6 Transcriptomics: concept of transcriptome and techniques used for transcriptomics - micro array, RNA seq; RNA	

Module 3	interference. 3.7 Correlation of gene expression data to biological process: methods for differential expression analysis- micro array data analysis, RNA seq data analysis, gene prioritization; expression patterns in different physiological state - yeast. 3.8 RNA databases; RNA structure analysis and prediction tools; RNA regulatory networks; introduction to comparative transcriptomics. 3.9 Functional Genomics: approaches to gene functional annotation – sequence, structure and binding site comparison. Pharmacogenomics: role of SNP in Pharmacogenomics.	**12 hrs**
Module 4	4.1 Molecular phylogeny and evolution: introduction; goals of molecular phylogeny. 4.2 Molecular phylogeny: properties of trees; tree roots; types of trees. 4.3 Phylogenetic analysis: five stages of phylogenetic analysis - selection of sequences, MSA of sequences, specification, tree building, tree evaluation. 4.4 Phylogenetic methods: UPGMA; neighbour joining method; phylogenetic inference; maximum parsimony; maximum likelihood method. Software tools for phylogenetic analysis. 4.5 Proteome profiling methods - peptide mass fingerprinting, protein micro arrays. Identifying protein-protein interactions: importance; 4.6 PPI detection methods - yeast two hybrid system, tandem affinity purification (TAP) tagging, structure and sequence-based prediction approaches.	**12 hrs**

LEARNING RESOURCES

1. Introduction to Genomics by Arthur M. Lesk, Oxford University Press 2017.
2. Computational Non-coding RNA Biology by Yun Zheng, Elsevier Science, 2018.
3. Computational Biology: A Hypertextbook by Scott T. Kelley, Dennis Didulo, WILEY publishers, 2020.
4. Bioinformatics and Functional Genomics by Pevsner, J., John Wiley and Sons, USA. 2009.
5. Computational Exome and Genome Analysis by Peter N. Robinson, Rosario Michael Piro, Marten Jager, CRC Press LLC, 2020.
6. Bioinformatics: Principles and applications,1st edition, by Ghosh and Mallick, oxford university press. 2008.
7. 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.

8. Introduction to Proteomics: Principles and Applications by Nawin C. Mishra John Wiley & Sons, 2011.
9. An Introduction to Molecular Evolution and Phylogenetics by Lindell Bromham, Oxford University Press, 2016.

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Define Genomics and Proteomics. (3 marks)
2. Mention the applications of MSA. (3 marks)
3. Discuss the RNA databases and predict the various tools involved in it. (5 marks)
4. What is molecular phylogeny? Discuss the different stages in phylogenetic analysis. (5 marks)
5. Explain protein profiling and protein detection methods in detail. (10 marks)

Semester	Type of Course	Course Code	Course Name
II	**Core**	**MSCPB02DSC08**	**Python Programming**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The comprehensive Python Programming theory course is designed to provide students with a solid foundation in the principles and concepts of Python programming. This course covers a wide range of topics, from the basics of Python syntax to more advanced concepts, such as object-oriented programming and data manipulation. The course also introduces python tools such as Biopython, which is used specifically for biological computation. Throughout the course, students will learn the theory behind various programming concepts and gain a deep understanding of how Python works. By the end of the Python Programming theory course, students will have a strong theoretical foundation in Python programming and will have the knowledge to design and implement Python applications and leverage various Python libraries and tools.

COURSE OBJECTIVES:

- To understand different coding environments and develop programming skills
- To Understand NumPy library of Python
- To understand file operations using Python
- To use Biopython for biological sequence analysis.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Understand the fundamentals of writing Python programs in different environments with adequate fluency
CO2	Understand Numpy Library
CO3	Learn file operations using python scripts
CO4	Learn various bioinformatics operations using Biopython scripts

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS:

Module	Description	Teaching Hours
Module 1	1.1 Introduction to Python: Popular tools used in data science; evolution of Python; Python as a programming language; advantages of using python. Coding environment: integrated development environment; spyder; pycharm; jupyter notebook. 1.2 Basic libraries in Python: numpy; pandas; matplotlib; sklearn. 1.3 Variables: naming variables; naming conventions; assigning values to multiple variables. Data types: basic data types- boolean; integer; complex; float; string; identifying object data type; verifying object data type; coercing object to new data type. 1.4 Operators and operands: arithmetic operators; hierarchy of arithmetic operators; assignment operators; relational or comparison operators; logical operators; bitwise operators; precedence of operators; unary operators; identity operators; is operator; is not operator; membership operators.	**13 hrs**
Module 2	2.1 Introduction to numpy: numpy array; creation of array; numpy attributes; numpy arithmetic operations. 2.2 General sequence data methods: string methods-object initialization, len(), clear(),append(),update(); dictionary methods; list methods- insert(); pop();remove(); extend(); array operations, list operations. 2.3 Set operations-union, intersection. Sequences: sequence data types; sequence object initialization; string indexing; list indexing; array indexing; tuple indexing; set indexing; dictionary indexing; range indexing. 2.4 Sequence data operations -slicing, concatenation,	**10 hrs**

	multiplication.	
Module 3	3.1 File Formats: commonly used file formats; read data from csv format; .xlsx format and .txt format. 3.2 Pandas dataframes: introduction to pandas; importing data into spyder; creating copy of original data; attributes of data; indexing and selecting data; data types-numeric, character. checking data type of each column; count of unique data types; selecting data based on data types; concise summary of data frames; checking format of each column; getting unique elements of each column; 3.3 Importing data; converting variable's data types; category vs object data type; cleaning column doors; getting count of missing values. control structures in Python: if elif family; for; while. Functions: functions with multiple inputs and outputs. Frequency tables: two -way tables-joint probability, marginal probability, conditional probability. 3.4 Data Visualization: scatter plot; histogram; bar plot; dealing with missing values; identifying missing values; approaches to fill the missing values. Computation of correlation and regression coefficients.	**11 hrs**
Module 4	4.1 Biopython: introduction; Bio.Seq and Bio.SeqRecord modules. 4.2 Using Seq class; sequences reading and writing. Bioclasses for sequences: Bio.SwissProt.SProt and Bio.WWW.ExPASy. 4.3 Regular expressions in Python; Prosite; Bio.GenBank; reading entries; running Blast and Clustalw. 4.4 Running other bioinformatics programs under Pise.	**11 hrs**

LEARNING RESOURCES

1. Mark Lutz, David Ascher (2003) Learning Python. O'Reilly & Associates
2. Alan Gauld (2000), Learn to program Using Python, Addison –Wesley
3. Python: The complete reference. Martin C Brown. Osborne/McGraw-Hill, 2018
4. URL: http://www.python.org
5. URL: http://www.biopython.org

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. List various datatypes in Python (3 Marks)
2. Explain (i) Logical operators (ii) Bitwise operator. (3 Marks)
3. Explain Bio.GenBank package and its Submodules. (5 Marks)
4. Write a note on running bioinformatics programs under Pise (5 Marks)
5. Do you think that Python is a handy tool for biological researchers? Justify your answer. (10 Marks)

Semester	Type of Course	Course Code	Course Name
II	**Core**	**MSCPB02DSC09**	**R Programming**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The theory course on ‘R programming’ designed to provide a comprehensive understanding of the language's underlying principles and to equip students with the knowledge necessary to use R effectively and efficiently. In this theory course, the focus is primarily on understanding the fundamental principles and concepts of R programming that includes data structures, functions and packages, R syntax and expressions, file operations, data visualization etc. Upon completion of the theory course, students should have a solid theoretical foundation in R programming, enabling them to understand the language's core concepts, syntax, and best practices.

COURSE OBJECTIVES:

- Understand the fundamentals of R language
- Understand the use of R in statistical analysis
- Understand dplyr package
- Perform basic file operations using R.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Structure of R programming and creating basic data-structures
CO2	Matrix operations and string manipulations in R Programming
CO3	Data manipulation with dplyr package in R
CO4	Various data visualization practices used in R Programming
CO5	Reading and writing into various file formats using R

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	**Description**	**Teaching Hours**
Module 1	1.1 Fundamentals of R:installation of R & R Studio; features of R; variables in R; constants in R. 1.2 Operators in R- Arithmetic, relational, logical, assignment, miscellaneous. 1.3 Datatypes and R objects- numeric, integer, complex, logical, character datatypes. 1.4 Object creation; accepting input from keyboard; important built-in functions. 1.5 Vectors: creating vectors; accessing elements of a vector; operations on vectors; vector arithmetic. 1.6 Control statements: if statement; if…else statement; ifelse () function; switch()function; repeat loop; while loop; for loop; break statement; next statement 1.7 Functions in R: formal and actual arguments; named arguments; global and local variables; argument and lazy evaluation of functions; recursive functions.	**12hrs**
	2.1 Matrices: creating matrices; accessing elements of a matrix;	

Module 2	operations on matrices; matrix transpose. 2.2 Strings: creating strings; paste() and paste0(); formatting numbers and string using format(); string manipulation. 2.3 Lists: creating lists; manipulating list elements; merging lists; converting lists to vectors. 2.4 Arrays: creating arrays; accessing array elements; calculations across array elements. 2.5 R factors: understanding factors; modifying factors. 2.6 Data frames: creating data frame; factors in data frames; operations on data frames; accessing data frames; creating data frames from various sources.	**12hrs**
Module 3	3.1 Data visualization in R: need for data visualization; bar plot; plotting categorical data; stacked bar plot; histogram; plot() function and line plot; pie chart / 3D pie chart; scatter plot; box plot. 3.2 stringr package: important functions in stringr; Regular expressions. 3.3 dplyr Package: load data into data frame; viewing the data; selecting columns; selecting rows; reordering the rows; pipe operator; group operations.	**12hrs**
Module 4	4.1 File operations: file handling in R- opening a file, creating a file, editing a file, renaming a file, removing a file; reading files- table format, CSV files, excel files; write in to files- printing to the screen, writing to CSV file, writing a table to a file. 4.2 Import data using Rstudio interface: built-in functions for reading data - scan( ), readLines( ), read.table( ), read.csv( ); built-in functions for writing data- write( ), writeLines( ), write.table( ), write.csv( ); getting and setting directory- getwd( ) and setwd( ). 4.3 Statistics using R: basic statistical operations- mean, median, range, minima and maxima, variance, standard deviation, correlation coefficient, covariance.	**11 hrs**

LEARNING RESOURCES

1. Learning R Programming by Kun Ren, 2016
2. Efficient R Programming: A Practical Guide to Smarter Programming by Colin Gillespie, Robin Lovelace, 2016
3. Beginner's Guide for Data Analysis using R Programming by Jeeva Jose; Khanna Publishing House, 2019

4. R Programming for Bioinformatics by Robert Gentleman, 2008
5. Programming with R by S R Mani Sekhar, Dr. T V Suresh Kumar, Dr. Madhavi Kasa, Dr. Sunil Kumar, S Manvi. Cengage Learning India Pvt. Ltd.- 2017

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Give examples of while and for loops in R. (3 Marks)
2. How can you load a .csv file in R? (3 Marks)
3. What is the use of stringr package? Give some examples of the functions in stringr? (5 Marks)
4. How would you write a customer function in R? Give an example. (5 Marks)
5. What are different data structures in R? Briefly explain about them? (10 Marks)

Semester	Type of Course	Course Code	Course Name
II	**Core**	**MSCPB02DSC10**	**Practical 4: Computational Genomics and Proteomics**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	4	2	-	60	60	40	60	100

L/T = Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The practical course on 'Computational Genomics and Proteomics' will provide students with the opportunity to gain hands-on experience in various omics tools and techniques used in sequence analysis, genomics, proteomics and structure prediction.

COURSE OBJECTIVES:

- To provide students with hands-on training in different computational tools and techniques in genomic data analysis.
- To provide students with hands-on training in different computational tools and techniques in proteomic data analysis.
- To understand the principles, concepts and importance of various techniques in genomic and proteomic research.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Gain a comprehensive understanding of the principles and algorithms used in sequence similarity searching and sequence alignment.

CO2	Learn the applications of MSA in biological research.
CO3	Develop a thorough understanding of the principles and methodology of phylogenetic tree construction.
CO4	Familiarize with the concept of ORF and acquire knowledge regarding physiochemical properties of macromolecules.
CO5	Analyze and interpret the predicted secondary as well as tertiary structures to gain insights to protein folding and function.
CO6	Develop skills in homology modeling techniques.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

1. Develop the methodology to generate the three-dimensional structure of a protein with known primary sequence and unknown structure
    a. Retrieve the protein sequence from Uniprot.
    b. Characterization of newly obtained sequences (sequence similarity searching)
    c. Identify conserved regions in protein primary sequence (multiple sequence alignment)
    d. Computational analysis of the physiochemical properties of the protein (atomic composition, half-life, etc. using primary sequence)
    e. Find out the three-dimensional structure of proteins from its amino acid sequences using template homologous structures. (Homology Modelling - HMMER, MODELLER).
    f. *In silico* prediction of physiochemical properties of the newly build protein.
    g. Structure refinement and validation of the newly modelled protein structure.
2. Protein structure prediction using AlphaFold.
3. Protein secondary structure prediction.
4. Predict the evolutionary relationship of the protein/DNA sequence (Phylogenetic tree construction)
5. Comparison of protein sequence with a genomic DNA sequence, protein to protein sequence

6. RNA databases and RNA secondary structure prediction.
7. Identify the functionally important segments of newly sequenced DNA (ORF finding tools)

LEARNING RESOURCES

1. Computational Exome and Genome Analysis by Peter N. Robinson, Rosario Michael Piro, Marten Jager, CRC Press LLC, 2020
2. Introduction to Genomics by Arthur M. Lesk, Oxford University Press, 2017
3. Introduction to Proteomics: Principles and Applications by Nawin C. Mishra, John Wiley & Sons, 2011.

TEACHING LEARNING STRATEGIES

- Laboratory exercises, Assignments, Record evaluation

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Semester	Type of Course	Course Code	Course Name
II	**Core**	**MSCPB02DSC11**	**Practical 5: Programming Lab II – Python Programming**

Credit			**Teaching Hours**			**Assessment**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	4	2	-	60	60	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The practical course Python Programming' covers foundational aspects of python programming with special emphasis on scripting, basic data manipulation, and program organization. Hands-on session on BioPython and RDKit will teach students to apply different python libraries specific to different bioinformatics/cheminformatics analysis.

COURSE OBJECTIVES:

- To familiarize with general structure of python program
- To understand the general control flow in python program
- To do various computational operations using python codes
- To familiarize with bio python modules to work with biological sequences

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Perform various computational operations using python codes
CO2	Familiarize with various python and biopython modules
CO3	Retrieve data from various file types and learn file manipulation
CO4	Handle biological data using biopython

CO5	Search and retrieve sequences from various databases

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

I. Programming in Python

1. Usage of basic data type in python.
2. Create a list and perform operations using list methods.
3. Create a dictionary and perform operations by applying dictionary methods
4. Create a tuple and perform the operations using tuple methods.
5. Learn control flow statements with example codes
6. Work with argumented function, accepting inputs from user.
7. Develop for and while loop constructs.
8. Python program to find factorial of a given number using functions
9. Using calendar module
10. Perform array operations using numpy module.
11. Set background color and shape fill options using turtle module
12. Perform file handling operations

II. Programming with Biopython

1. Handling sequences with Bio.seq class
    a. Complement and reverse_complement method
    b. Transcribe and back_transcribe method
    c. Translate method
    d. Retrieve nucleotide sequence of genome using Entrez search
2. Usage of Bio.SeqRecord module to represent a sequence record, a sequence with annotation
    a. Create SeqRecord object to hold a sequence and information about it.
    b. Save SeqRecord objects to a sequence file using Bio.SeqIO.
3. Find similar nucleotide sequence from databases using blast tool.

4. Find out major protein synthesized by a genome and save the sequence in fasta format.

III. Programming with RDKit

1. Understand the following RDKit tools
    a. MolGears
    b. WONKA
    c. OCEAN

LEARNING RESOURCES

1. Mark Lutz; David Ascher (2003) Learning Python. O'Reilly & Associates
2. Alan Gauld (2000) Learn to program Using Python Addison –Wesley
3. Python: The complete reference. Martin C Brown.Osborne/McGraw-Hill
4. URL: http://www.python.org
5. Biophyton - URL: http://www.biopython.org
6. RDKit – URL: https://www.rdkit.org

TEACHING LEARNING STRATEGIES

- Laboratory exercises, Assignments and Record evaluation

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Semester	Type of Course	Course Code	Course Name
II	**Core**	**MSCPB02DSC12**	**Practical 6: Programming Lab III – R Programming**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	4	2	-	60	60	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The R programming practical course is designed to provide hands-on experience and practical skills in using the R programming language for data analysis, statistical modeling, and data visualization. Throughout the course, students are typically given practical assignments to reinforce their learning and apply R programming skills to real-world datasets. These assignments may involve data analysis and visualization biological datasets. By the end of the course, students will have a strong foundation in R programming and be able to tackle data analysis tasks, visualize data effectively, and perform statistical analysis.

COURSE OBJECTIVES:

- To use R for analytical programming.
- To apply object-oriented programming concepts in R
- To do data visualization with R
- To perform error handling in R.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Explain R programming concepts and demonstrate how to install and configure RStudio
CO2	Apply OOP concepts in R programming
CO3	Use data structure and loop functions in R
CO4	Create R programs to do statistical analyse of data and generate reports

M Sc Computational Biology Syllabus - Kannur University (2023 onwards)

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

1. To perform the basic mathematical operations in R
2. Implementation of vector and list data objects operations
3. Implementation of various operations on matrix, array and factors in R
4. Implementation and perform the various operations on data frames in R
5. To create sample (dummy) data in R and perform data manipulation with R
6. Study and implementation of various control structures in R
7. Data manipulation with dplyr package
8. Study and implementation of data visualization with ggplot2
9. Perform various file operations through R
10. Statistical operations on biological data

LEARNING RESOURCES

1. The Art of R Programming A Tour of Statistical Software Design By Norman Matloff, Norman S. Matloff, 2011.
2. A Data Scientist's Guide to Acquiring, Cleaning, and Managing Data in R By Samuel E. Buttrey, Lyn R. Whitaker, 2017
3. R for Data Science Import, Tidy, Transform, Visualize, and Model Data By Hadley Wickham, Garrett Grolemund, 2016
4. Practical R for Biologists An Introduction By Donald L. J. Quicke, Buntika A. Butcher, Rachel A. Kruft Welton, 2021
5. Introduction to Nonparametric Statistics for the Biological Sciences Using R By Thomas W. MacFarland, Jan M. Yates, 2016

TEACHING LEARNING STRATEGIES

- Laboratory exercises, Assignments and Record evaluation

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Semester	Type of Course	Course Code	Course Name
II	**Elective**	**MSCPB02DSE05**	**Biophysics**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

Biophysics deals with the application of physics to biological systems. This course provides brief description of biophysical properties, thermodynamics and kinetics relevant to biological system. It also deals with structure and interactions of biological macromolecules like proteins and nucleic acids.

COURSE OBJECTIVES:

- Understand important biophysical properties.
- Understand the basic thermodynamics of living systems.
- Understand the structure and conformation biological macromolecules.
- Understand inter-molecular interactions involving biological molecules.

COURSE OUTCOMES:

On successful completion of the course, students will be able to

CO1	Explain the principles of biophysical properties like diffusion, osmosis, dialysis, surface tension and adsorption
CO2	Explain the basic principles of thermodynamics and kinetics of the chemical

	reactions in living system.
CO3	Explain the structure and conformation of proteins
CO4	Explain the structure and conformation of DNA and t-RNA
CO5	Explain different forces that stabilize molecular structures
CO6	Explain the principle of protein folding
CO7	Explain theories of Receptor-ligand interactions

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	Principles of Biophysical chemistry: 1.4 Diffusion: Fick's law and diffusion, Gibb's Donnan equilibrium. Diffusion across biological membranes. 1.5 Osmosis: Osmotic pressure, Vant Hoff's laws. 1.6 Dialysis: Diffusion dialysis and electrodialysis, hemodialysis. 1.7 Surface tension: Cohesive and adhesive forces, thermodynamic theories of surface tension, surfactants. 1.8 Adsorption: types of adsorption, adsorption isotherms, adsorbents.	**11hrs**
Module 2	2.4 Thermodynamics of biological system: open, closed and isolated systems, Laws of thermodynamics, Enthalpy, Entropy and Free energy, exothermic and endothermic reactions, Equilibrium and non-equilibrium thermodynamics 2.5 Overview of light dependent reactions (Z-scheme), production of ATP, high energy phosphate compounds, coupled reactions. 2.6 Rate, order and molecularity of a reaction,activation energy and role of enzymes in a reaction.	**11hrs**
Module 3	3.3 Structure of globular proteins: primary, secondary, tertiary and quaternary structure, preferred main chain torsion angles and Ramachandran plot.	**12hrs**

	3.4 Motifs and domains in proteins: H-L-H, Zn-finger and Leucine zipper motifs. Different protein folds (each with one example): All alpha helix, all β sheet, α / β and α+β folds. 3.5 Structure of membrane proteins. 3.6 Nucleic acid structure: DNA double helix, forces stabilizing DNA structure, preferred sugar conformations. Non-conventional DNA structures: Holliday junction, Triple helices and quadruplexes. DNA supercoiling. 3.7 t-RNA structure.	
Module 4	4.4 Forces stabilizing macromolecular structures: Dipole-dipole, ion-dipole interactions, ionic bonds, Hydrogen bonds, Van der Waals, Hydrophobic and hydrophilic interactions. 4.5 Protein folding: Anfinsen's experiments, Levinthal paradox and free energy funnel, folding intermediates, molten globular structures, folding accessory proteins. Thermodynamics of protein folding, driving forces. 4.6 Receptor-ligand interactions: theories of receptor activation, agonists and antagonists, affinity and efficacy, dose-response relationship	**11hrs**

LEARNING RESOURCES

1. Biophysical chemistry (9th Ed) - Gurtu, 2015, Pragati Prakasan
2. Biological thermodynamics (2nd Ed)- Donald T. Haynie, 2013, Cambridge University Press, Cambridge.
3. Biophysics (2nd Ed) - Vasantha Pattabhi and N. Gautham, 2009, Alpha Science International Ltd.
4. Essentials of Biophysics - P. Narayanan, 2005, New Age International publishers
5. Introduction to Protein Structure - C. Branden and I. Tooz, 2012, Garland Science
6. Principles of Protein Structure - G.E.Schulz&R.H.Schirmer, Springer
7. Principles of Nucleic Acid Structure - W. Saenger, Springer
8. Protein Folding (2nd Ed) - B. Noelting, 2005, Springer
9. Structure and Mechanism in Protein Science - Alan Fersht, 2017, World Scientific

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcome:

1. Prove that the value of state variables depends only on the current state of the system and not the path of the system. (5 marks)
2. Compare reversible and irreversible processes. (3 marks)
3. Explain Gibbs free energy and spontaneity of a process. (3 marks)
4. Discuss the importance of high energy phosphate compounds. (10 marks)
5. Establish that entropy of the universe always increases. (5 marks)

Semester	Type of Course	Course Code	Course Name
II	**Elective**	**MSCPB02DSE06**	**Fundamentals of Molecular Biology and Recombinant DNA Technology**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course ‘Fundamentals of Molecular Biology and Recombinant DNA technology’ is designed to provide students with a comprehensive understanding of molecular processes at the cellular level, including DNA replication, transcription and translation in both prokaryotes as well as eukaryotes. Moreover, this course aims to familiarize students with various tools and techniques used in recombinant DNA technology, which includes the applications of DNA modifying enzymes, vector types, selection and screening of recombinant DNA.

M Sc Computational Biology Syllabus - Kannur University (2023 onwards)

COURSE OBJECTIVES:

- To understand the organization of genome.
- To familiarize with cellular processes such as transcription and translation.
- To understand the regulation of gene expression.
- To familiarize with the advanced genetic engineering techniques and the appropriate application of genetic engineering technique for the mass production of protein of interest.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Familiarize the student with the mechanisms of gene expression in prokaryotic and eukaryotic systems.
CO2	Describe the structure of DNA, its properties and learn about the process of DNA replication in prokaryotes and eukaryotes.
CO3	Explain the molecular basis of transcription and translation, regulation of gene expression in prokaryotes and eukaryotes, and the concept of operons.
CO4	Articulate the basics of recombinant DNA technology, including the enzymes involved in manipulating genetic material, the types of vectors, gene transfer techniques, and host cells.
CO5	Explain the construction and screening of genomic and cDNA libraries, as well as the basic principles, applications of PCR and blotting techniques.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Structure of DNA: Watson – Crick Model; Chargaff's Rule; different types; secondary, tertiary and quaternary structure; DNA supercoiling. 1.2 Properties of DNA: melting temperature (T_m) and its association with thermodynamic parameters ($\Delta G°$ or $\Delta H°$ & $\Delta S°$); 1.3 Renaturation and denaturation of DNA; C_0t curves; DNA banding patterns. 1.4 DNA replication: overview of steps involved; enzymes of	**11hrs**

	replication; prokaryotic and eukaryotic DNA replication mechanisms – an overview.	
Module 2	2.1 Molecular basis of transcription (basics only): types of RNA and RNA polymerases in prokaryotes and eukaryotes; control of transcription in prokaryotes and eukaryotes; post transcriptional modifications of RNA 2.2 Molecular basis of translation (basics only): genetic code, translational process, control of translation, post-translational modifications. 2.3 Regulation of gene expression in prokaryotes and eukaryotes: operon concept – lac; DNA methylation and demethylation.	**12hrs**
Module 3	3.1 Introduction to recombinant DNA technology: historical perspectives; basics steps involved; 3.2 Enzymes involved in manipulation of genetic material (overview only). Host cells – an overview. 3.3 Vectors: plasmids, artificial chromosomes, expression vectors. Linkers and adapters. 3.4 Gene transfer techniques (overview only) – transformation, conjunction, electroporation, transduction, direct transfer.	**11hrs**
Module 4	4.1 Genomic library: construction of gene library; cDNA library construction; screening of genomic library (overview). 4.2 Polymerase Chain Reaction (PCR): basic principle; applications – Gene expression, DNA sequencing. 4.3 Principles involved in blotting techniques: southern, northern and western. 4.4 DNA fingerprinting technique and its applications.	**11 hrs**

Demonstration session (only for demonstrating the techniques, not to be included as a part of ESE):Demonstration sessions will be provided for the following basic molecular biology and rDNA techniques:

a. Isolation of genomic DNA and RNA
b. Electrophoresis using DNA/proteins
c. Blotting techniques
d. Isolation of plasmid DNA
e. Agarose gel electrophoresis & restriction mapping of DNA
f. Construction of restriction map of plasmid DNA
g. Preparation of single stranded DNA template
h. Polymerase Chain Reaction (PCR)

LEARNING RESOURCES

1. Molecular Cell Biology by Lodish, H., Baltimore, D. Berk, A., Zipursky, S. L. Matsudaira, P. and Darnell. J, 3rd edition, W H. Freeman & Co, 1995.
2. Molecular Genetics - An Introductive Narrative by Stent, G. S. and Calender R, CBS Publishers and Distributors, New Delhi, 1986.
3. Basic Genetics by Weaver, R E & Hedrick, PW, WMC, Brown Publishers, 1985.
4. Molecular Biology of the Cell by Bruce Alberts, Norton publishers, 2017
5. Alberts, B, Bray,D. Lewis, Julian, Raffn M. Roberts, K. and J. D. Watson, J.D. 1994, 3rd edition, Garland Publishing Inc, 1994.
6. Genetics of Bacteria and their viruses, Hayes W, 2nd edition, CBS Publishers and Distributors, New Delhi, 1994.
7. Lewis Genes XII Benjamin by Jocelyn E. Krebs & Elliott S. Goldstein & Stephen T. Kilpatrick, 2017.
8. Principles of gene manipulation- An Introduction to Genetic Engineering by Old, RW & Primrose, 5th Edn, Blackwell Sci Pub, 1995.
9. Molecular Cloning- A Laboratory Manuel by Sambrook, J., Fritsch, E. F. and Maniatis, T,2nd Edition. Cold Spring Harbor Laboratory Press, 1989.
10. Recombinant DNA technology- Concepts and Biomedical Applications by Steinberg, Guyden, J., Calhann, D, Staiano- Coico, L., Coico, R, Ellice Horwood Prentice Hall, 1993.
11. Recombinant DNA by Watson, J. D., Gilman, M., Witkowski, J. and Zoller, M, 2nd Edition. Scientific American Books, WH Freeman & Co, 1992.
12. From Genes to Clones: Introduction to Gene by Winnacker, E. L. 1987.

For laboratory demonstration sessions:

1. Molecular Cloning- A Laboratory Manuel by Sambrook, J., Fritsch, E. F. and Maniatis, T. Second Edition. Cold Spring Harbor Laboratory Press, 1989.
2. Cell and Molecular Biology Lab Manual David A Thompson 2009.
3. Methods in Molecular Biology Vol. 28. Protocols for Nucleic acid analysis by non – radioactive probes. Edited by Issac P. G. Human Press, 1994.
4. Recombinant DNA manual 1st edition by Judith W. Zyskind, Sanford I, Bernstein, 2014.
5. Recombinant DNA technology by Keya Chaudhuri, TERI press, 2013.
6. Molecular Biology & rDNA technology by Ashok Kumar, 2011.

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Mention the properties of DNA. (3 marks)
2. What is cDNA library? (3 marks)
3. State the difference between southern and northern blotting techniques. (5 marks)
4. Differentiate between renaturation and denaturation of DNA. (5 marks)
5. Explain the regulation of gene expression in eukaryotes. (10 marks)

Semester	Type of Course	Course Code	Course Name
II	**Elective**	**MSCPB02DSE07**	**Food Microbiology**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The aim of the course is to provide a comprehensive overview of the field of food microbiology, which includes issues related to food safety, preservation and food production. In particular, the course provides an overview of microbial ecophysiology, identification and control of food microorganisms, and the spread of spoilage and pathogenic microorganisms of plant and animal foods. Finally, the course provides an overview of the most important fermented foods.

COURSE OBJECTIVES:

- To give a general knowledge on various factors affecting microbial spoilage of food.
- To give detailed information on various strategies that can be adopted for preservation of food.
- To give detailed knowledge on various microbial derived food products.
- To give detailed information on regulatory mechanisms in maintaining quality of food.

COURSE OUTCOMES:

Course Learning Outcomes: At the end of the Course, the Student will be able to -

CO1	Acquire knowledge in the type and analysis of microbial communities and loads in food beverages.
CO2	Analyze types of food poisoning microorganisms that are present in the food and beverages.
CO3	Formulate strategies for preservation of food and beverages.
CO4	Identify the concepts of quality checking in food industry.

COURSE CONTENTS:

Module	Description	Teaching Hours
Module 1	1.1 Factors which influence microbial growth, survival and death in foods, spores and their significance 1.2 Indicator microorganisms and microbiological criteria. 1.3 Microbial spoilage of foods 1.4 Factors affecting food spoilage at different levels– intrinsic and extrinsic factors	**13hrs**
	2.1 Spoilage of meat, poultry and sea foods, milk and dairy products, fruits, vegetables and grains. 2.2 Preservation methods and preservatives:	

Module 2	2.3 Physical methods of preservation, chemical preservatives and natural antimicrobial compounds, biologically based preservation system. 2.4 Problems associated with preservatives.	**10hrs**
Module 3	3.1 Food fermentations: fermented dairy products, 3.2 Fermented vegetables, fermented meat, poultry and fish products, 3.3 Traditional fermented foods, cocoa and coffee, beer and wine. 3.4 Probiotics and prebiotics	**12hrs**
Module 4	4.1 Food borne pathogens: Food poisoning, intoxications like botulism and aflatoxins. 4.2 Food hygiene and control. Single Cell Protein. 4.3 HACCP. Molecular techniques in food microbiology. 4.4 Food security, food safety and GM foods	**10hrs**

LEARNING RESOURCES

1. Food microbiology–Adams MR and Moss MO
2. Food Microbiology–Frazier WC and Westhoff
3. Food Microbiology (2nd Ed)–Doyle et al.
4. Basic food microbiology –Banwart GJ
5. Dairy Microbiology–RobinsonRK
6. Valorization of Food Processing By- Products, Fermented Foods and Beverages Series, (Ed)M Chandrasekaran CRC Press

Teaching Learning Strategies

- Assignments, Internal examinations/Unit tests, Seminar presentations

Mode of Transaction

- Off-line mode, Black Board and Chalk, PowerPoint presentation,Quizzes.

Assessment Rubrics

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

SEMESTER III
(Total Credits Required – 24)

Semester	Type of Course	Course Code	Course Name
III	**Core**	**MSCPB03DSC13**	**Introduction to Big Data Biology**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course "Introduction to big data biology" is designed to introduce students to the highly interdisciplinary areas at the interface of biology, computing, data science and information technology. Students will develop skills to analyze large biological data sets such as in genomics and in next generation sequencing. This will enable them to explore careers in relevant academic or industry domains.

COURSE OBJECTIVES:

- To understand the big data concepts and terminology.
- To understand different big data processing and analyzing concepts
- To understand next generation sequencing techniques and the large-scale data analysis
- To understand the major applications of NGS

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Explain the types of big data and stages of big data processing
CO2	Analyze and interpret big data using various big data analyzing techniques.

CO3	Sequence and analyze large biological data sets.
CO4	Explain various file types and NGS applications in big data biology.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Understanding big data: concepts and terminology - datasets, data analysis, data analytics, business intelligence (BI). 1.2 Characteristics of big data: five V's – volume, velocity, variety, veracity, value. 1.3 Different types of data: structured data; unstructured data; semi-structured data; metadata	**10 hrs**
Module 2	2.1 Storing and analyzing big data: big data storage concepts- clusters, file systems, distributed file systems, NoSQL, sharding, replication, CAP theorem, ACID, BASE. 2.2 Big data processing concepts: parallel data processing; distributed data processing; hadoop; cluster. 2.3 Big data analysis techniques: quantitative analysis; qualitative analysis; machine learning-classification, clustering; statistical analysis – A/B testing	**11 hrs**
Module 3	3.1 Integrated genomic maps; gene expression profiling: northern blotting. 3.2 Large scale genome sequencing strategies: shotgun sequencing; automated DNA. High-throughput sequencing: pyrosequencing; helicos sequencing. 3.3 Genome editing technologies: CRISPR-Cas9. 3.4 Introduction to single cell transcriptomics; Introduction to computational genomics in medicine.	**10 hrs**
Module 4	4.1 Introduction to next generation sequencing (NGS): how to sequence DNA; typical NGS experimental workflow; ins and outs of different NGS platforms; Genome Aggregation Database (gnomAD). 4.2 Illumina sequencing principle; ion torrent sequencing principle; pacific biosciences SMRT sequencing principle; nanopore sequencing technology. 4.3 Computing needs for NGS data management and analysis: common file types used in NGS Data Analysis- BAM, BCF, BCL, FASTQ, SAM, VCF, WIG. 4.4 Major applications of NGS: genetic mutation and variation discovery; denovo assembly; chIP Seq; methylseq; genome	**14 hrs**

	seq data analysis.	

LEARNING RESOURCES

1. Big Data Analytics in Chemoinformatics and Bioinformatics- With Applications to Computer-Aided Drug Design, Cancer Biology, Emerging Pathogens and Computational Toxicology by Subhash C. Basak, Marjan Vračko, Elsevier Science, 2022
2. Big Data Analytics for Healthcare edited by Pantea Keikhosrokiani, Elsevier Science, 2022
3. Computational Genomics with R by Altuna Akalin, CRC Press, 2020
4. Next-generation Sequencing Data Analysis by Xinkun Wang, CRC Press, 2021
5. Big data Fundamentals: concepts, drivers and Techniques by Thomas Erl,Wajid Khattak, Paul Buhler, Parentice Hall and Service tech Press, 2015.
6. Algorithms for Next-Generation Sequencing by Wing-Kin Sung, CRC Press, 2017.

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Explain the different characteristics of big data. (3 marks)
2. Write a note about next generation sequencing. (3 marks)
3. Explain two techniques to analyze big data. (5 marks)
4. Illustrate integrated genomic maps. (5 marks)
5. Discuss *de novo* assembly (10 marks)

Semester	Type of Course	Course Code	Course Name
III	**Core**	**MSCPB03DSC14**	**Computational Systems Biology**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The 'computational systems biology' course is designed to provide students with knowledge in cellular level of systems biology. This course aims to introduce key concepts of mathematical modelling within the context of different biological networks. This also includes topics such as modelling of dynamic systems, parameter estimation, constraint-based modeling of genetic networks, emphasizing various software tools and their computational aspects for systems biology.

COURSE OBJECTIVES:

- To understand the systems level modelling of biological systems.
- To understand the concepts of graph theory, network structures and parameters.
- To understand the concepts of dynamic modelling and constraint-based modelling.
- To understand the application of computational system biology in medicine and drug development.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Articulate the different approaches in computational modelling of various biological systems.

CO2	Articulate the significance of systems biology and its relevance in scientific research.
CO3	Explain the basics of graph theory and its applications in biology.
CO4	Articulate dynamic modelling and learn about parameter estimation techniques.
CO5	Explain the concepts and applications of constraint-based models in drug target identification and discuss their limitations.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 System biology: introduction; significance of systems biology. 1.2 Towards system level understanding of biological systems: measurement technologies and experimental methods for systems biology; system structure identification; system behaviour analysis. 1.3 Introduction to modelling: definition of a model; practice of modelling – model scope, making assumptions, modelling paradigms, building the model - variables, parameters, and constants, model analysis, simulating the model. 1.4 Model examples - Lotka Volterra model.	**10hrs**
Module 2	2.1 Graph theory: basics, types of graphs; computational representations of graphs - data structures, adjacency matrix, Laplacian matrix. 2.2 Representation of biological networks using graph: gene regulatory networks; protein structure networks; metabolic networks. Software tools for network analysis. 2.3 Analysis of networks: different network parameters used; canonical network models – ER model; community detection - similarity-based clustering, Girvan-Newman algorithm; network perturbations; software tools used. 2.4 Applications of network biology: protein structure and conformational networks.	**11hrs**
	3.1 Dynamic modelling: introduction; constructing dynamic models; mass-action kinetic models; modelling enzyme kinetics - michaelis–menten model; co-operativity hill	

Module 3	kinetics; software tools. 3.2 Parameter estimation: for linear systems - linear regression for single variable; linear regression for multiple variables; for non-linear systems – comprehensive grid search, non-linear regression, genetic algorithm, typical challenges.	**12hrs**
Module 4	4.1 Constraint based modelling: introduction; constraints - types; mathematical representation; need of constraints; flux balance analysis (FBA); software tools used; applications of constraint-based models - drug target identification; limitations. 4.2 Systems biology in drug development: personalized mathematical models; role of systems biology in drug development – computational target and lead identification; receptor dynamics; pharmacokinetic modelling.	**12 hrs**

LEARNING RESOURCES

1. An Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon, 2nd edition, 2020.
2. Computational Systems Biology from Molecular Mechanisms to Disease 1st Edition by Andres kriete, Elsevier science, 2013.
3. An introduction to computational systems biology: system level modelling of cellular networks by Karthik Raman, 1st Edition, CRC Press,2021.
4. A First Course in System Biology by Eberhard O.Voit , Garland Science, 2013.
5. Molecular Biology of the Cell by Alberts Bruce *et al*, Garland Science, 2002.
6. Foundation of System Biology by Hiroaki Kitano, MIT press 2001.

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Define systems biology. Mention the significance of systems biology. (3 marks)
2. What is graph theory? Discuss the different types of graph theory. (5 marks)
3. Explain Lotka Volterra model. (5 marks)
4. Explain the parameters for linear systems and nonlinear systems in detail. (10 marks)
5. Elaborate on applications of system biology in drug development. (10 marks)

Semester	Type of Course	Course Code	Course Name
III	**Core**	**MSCPB03DSC15**	**Cheminformatics and Computer Aided Drug Designing**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course 'Cheminformatics and Computer-Aided Drug Designing' is a specialized course that involves the application of computational methods and tools to analyze and manipulate chemical data, predict properties of compounds, and optimize their structures for drug development, to aid in the discovery and design of new drugs. The course often includes case studies highlighting successful applications of cheminformatics and computer-aided drug design in real-world drug discovery projects. Students gain insights into the challenges and strategies involved in drug development.

COURSE OBJECTIVES:

- To understand the concepts and steps involved structure-based and ligand-based drug designing
- To understand molecular mechanics concepts and the molecular dynamics simulation methodology.
- To understand the theory and different methods of molecular docking

- To familiarize with the concepts and methods of quantifying structure-activity relationships

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Learn the fundamental concepts and principles of cheminformatics, including the representation of chemical structures, molecular descriptors, and fingerprints
CO2	Explain the basics of biomolecular simulation techniques and its applications.
CO3	Explain the theoretical aspects of molecular docking
CO4	Explain different steps involved in structure-based and ligand-based computer aided drug designing
CO5	Explain QSAR and its applications in drug discovery
CO6	Understand the integration of cheminformatics with experimental techniques in drug discovery and learn how to collaborate with experimental chemists and biologists, effectively communicate results, and contribute to interdisciplinary research teams

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Module contents	Teaching Hours
Module 1	1.1 Cheminformatics role in modern drug discovery. 1.2 Representation of molecular structures: graph theoretic representation; connection tables; linear notations; Morgan algorithm; 3D representations. 1.3 Molecular descriptors: descriptors from 2D structure; 2D fingerprints; 3D pharmacophores; pharmacophore keys. Similarity and distance coefficients. Pharmacophore generation. 1.4 Ligand based drug design: analysis of large database of ligands using similarity, rule of five, rule of three, sub-structure based methods. ADME and its prediction.	**11 hrs**
	2.1 Molecular dynamics simulation: Introduction - theoretical approaches to biomolecular structures.	

Module 2	2.2 Molecular mechanics concepts: Born-Oppenheimer approximation; force fields – introduction, potentials - bond stretching, angle bending, torsional terms, nonbonded - Lennard-Jones, Coulomb. Energy minimization. 2.3 Molecular dynamics (MD) simulation concepts: introduction; phase space, periodic boundary condition and minimum image convention; Newtonian dynamics (overview). 2.4 MD ensembles - NPT, NVT, NVE; simulated annealing.	**13 hrs**
Module 3	3.1 Structure based drug design (SBDD): Introduction and steps in SBDD. 3.2 Molecular docking: different methods of docking - shape complementary methods, fragment-based methods, stochastic search method. 3.3 scoring functions – force-field based, empirical, knowledge-based; rigid and flexible docking; applications.	**11 hrs**
Module 4	4.1 QSAR: introduction; Hansch and Free Wilson analysis. 4.2 Descriptors used in QSAR study; QSAR model building - regression analysis; 4.3 QSAR model validation methods - squared correlation coefficient, cross validation, standard error of prediction, confusion matrix and ROC curve. 4.4 Applications of QSAR.	**10 hrs**

LEARNING RESOURCES

1. Molecular Modeling Principles and Applications (2nd edition) by Andrew R. Leach, Prentice Hall, USA, 2001
2. Molecular Modelling for Beginners, (2nd edition) by Alan Hinchliffe, John Wiley & Sons Ltd., 2008
3. Molecular Modeling and Simulation – An interdisciplinary Guide (2nd edition) by Tamar Schlick, Springer, 2010
4. Structural Bioinformatics (2nd edition). Ed. By P. E. Bourne and Jenny Gu. Wiley-Blackwell, 2009
5. Chemoinformatics: A Textbook. Ed by J Gasteiger, T Engel John, Wiley and Sons, 2003
6. Molecular modelling and drug design by Andrew Vinter and Mark Gardner and Boca Raton, CRC Press, 1994

7. Advances in QSAR Modeling: Applications in Pharmaceutical, Chemical, Food, Agricultural and Environmental Sciences by Kunal Roy, Springer, 2017
8. Molecular Docking for Computer-Aided Drug Design: Fundamentals, Techniques, Resources and Applications (1st edition) by Mohane S Coumar, Academic Press, 2021
9. An Introduction to Chemoinformatics by Andrew R Leach and Vaalarie J. Gillet, Springer International Edition, 2009

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. What are Structure Definition Files? (3marks)
2. How to generate a molecular graph for a chemical compound? (5 marks)
3. Explain the principle of shape complementarity method of molecular docking (3 marks)
4. Discuss the different 1D, 2D and 3D representations of chemical molecules used in cheminformatics (10 marks)
5. Demonstrates the pharmacophore-based virtual screening. (5 marks)

Semester	Type of Course	Course Code	Course Name
III	**Core**	**MSCPB03DSC16**	**Advanced Algorithms in Computational Biology**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course "Advanced Algorithms in Computational Biology" is designed to provide students with an in-depth understanding of the algorithms and techniques used in computational biology to analyze biological data. Throughout the course, students will explore the steps involved developing efficient algorithms and learn various algorithmic approaches and computational methods used to solve complex biological problems. Students will develop a strong theoretical understanding of algorithms specifically tailored for analyzing biological data, including DNA and protein sequences, gene expression data, and biological networks.

COURSE OBJECTIVES:

- To understand design and analysis of various algorithms used in computational biology
- To understand the basics of Hidden Markov Model and its applications in biology
- To understand the basics of data ware housing and data mining
- To understand basic data structure operations and graph theory

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Learn the methods of designing algorithm to solve a specific problem and optimize it using various techniques.
CO2	Understand the Hidden Markov Model and their applications.
CO3	Learn the data mining architecture and algorithms.
CO4	Learn how to access or traverse through a data structure.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Algorithm design: introduction; steps in developing algorithm; methods of expressing an algorithm in natural language, flow chart, pseudocode and programming language; important problem types – sorting, searching, string processing, graph problems, combinatorial problems, geometric problems and numerical problems. 1.2 Basic technique for design of efficient algorithm: brute force approach; divide-and-conquer approach; branch-and-bound technique; greedy approach - hill climbing algorithm; dynamic programming; backtracking. 1.3 Algorithm analysis: importance of algorithm analysis; time and space complexity. 1.4 Application of different algorithm techniques in biology: motif finding (brute force approach), analyse undetermined biochemical models (divide-and-conquer approach), 2D protein folding problem (branch-and-bound technique), protein structure prediction (hill climbing algorithm), sequence comparison (dynamic programming), protein sequence alignment (backtracking)	**11 hrs**
Module 2	2.1 Genetic algorithm: basic concepts- reproduction, cross over, mutation, fitness value; optimization using GA's; applications of genetic algorithm in bioinformatics. 2.2 Hidden Markov model: Markov processes and Markov models; hidden Markov models; forward and backward algorithms. 2.3 Most probable state path: Viterbi algorithm. Parameter estimation for HMM's: Baum-welch algorithm; 2.4 Applications of profile HMM's for multiple alignment of	**10 hrs**

	proteins and for finding genes in the DNA.	
Module 3	3.1 Data; information; knowledge; Data ware house concepts: definition; terminologies-subject oriented, time variant, non-volatile, integrated, extraction, loading; architecture; working. 3.2 KDD (Knowledge Discovery in Databases): KDD steps-data selection, data pre-processing, data transformation, data mining, evaluation, knowledge. 3.3 Data mining: Importance of data mining; Architecture of data mining systems; Steps in KDP (Knowledge Discovery Patterns); 3.4 Data mining algorithms- Apriori algorithm; application of Apriori algorithm in bioinformatics- frequent annotation mining.	**12 hrs**
Module 4	4.1. Introduction to data structure: data management concepts; data types – primitive and non-primitive; types of data structures- linear & non-linear data structures. 4.2 Trees: terminologies; traversals- inorder, preorder, post order; applications of tree- suffix tree, spanning tree. 4.3 Graphs: definition; different types of graphs; graph models; basic terminology; representing graphs; graph traversals - depth-first traversal, breadth-first traversal; shortest-path algorithm; Dijkstra's algorithm; minimum spanning tree; prim's and Kruskal's algorithms. 4.4 Applications of graphs: evolutionary tree construction; protein structural domain decomposition.	**12 hrs**

LEARNING RESOURCES

1. Introduction to Algorithms, fourth edition by Thomas H. Cormen **,** Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, 2022
2. Algorithms in a Nutshell, second edition by George T Haineman, Garry Pollice, Stanley Selkow,2016
3. Analysis of algorithms - An active learning approach by Jeffrey. J. McConnell, 2nd Edition, Jones & Bartlett Learning, 2009
4. Algorithms in Computational Molecular Biology Techniques, Approaches and Applications By Mourad Elloumi, Albert Y. Zomaya · 2011
5. Biological Network Analysis Trends, Approaches, Graph Theory, and Algorithms By Pietro Hiram Guzzi, Swarup Roy · 2020
6. An introduction to bioinformatics algorithms by Neil C. Jones, Pavel Pevzner. MIT Press.2004
7. Algorithms for Molecular Biology by Ron Shamir Lecture, Fall Semester, 2001

8. Bioinformatics: the machine learning approach by Pierre Baldi, Søren Brunak. MIT Press.2001
9. Algorithms in Bioinformatics by Benson G. and Page R. D.M, Springer, 2003
10. Introduction to Computational Biology-Maps, sequences and genomes by Michael Waterman, Chapwan& Hall/CRC, 2000.
11. Computational Molecular Biology- An Algorithmic Approach, Pavel A.Pevzner, MIT Press,2000

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Illustrate basic steps of designing an algorithm (3 Marks)
2. List down the biological applications of Hill climbing algorithm. (3 Marks)
3. Compare biological and computer algorithms. (5 Marks)
4. How does data structure Tree differ from Graph? (5 Marks)
5. Explain how HMM used in predictions. (10 Marks)

Semester	Type of Course	Course Code	Course Name
III	**Core**	**MSCPB03DSC17**	**Practical 7: Cheminformatics and Computer Aided Drug Designing**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	4	2	-	60	60	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

This laboratory course on Cheminformatics and Computer-Aided Drug Designing offers hands-on training in the application of computational tools to analyze and manipulate chemical data, predict properties of compounds, and optimize their structures for drug development, to aid in the discovery and design of new drugs. The course also provides hands-on session on application of molecular dynamics simulation tools in computer-aided drug designing. Students will gain insights into the application of computers in various fields of drug discovery.

COURSE OBJECTIVES:

- To learn the steps involved structure-based and ligand-based drug designing
- To learn the molecular dynamics simulation methodology.
- To understand the different steps involved in molecular docking
- To learn the application of various computer tools to aid drug discovery

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Learn to use different molecular visualization tools
CO2	Design and perform molecular docking experiments
CO3	Hands on experience in molecular dynamics simulations tools
CO4	Learn the steps in involved in de novo ligand designing
CO5	Hands on experience in ligand based virtual screening
CO6	Understand ADME prediction tools and its importance in drug development
CO7	Hand on experience in QSAR model building and structure-activity prediction

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

(The laboratory work will consist of any 5-7 experiments from the following list)

1. Identification of various chemical interactions in biomolecular complexes using visualization tools (Pymol/VMD)
2. Finding the best possible binding mode of ligand to protein using protein-ligand docking protocols.
3. Explore structural dynamics of protein in water using molecular dynamics (MD) simulations tools.
4. De novo ligand designing
5. Ligand-based virtual screening – Substructure/similarity search using different ligand databases
6. Ligand-based virtual screening - Pharmacophore mapping and virtual screening
7. Computation of pharmacokinetic properties of small molecules
8. ADME prediction of small molecules and evaluation of drug-likeness
9. Predicting structure-activity relationship using QSAR modelling

LEARNING RESOURCES

1. Chemoinformatics: Concepts, Methods, and Tools for Drug Discovery: 275 (Methods in Molecular Biology) by Jurgen bajorath, Humana Press, 2010.
2. http://www.mdtutorials.com/gmx.
3. Computational Modeling and Simulations of Biomolecular Systems by Benoît Roux, World Scientific Publishing Company, 2021.
4. Advances in QSAR Modeling: Applications in Pharmaceutical, Chemical, Food, Agricultural and Environmental Sciences by Kunal Roy, Springer, 2017.
5. Molecular Docking for Computer-Aided Drug Design: Fundamentals, Techniques, Resources and Applications 1st Edition by Mohane S Coumar, Academic Press, 2021.

TEACHING LEARNING STRATEGIES

- Laboratory exercises, Assignments, Record evaluation

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Semester	Type of Course	Course Code	Course Name
III	**Core**	**MSCPB03DSC18**	**Practical 8: Computational Systems Biology**

Credits			**Teaching Hours**			**Assessment**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	2	1	-	30	30	40	60	100

L/T = Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The 'Computational Systems Biology' practical course will provide students with the opportunity to gain hands-on experience and explore real-world applications. During this course, students will be engaged in visualize, analyze, simulate complex biological pathways and networks, allowing them to enhance their skills in computational biology and network analysis

COURSE OBJECTIVES:

- To provide students with a comprehensive understanding of complex interactions and relationships within biological systems.
- To offer a user-friendly platform for visualizing and analyzing biological networks, enabling students to comprehend complex biological phenomena.

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Develop skills in visualizing and analyzing biological pathways and networks using cytoscape
CO2	Utilize igraph, gephi for visualizing and analyzing biological networks to interpret complex biological data.
CO3	Acquire skills in simulating and analyzing biological networks, including interventions on network behavior and the study of emergent properties.

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

1. Visualization and analysis of various molecular interaction networks and biological pathways and integrating of networks with annotations, gene expression profiles etc using Cytoscape.
2. Network analysis using igraph.
3. Visualization and analysis biological networks using Gephi.
4. Simulation and analysis of biochemical networks and their dynamics using COPASI.

LEARNING RESOURCES

1. An introduction to computational systems biology: system level modelling of cellular networks. 1st edition CRC Press by Karthik Raman, 2021.
2. An introduction to systems biology: design principles of biological circuits, 2nd edition by Uri Alon, 2020.
3. Modeling and simulation in systems biology: from concepts to petri nets to virtual physiology by G.Defabritiis and A.Tribiani, 2018.

TEACHING LEARNING STRATEGIES

- Laboratory exercises, Assignments and Record evaluation

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Semester	Type of Course	Course Code	Course Name
III	**Core**	**MSCPB03DSC19**	**Practical 9: Big Data Biology**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	4	2	-	60	60	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The practical course on "Big Data Biology" is designed for the students to acquire hands-on experience in the field of genomic data analysis and its biological interpretation. The course is focused on NoSQL databases also.

COURSE OBJECTIVES:

- To familiarize with big data processing
- To get hands-on experience in NGS data quality check and analysis
- To familiarize with interpretation of genomic data with respect to different biological problems
- To familiarize with genomic data analysis using R

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Explain about different NoSQL databases
CO2	Analyze and interpret DNA sequencing data

CO3	Analyze RNA-Seq data
CO4	Analyze metagenomic data
CO5	Evaluate genomic data using R

COURSE CONTENTS

(The laboratory work will consist of any 4-6 experiments from the following list)

1. Differentiate between different types of NoSQL databases (MongoDB, Cassandra, Redis and Neo4j)
2. How to identify genetic disorders from the given genome: Identify the structural variants within DNA sequences (Galaxy / VM VirtualBox)
    a. Retrieve NGS data
    b. Perform the quality check analysis of NGS data
    c. Alignment or mapping of NGS data
    d. NGS data analysis
3. Identification of mutations
4. Correlation of structural variants to biological processes
    a. Variant prevalence
    b. Functional impact
    c. Assertion of clinical significance
5. Identification of differentially expressed genes from RNA-Seq data (Bioconductor)
6. Examine the diversity of organisms present in specific environments as well as human body (Analyze metagenomic data)
7. Statistical analysis and data visualization of genomic data using R- ggplot, dplyr, seqinr, Biostrings.

LEARNING RESOURCES

1. Computational Genomics with R by Altuna Akalin, CRC Press, 2020
2. Next-generation Sequencing Data Analysis by Xinkun Wang, CRC Press, 2021

3. Big Data Analytics in Chemoinformatics and Bioinformatics- With Applications to Computer-Aided Drug Design, Cancer Biology, Emerging Pathogens and Computational Toxicology by Subhash C. Basak, Marjan Vračko, Elsevier Science, 2022
4. http://www.sthda.com/english/wiki/visualize-ngs-data-with-r-and-bioconductor

TEACHING LEARNING STRATEGIES

- Laboratory exercises, Assignments, Record evaluation

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60 %
Continuous Evaluation	40 %

Semester	Type of Course	Course Code	Course Name
III	**Elective**	**MSCPB03DSE08**	**Introduction To Machine Learning**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I = Practical/Internship, CE = Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course 'Introduction to Machine Learning' is a foundational course that provides an overview of the fundamental concepts, algorithms, and techniques used in the field of data mining and machine learning. In this course, students are initially introduced to the basic principles and techniques of data mining and data preprocessing. Later part of the course will be focused on providing the basic principles and techniques of machine learning, including supervised learning, unsupervised learning, and reinforcement learning. They learn how to train and evaluate machine learning models using real-world datasets, and understand the underlying mathematical and statistical principles behind these models.

COURSE OBJECTIVES:

- To learn various mining techniques and to analyze biological data in order to explore the hidden patterns
- To understand the concepts of datamining and data preprocessing models
- To make few predictions by learning the concepts of classification and prediction methods
- To understand machine learning concepts of supervised, unsupervised and reinforcement learning algorithms
- To demonstrate the application of machine learning algorithms with real-world examples

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Mine data from databases using classification and clustering algorithms
CO2	Explain naïve bayes classification theorem and identify basic clustering methods
CO3	Understand KNN algorithms and their applications in bioinformatics
CO4	Explain SVM techniques and ANN terminologies
CO5	Understand concept of decision tree, linear regression and other applications in machine learning

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 Overview: data mining; process; KDP (Knowledge Discovery Process). 1.2 Data pre-processing: an overview; data quality; major tasks in data pre-processing. 1.3 Data cleaning. 1.4 Data integration: entity identification problem; tuple duplication; issues in data integration. 1.5 Data reduction: methods; data cube aggregation, data compression methodologies. 1.6 Transformation and discretization: strategies; techniques; data transformation by normalization. 1.7 Mining frequent patterns: basic concepts; market basket analysis.	**10 hrs**

Module 2	2.1 Basic concepts: classification and prediction; clustering. 2.2 Bayes' classification method: Bayes' theorem; Naive Bayesian classification. 2.3 Rule-based classification: using IF-THEN rules. 2.4 Cluster analysis:requirements; overview of basic clustering methods - partitioning, hierarchical, density-based, grid-based, model-based, constraint-based. 2.5 Advantages and disadvantages: classification and clustering. 2.6 Algorithms: K-mean and KNN algorithmand their applications in bioinformatics.	**10 hrs**
Module 3	3.4 Support vector machines: introduction; hyperplane separation (maximum and soft margin hyperplanes); linear classifier; kernel functions; large margin classification; optimization problem with SVM. 3.5 Applications of SVM in bioinformatics. 3.6 Artificial neural networks: introduction; ANN terminology-weights, bias, activation function, threshold, learning rate, target value, error; perceptron model-simple perceptron for pattern classification, multilayer perceptron. 3.7 Models of ANN - McCulloch-Pitts neuron model, Adaline model; back propagation- static back propagation, recurrent back propagation, advantages and disadvantages of back propagation. 3.8 Applications of ANN -secondary structure prediction.	**12 hrs**
Module 4	4.1 Introduction; need for machine learning; machine learning process; classification of machine learning. 4.2 Supervised learning – how it works?, types - linear regression, classification – types of learners, algorithms - decision tree; 4.3 Unsupervised learning – types; working process; algorithms - advantages and disadvantages; 4.4 Semi-supervised learning – basics, working process; 4.5 Basics of reinforcement learning. 4.6 Applications of machine learning in biology: drug discovery, gene prediction, structure prediction	**13hrs**

Demonstration sessions (for demonstration, not to be included as a part of ESE):

Following machine learning basics will be demonstrated in the computer lab, using python.

- Data preparation in machine learning. (Data sets like Kaggle, NCBI etc.)
- Building simple machine learning models (For example: screening candidateresumes, image recognition etc.)
- Machine learning techniques in biology (For example: DNA sequencing, disease prediction etc.)

LEARNING RESOURCES

1. Data Mining: Concepts and Techniques, 3rd ed 2012, Jiawei Han, Micheline Kamber and Jian Pei. Elsevier Inc.
2. Deep Learning in Bioinformatics, 1st Edition, Habib Izadkhah - January 8, 2022.
3. Data Mining for Bioinformatics, 1st Edition, By Sumeet Dua Pradeep Chowriappa by CRC Press, 2013.
4. Data Analytics in Bioinformatics: A Machine Learning Perspective, 2021 by RabinarayanSatpathy (Editor), Tanupriya Choudhury (Editor), Suneeta Satpathy (Editor), Sachi Nandan Mohanty (Editor), Xiaobo Zhang (Editor).
5. Data Mining for Bioinformatics Applications, 1st Edition 2015 He Zengyou, eBook ISBN: 9780081001073, Hardcover ISBN: 9780081001004.
6. Insight into Data Mining- Theory and Practice- K. P. Soman, Shyam Diwakar, V. Ajay, PHI, 2006.
7. Introduction to Data Mining, Pang-Ning Tan, Michael Steinbach and Vipin Kumar, 2016 Pearson India Education Services Pvt. Ltd.
8. Data Mining and Knowledge Discovery Handbook. Oded Maimon, Lior Rokach (Eds). 2nd Edition 2010, Springer New York.
9. Machine Learning for Beginners, by Harsh Bhasin, BPB Publications 2020.

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. What are different types of machine learning algorithms? (3 Marks)
2. Define Bayes' theorem. (3 Marks)
3. Explain applications of SVM in bioinformatics (5 Marks)
4. Differentiate between a tree and a graph data structures. (5 Marks)
5. Describe the steps in KDD process. (10 Marks)

Semester	Type of Course	Course Code	Course Name
III	**Elective**	**MSCPB03DSE09**	**Environmental Microbiology**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

L/T = Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

Students will learn about microbiology in the environment, the study of microbes in natural settings like land, water, and air, through this course. Along with commonly used biology techniques, the analysis will concentrate on microbial diversity, physiology, biochemistry, function, and ecology. Additionally covered may be topics in climate microbiology min extreme conditions.

COURSE OBJECTIVES:

- Microbial biodiversity in different environments and factors affecting microbial population.
- Environmental, Agricultural, Medical and Industrial applications of microorganisms.

COURSE OUTCOMES:

Course Learning Outcomes: At the end of the Course, the Student will be able to -

CO1	Explain and demonstrate the dispersal and adaptability of diverse microorganisms in different environments
CO2	Evaluate the role of microorganisms and their beneficial aspects in environment
CO3	Evaluate the role of microorganisms and their beneficial aspects in agriculture, health and industry
CO4	Evaluate the role of microorganisms and their beneficial aspects in health and industry

Course Contents:

Module	Description	Teaching Hours
Module 1	1.1 Microbial behavior in ecosystems: Microbial biodiversity, Interactions among microbial populations. Animal-microbe and plant-microbe interactions. 1.2 Microbiology of soil: Soil as habitat for microorganisms. Soil microflora, Decomposition of organic matter - Soil as source of industrial strains. 1.3 Biodegradation of recal citrants by soil microbes. 1.4 Geocycles of C, N, S, P. iron and sulphur oxidation. N2 fixation.	**10 hrs**
Module 2	2.1 Microbiology of water: Microbial communities in aquatic environments, factors affecting microbial population in natural waters, Air water interface, Microbial Corrosion, 2.2 Bacteriological analysis of drinking water. Water purification and various steps involved. 2.3 Microbiology of air: Composition of air micro flora, Significance of air micro flora, Airborne diseases, Hazards of laboratory techniques, Air sanitation. Biological weapons, their regulation and precautions.	**12 hrs**

	2.4 Microorganisms in extreme environments: Environmental Determinants that Govern Extreme environments, Extremes of pH & temperature, salinity, Hydrostatic pressure, Nutrient limitation.	
Module 3	3.1 Pollution and environment, Biosensors and Biological indicators, 3.2 Waste water management and sewage treatment, BOD concepts, Solid waste management and landfilling, 3.3 Degradation of xenobiotics, Microbes and bioremediation. 3.4 Microbial Biofilms: Physiology, Morphology and Biochemistry of microbial bio films	**11 hrs**
Module 4	4.1 Production of microbial biofertilizers– cyanobacteria, Rhizobium, Azotobacter, Azospirillum, Phospho bacteria and VAM, Biopesticides 4.2 Microbes as a health food (SCP)- Spirulina and its production methods. Probiotics- use of Lactobacilli and Bifidobacterium- therapeutic and nutritional value 4.3 Microbial enhanced oil recovery, Microbial production of fuels. 4.4 Microbial leaching of ores and biomining, Biopolymers and biosurfactants.	**12 hrs**

LEARNING RESOURCES

1. R.M. Atlas and R. Bartha (1998) Microbial Ecology-Fundamentals and Applications. Addison Wesley Longman Inc.
2. Buckley R G, Environmental Microbiology by, CBS
3. N.S. Subbarao, Biological Nitrogen Fixation
4. Alexander and Martin , Microbiology of Soil
5. Soil Microbiology. Mark Coyne Thompson Learning
6. Ivanov, Environmental Microbiology for Engineers, Taylor &Francis Exclusive (Cbs)

Teaching Learning Strategies

- Assignments, Internal examinations/Unit tests, Seminar presentations

Mode of Transaction

- Off-line mode, Black Board and Chalk, PowerPoint presentation

Assessment Rubrics

	weightage
End Semester Evaluation	60%

Continuous Evaluation	40%

Semester	Type of Course	Course Code	Course Name
III	**Elective**	**MSCPB03DSE10**	**Biotechnology in Medicine, Health, Agriculture and Environment**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	3	45	-	45	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course aims to highlight the applications and advances in Biotechnology in the field of Medicine, Health, Agriculture and Environment.

COURSE OBJECTIVES:

- Apply Biotechnological techniques to the current lacunae in the field of agriculture, medicine and environment conservation
- Analyze and explain the need of biotechnology in improving day to day life

- Impress upon the application of biotechnological tools

COURSE OUTCOMES:

Course Learning Outcomes: At the end of the Course, the Student will be able to –

CO1	Evaluate the use of Biotechnology tools and products in the field Medicine
CO2	Suggest biotechnological tools for betterment of Health
CO3	Differentiate between the old and new approaches of improving agriculture
CO4	Analyze the use of biotechnology to solve environmental issues
CO5	Suggest biotechnological tools for betterment of aquaculture, forestry, wildlife, and veterinary sciences

Course Contents

Module	Module contents	Teaching Hours
Module 1	1.1 Developments in gene therapy 1.2 Molecular basis, identification, and cure of genetic disorders: like Immunodeficiencies, Diabetes mellitus, coronary artery disease, Neurogenetic disorders, cancer, Muscular Dystrophy, mitochondrial disease 1.3 Diagnosis based on genomic and cDNA microarray 1.4 1.4 Therapies based on RNA and stem cells.	**10hrs**
Module 2	2.1 Gene edited plants and transgenic plants grown as crops. 2.2 Bioreactors in plant production and scale up. Plants as bioreactors 2.3. Engineering for secondary metabolites, herbicide resistance and improvement of food quality 2.4 Biofertilizers, Biopesticides	**12hrs**
Module 3	3.1 Biotechnological monitoring of air, water, and soil pollution. 3.2 Biosensors. Biological indicators 3.3 Strategies for waste management and control. 3.4 Biofuels Biofuels: biogas; bioethanol; biodiesel;	**11hrs**

	biohydrogen 3.5 Bioremediation: Fundamentals, methods, and strategies of application (biostimulation, bioaugmentation) – examples	
Module 4	4.1 Biotechnologically produced clinical products. 4.2 Nanomedicine: Nanodevices medical microbots, nanorobotics, nanomedicine, nanosurgery 4.3 Nanoparticles for biological assays and as drug delivery vehicles 4.4 Applications of Biotechnology in aquaculture, forestry, wildlife, and veterinary sciences.	**12hrs**

LEARNING RESOURCES

1. Singh, B., Mal, G., Gautam, S.K., Mukesh, M. (2019). Biotechnology for Wildlife. In: Advances in Animal Biotechnology. Springer, Cham. https://doi.org/10.1007/978-3-030-21309-1_46
2. An Introduction to Molecular Biotechnology: Fundamentals, Methods and Applications. Michael Wink (Ed) Germany: 2021. Wiley.
3. Gene cloning and DNA analysis: An Introduction 8th Edition T.A. BrownWileyBlackwell 2020
4. Principles of NanomedicineSourav Bhattacharjee (Ed) 1st Edition 2019 Jenny Stanford publishing DOIhttps://doi.org/10.1201/9780429031236Taylor and Francis
5. Techniques for Wildlife Investigation and Management, 6th Ed., C. Braun 2005.TheWildlifeSociety, Bethesda,MD.
6. Forest genomics and biotechnology Pages: 142 – 158 Editors: R. Mellan,M. Kirst 2019 Cabi digital library
7. Agina Onyinyechukwu Ada Animal Research International (2022) 19(3): 4604 – 4616 Application of advanced biotechnology tools in veterinary medicine
8. Agricultural Biotechnology: Latest Research and TrendsDinesh Kumar Srivastava, Ajay Kumar Thakur, Pankaj Kumar (Ed) 2021 Springer
9. Environmental Biotechnology: For Sustainable Future Ranbir Chander Sobti, Naveen Kumar Arora, Richa Kothari (Ed) 2019 Springer

10. Genetic Engineering: Emerging Concepts and Technologies Patrick Faraday 2018 Syrawood Publishing House

11. Handbook of Advanced Approaches towards Pollution Prevention and Control Volume I: Conventional and Innovative Technology and Assessment Techniques for Pollution Prevention and Control Edited by Rehab O Abdel Rahman and Chaudhery Mustansar Hussain 2021 Elsevier Inc.

12. Handbook of Biofuels Sanjay Sahay (Ed) 2021 Elsevier Inc.

Teaching Learning Strategies

- Assignments, Internal examinations/Unit tests, Seminar presentations

Mode of Transaction

- Off-line mode, Black Board and Chalk, PowerPoint presentation

Assessment Rubrics

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions to test Outcomes.

1.How can we improve food quality through genetic engineering? Explain with examples (10 marks 2 questions)

2. Using DNA microarray how would you detect the cause of a particular type of cancer (5 marks 5 questions)

3. How would you make an iPSC (3 marks x 5 questions)

SEMESTER IV

Total Credits: 16, Period: 5 Months

Semester	Type of Course	Course Code	Course Name
IV	**Core**	**MSCPB04DSC20**	**Research & Dissertation**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
-	-	12	-	5	25	40	60	100

Students have to take up a research project of 5 months duration in the fourth semester for which they are encouraged to go to national research institutes or industries. The students may also get opportunity to undergo 1-2 weeks training in industrial / research institutions in the field. The candidate has to present the project before the board of examiners which will be followed by a viva voce. The ESE of the project will be based on the dissertation (weightage 20), its presentation (weightage 20) and viva voce (weightage 20). The weightage from CE and ESE for Project /Dissertation work will be in the ratio of 40:60, with a total of weightage 100.

Semester	Type of Course	Course Code	Course Name
IV	**Elective**	**MSCPB04DSE11**	**Introduction to Parallel and Cloud Computing**

Credits			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	2	30	-	30	40	60	100

L/T = Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The Introduction to Parallel and Cloud Computing theory course provides students with a comprehensive understanding of the fundamental concepts, principles, and technologies related to parallel and cloud computing. This course explores the world of distributed computing, parallel processing, and cloud infrastructure, preparing students for the challenges and opportunities in today's computing landscape.

COURSE OBJECTIVES:

- To learn concepts of client server architecture
- Understand the need of high-performance computing
- To learn parallel programming
- Understand cloud computing concepts and service models
- To practice few parallel programming and cloud computing programs

COURSE OUTCOMES:

At the end of the course, the student will be able to

CO1	Understand computer networks, networking devices and client server architecture concepts

CO2	Understand parallel computing and computer memory architecture
CO3	Differentiate serial and parallel processing
CO4	Design parallel programs
CO5	Understand concept of cloud computing
CO6	Explain cloud computing service models
CO7	Design virtual programs

**Course outcomes based on revised Bloom's taxonomy*

COURSE CONTENTS:

Module	Description	Teaching Hours
Module 1	1.1 Computer network: characteristics. 1.2 Network devices: router; hub; switch; gateway; network cards; cable modem; wireless modem; Guided and unguided media. 1.3 Data communication: ISDN; OSI reference model; TCP/IP model. 1.4 Network topologies: bus; star; tree;mesh. Types of networks: PAN; LAN; MAN; WAN. 1.5 Concepts of client server architecture Concept of search engine: database search engines.	**10hrs**
Module 2	2.1 Need of high-performance computing; Parallel computing overview- what is parallel computing? 2.2 Von Neumann computer architecture, Flynn's taxonomy; 2.3 Terminology: decomposition; task; task dependency graph; node; granularity; fine grained decomposition; coarse grained decomposition; maximum degree of concurrency; average degree of concurrency; critical path; critical path length; speedup; task interaction graph; pipeline; scalability; shared memory; load; work of time. merits and demerits of parallel computing. 2.4 Memory architecture: shared; distributed; hybrid. determining priority. reporting.	**11hrs**
Module 3	3.9 Serial vs parallel processing: need to parallelize; parallel overhead. 3.10 parallel programming models: shared memory model; thread model; distributed model; data parallel model; hybrid	**12hrs**

	model; SPMD and MPMP. 3.11 designing parallel programs: automatic vs manual parallelization; understand the problem and program; partitioning; communications; synchronization; data dependencies; load balancing; granularity; I/O; debugging; performance analysis and tuning. 3.12 job submission with slurm: batch jobs, interactive jobs; job scheduling; slurm commands; sbatch options; slurm environment variables; application timing; time command.	
Module 4	4.1 Overview of cloud computing: what is cloud? 4.2 Terminology: computing resources; virtualization; cloud computing software; hypervisor; virtual machine; container. cloud computing architecture: front end (client infrastructure); internet; back end (application, service, runtime cloud, storage, management, security). 4.3 cloud computing types: public cloud; private cloud; hybrid cloud. 4.4 cloud computing service models: Iaas; Paas; Saas. advantages of cloud computing. risks in using cloud computing. ***Demonstration sessions (for demonstration, not to be included as a part of ESE):***Following parallel and cloud computing basics will be demonstrated in the computer lab. Demonstration of Parallel computing (compatible with next flow) 1. Register-Memory and remote memset operations 2. Demo program to parallelize a loop in python Demonstration of cloud computing (compatible with Jetstream) 1. Make use of virtual box for implementing virtualization concept. 2. Execute Linux commands in virtual machine.	**12hrs**

LEARNING RESOURCES

1. Parallel computers architecture and programming By V. Rajaraman, Ram Murthy C. Siva, 2016, PHI learning private limited.
2. Advances on P2P, Parallel, Grid, Cloud and Internet Computing: edited by Leonard Barolli, Peter Hellinckx, JuggapongNatwichai, 2019, Springer.
3. An Introduction to Parallel Programming by Peter Pacheco, Matthew Malensek,2022, MK.
4. Cloud Computing: Concepts, Technology & Architecture By Thomas Erl, Ricardo Puttini, Zaigham Mahmood, 2013, Prentice Hall
5. Cloud computing: M.N. Rao, 2015, PHI learning private limited.

TEACHING LEARNING STRATEGIES

- ICT enabled classes, Quizzes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes:

1. Differentiate LAN and WAN. (3 Marks)
2. Briefly discuss the benefits of cloud computing. (3 Marks)
3. Explain Flynn’s classification. (5 Marks)
4. What is the usage of virtualization platform in implementing cloud? (5 Marks)
5. List the applications of parallel processing (10 Marks)
6. Discuss various cloud computing service models (10 Marks)

Semester	Type of Course	Course Code	Name of the Course
IV	**Elective**	**MSCPB04DSE12**	**ETHICS, PATENCY AND INTELLECTUAL PROPERTY RIGHTS**

Credit			Teaching Hours			Assessment weightage		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3		2	30		30	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course Ethics, Patency and Intellectual Property Rights was designed to offer the students, to explain the importance of life forms, problems associated with the genetic alteration of life forms, the various types of intellectual property rights, importance of biosafety and the different levels of biosafety.

COURSE OBJECTIVES:

- To explicate how precious each life form is and the risks associated with altering the genetic makeup of an organism.
- To explain the ethical issues in biological research.
- To figure out India's IPR policy and the patent system in India.
- To interpret the importance of maintaining the biosafety measures

COURSE OUTCOMES:

On successful completion of the course, students will be able to -

CO1	To explicate the importance of individual life forms.
CO2	To point out the ethical issues associated with biological research.
CO3	To illustrate the patents and patent procedures in India.
CO4	To figure out the biosafety levels.

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1: Introduction to Bioethics 1.2: Ethical aspects of interfering in the natural process, Ethical issues associated with ART, Prenatal diagnosis, Bioethics in animal cloning, Ethical issues associated with stem cell research, Ethical issues with the use of animal models. 1.3: Ethics in human research- The Nuremberg code, The declaration of Helsinki, The Belmont report. 1.4: Ethical issues of transgenesis, Ethical issues related to GMOs.	**7 hrs**
Module 2	2.1: Patent, Types of patents, product patent and process patent. 2.2: General requirement of Patent law, Patent offices, Procedure to get a patent in India. claims, types of claims.	**8 hrs**

	2.3: Harmonization of Patent laws, international treaties on IPR, GATT, TRIPS, Strasbourg convention, UPOV convention. 2.4: Transfer of Technology. 2.5: Biopiracy, Bioterrorism	
Module 3	3.1: Patentability of microorganism, characterization and repeatability, Deposition of Culture collection, Budapest treaty, IDAs, 3.2: Diamond V. Chakrabarty case, Dimminaco A.G.V. Controller of Patents and Designs case 3.3: Patentability of transgenic animals, Onco mouse, Harvard college V. Canada (Commissioner of Patents) case.	**7 hrs**
Module 4	4.1: Biosafety, Definition, Objectives, Biological Containment (BC) and Physical Containment (PC) 4.2: Biosafety levels, Biosafety level Ⅰ, Biosafety level Ⅱ, Biosafety level Ⅲ, Biosafety level Ⅳ. The containment laboratory design and facilities. 4.3: Institutional biosafety committee (IBSC). Guidelines for rDNA research.	**8 hrs**

LEARNING RESOURCES

1. Bioethics for Scientist by John Bryant, Linda Baggott La Velle and John Searle, John Wiley & Sons Ltd, 2002.
2. Contemporary Issues in Bioethics by Tom L. Beauchamp & LeRoy Walters, 5th Edition.
3. Bioscience Ethics by Irina Pollard published in USA by Cambridge University Press,

New York. (2009).
4. Intellectual Property Rights under Globalization by Talwar Sabanna, Serials publications, New Delhi.
5. Intellectual property law by tina hart, linda fazzani & simon clark. (4th Edition), palgrave macmillan.
6. Agriculture and Intellectual Property Rights by V Santaniello, R E Evenson, D Zilberman and G A Carlson. University Press.
7. Intellectual Property by W R Cornish. (3rd Edition). Universal press.
8. Intellectual Property Law by Lionel Bently and Brad Sherman. Oxford, University press.
9. Intellectual Property Rights in Agricultural Biotechnology by F H Erbisch, K M Maredia. University press.

Teaching Learning Strategies

- Assignments, Internal examinations/Unit tests, Seminar presentations

Mode of Transaction

- Off-line mode, Black Board and Chalk, PowerPoint presentation

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions:

1. Biosafety cabinets? (3 marks)
2. Genetic make-up? (3 marks)
3. What is t-PA? (3 marks)
4. Write a short note on Process patent? (5 marks)
5. Describe the ethical issues behind stem cell biology? (5 marks)
6. Describe the term risk assessment? (5 marks)
7. Patentability of microorganism. Discuss? (10 marks)
8. Write a note on international treaties on IPR? (10 marks)
9. Explain about the guidelines for r DNA research? (10 marks)

Semester	Type of Course	Course Code	Name of the Course
IV	**Elective**	**MSCPB04DSE13**	**ENZYMOLOGY**

Credit			Teaching Hours			Assessment weightage		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
3	-	2	30	-	30	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

At the end of this course, students will gain knowledge about structure/activity relationships and its implications in enzyme mechanisms. They will also be capable of isolating and characterizing enzymes, know, and apply enzyme kinetics concepts, and know how to construct enzyme inhibitors. Students will also acquire skills to initiate a research or industrial career in food, pharmaceutics, or biotechnology.

COURSE OBJECTIVES:

- To understand the nomenclature, methods of isolation and purification, activity, and uses of enzymes.
- To understand the structure and function of enzymes.
- To understand enzyme kinetics and kinetic parameters
- To understand the mechanism of enzyme inhibition.

COURSE OUTCOMES:

At the end of the Course, the Student will be able to -

CO1	Explain the methods of isolation and purification, measurement of activity

	and uses of enzymes.
CO2	Explain the structure and function of enzymes.
CO3	Explain the kinetics of enzyme-substrate interactions.
CO4	Explain the mechanism of enzyme inhibition

COURSE CONTENTS:

Module	Description	Teaching Hours
Module 1	1.1 Basic definitions and nomenclature (EC recommended and classical) 1.2 Enzyme isolation and purification, measurement of enzyme activity, specific activity, molar activity (turnover number), criteria for purity 1.3 Coenzymes. Synthetic enzymes, abzymes, isoenzymes and ribozymes. 1.4 Use of enzymes in medicine and industry. Immobilized enzymes.	**07 hrs**
Module 2	2.1 Enzyme structure and function: folding of the polypeptide chain, active site and its location, binding site. 2.2 Allosteric enzymes: Subunit Interactions, regulation of enzyme activity, Jacob, and Monod model of allosteric enzymes, Koshland model 2.3 Detailed discussion using haemoglobin, ATPase (Effects of ATP and CTP) as examples 2.4 K class and V class allosteric enzymes. Structure and their function in metabolism	**08 hrs**
Module 3	3.1 Enzyme kinetics: Single substrate – single intermediate, Michaelis – Menten and Briggs – Haldane kinetics 3.2 Graphical analysis of kinetic data, progress curves, linear plots 3.3 Determination of Vmax and Km – experimental aspects 3.4 Importance of Km and Vmax	**08 hrs**
Module 4	1.1 Enzyme inhibition: Mechanisms and rate studies, degree of inhibition, competitive, non-competitive, and uncompetitive inhibition, activation 1.2 Graphical analysis (primary and secondary kinetic plots), 1.3 Two substrate reactions, sequential and Ping–Pong mechanisms,	**07 hrs**

	nature of rate equations, examples. Irreversible inhibition 1.4 Alteration of Km and Vmax in various types of inhibition. Feedback inhibition	

LEARNING RESOURCES

1. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, Trevor Palmer, Philip L.R. Bonner, 2008
2. Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins, Nicholas C. Price and Lewis Stevens, 1999
3. Essentials of Enzymology, Colby Smith, 2020
4. Fundamentals of Enzymology, Jo Phillips, **Ed:** 1st, 2020
5. Essentials of Enzymology, Rufus O. Okotore, 2015
6. Enzyme Kinetics- Bowden and Wharton
7. Immobilised Enzymes- Trevan
8. Handbook of Enzyme Technology- Alan Weisman- 3 rd ed Prentice- Hall
9. Enzyme Technology- Chapline and Bucke – Cambridge University Press
10. Biochemistry – Donald Voet & Judith Voet 1995. John Wiley and Sons, In

Teaching Learning Strategies

- ICT enabled classes, Assignments and Seminar presentations
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ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample questions to test outcomes

1. Describe the equations of enzyme kinetics
2. Discuss the methods used in enzyme kinetics
3. Evaluate kinetics of enzyme-substrate interactions
4. Illustrate different types of enzyme inhibition
5. Explore the mechanism of action of ribonucleotide reductase
6. Discuss the methods of isolation and purification

VALUE ADDITION COURSE

Semester	Type of Course	Course Code	Course Name
II	**Value addition course**	**MSCPB02VAC01**	**SCIENCE WRITING AND COMMUNICATION**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
2		2	30		30	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course 'Science Writing and Communication' is designed to impart the basic elements of good scientific communication skills to students.

COURSE OBJECTIVES:

This course is meant to develop and enhance the reading, analysing, written, verbal and visual media presentation skills required in areas of scientific research and communication.

COURSE OUTCOMES:

Course Learning Outcomes: At the end of the course, the student will be able to learn –

CO1	Learn the basic elements of good scientific writing
CO2	Learn structure of sentences and paragraphs
CO3	Develop effective communication and different presentation skills using professional ICT media and verbal communication formats

CO4	Learn different styles, sentence construction and identify common mistakes in written formats
CO5	Understand stages of the scientific communication (prewriting, drafting, revising, final edits, analyse the audience and purpose)
CO6	Understand plagiarism and learn how it can be avoided
CO7	Recognize authentic scientific literature sources and predatory journals
CO8	How to present scientific papers and posters at scientific forums

**Course Outcomes based on revised blooms taxonomy*

COURSE CONTENTS

Module	Description	Teaching Hours
Module 1	1.1 An overview on designing a research work -experimental design – format for writing thesis and papers – Formulation of hypothesis., ISBN & ISSN. Peer review. Impact factor and H-index of journals. 1.2 Essential features of abstract, Introduction, Review of literature, Materials and methods, results and discussion, Effective illustration, Tables and figures, reference style- Harvard and Vancouver system. Citation and Acknowledgement	**8 hrs**
Module 2	2.1 Speaking Skills – Importance of verbal and non-verbal communication. Voice modulation and emphasizing key phrases.	**6 hrs**
Module 3	3.1 Writing Skills – Common mistakes in sentence structuring. Importance of punctuation and grammar. – Identification of authentic scientific literature sources. Publishing and predatory journals. Identification of strong points in classic journal articles.	**8 hrs**
Module 4	4.1 Presentation tools: oral and poster, Microsoft PowerPoint and PDF slide ICT tools – Features of a good oral presentation. Effective utilization of ICT tools- PPTs and multimedia. 4.2 Effective PowerPoint presentations: Feature of a good PPT presentation. Contribution to scientific forums – Posters– Identification of scope of scientific forums- conferences,	**8 hrs**

	seminars and symposiums. Poster presentation techniques. Key features of an attractive scientific poster. Strategies for effective communication.	

LEARNING RESOURCES

1. Effective Science Communication - A practical guide to surviving as a scientist. Sam Illingworth and Grant Allen Published, IOP Publishing Ltd., 2016. ISBN: 978-0-7503-1171-7.
2. Science Communication - A Practical Guide for Scientists. Laura Bowater, Kay Yeoman, Wiley-Blackwell, 2013, ISBN: 978-1-119-99312-4.
3. Communication Skills for Engineers and Scientists. Sangetha Sharma and Binod Mishra. Prentice Hall India Learning Private Limited. 2009. ISBN-13: 978- 8120337190.
   On-line Sources
4. https://iversity.org/en/courses/scientific-writing-skills
5. https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/bes2.1258

Teaching Learning Strategies:

Assignments, Seminar Presentation on selected topics, Debates and projects.

Assessment:

Continuous evaluation / Formative Assessment by the faculty in charge of the course based on assignments, tests and presentation.

ABILITY ENHANCEMENT COURSE

Semester	Type of Course	Course Code	Name of the Course
II	**Ability Enhancement Course**	**MSCPB02AEC01**	**INTRODUCTION TO BIOLOGICAL DATABASES**

Credit			Teaching Hours			Assessment weightage		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
2	-	2	30	-	30	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course “Introduction to Biological databases” helps students to acquire information from different biological databases. The course also provides basic information about different tools in sequence alignment, structure prediction and proteomic data analysing. An introduction to next generation sequencing technologies is also included as a part of the course.

COURSE OBJECTIVES:

- To understand different biological databases
- To familiarize different methods for sequence alignment
- To familiarize protein and RNA structure prediction
- To understand different NGS technologies

COURSE OUTCOMES:

At the end of the Course, the Student will be able to -

CO1	Acquire information from different biological databases
CO2	Explain sequence similarity search

CO3	Explain different structural prediction methods
CO4	Explain NGS technologies and its different file types

COURSE CONTENTS:

Module	Description	Teaching Hours
Module 1	1.5 Biological databases: primary, secondary and composite databases; types of biological data. Database file formats: GenBank; FASTA; ALN/ClustalW2; PDB; PIR. 1.6 Information retrieval from biological databases: Nucleotide sequence databases: GenBank; EMBL; DDBJ. Protein databases: Uniprot; UniProtKB/TrEMBL; PIR; PDB, BMRB. Secondary and composite databases: Prosite; Interpro, MMDB; CATH; SCOP; BRENDA; KEGG. Specialist databases: OMIM, EST databases; SNP databases.	**8hrs**
Module 2	2.1 Database searching for similar sequences: introduction, FASTA sequence database similarity search, BLAST, Database searches with the smith waterman dynamic programming method, Database searches with a scoring matrix or Profile, searching sequence database with a position specific scoring matrix or sequence profile. 2.5 Introduction to Genomics and Proteomics. Tools for analysis of proteomics data (tools available at ExPASy proteomics server). Structure visualization tools: Rasmol, SPDBV, PyMol.	**7 hrs**
Module 3	3.1 Protein classification and structure prediction: introduction, alignment of protein structures, secondary structure prediction - Chou Fasman, GOR method. Tertiary structure prediction- Homology Modelling, Threading, Ab-initio method., evaluating the success of structure predictions 3.2 RNA structure prediction: introduction, self-complimentary regions in RNA sequences, minimum free energy method for RNA secondary structure prediction, suboptimal structure predictions by Mfold, RNA databases: RNA structure analysis and prediction tools.	**7hrs**
	4.1 Introduction to next generation sequencing (NGS): how to	

Module 4	sequence DNA; typical NGS experimental workflow; Illumina sequencing principle; ion torrent sequencing principle; pacific biosciences SMRT sequencing principle; nanopore sequencing technology. 4.2 Common file types used in NGS Data Analysis- BAM, BCF, BCL, FASTQ, SAM, VCF, WIG. Workflow for genome sequence data analysis.	**8 hrs**

Reading Lists:

1. Bioinformatics: Databases and Algorithms by N. Gautham; Alpha Science, 2006
2. Bioinformatics Sequence and Genome Analysis (2nd edition) by D. W. Mount; Cold Spring Laboratory Press, 2004
3. Structural Bioinformatics: An Algorithmic Approach by F. J Burkowski; CRC Press, 2008
4. Introduction to Bioinformatics (5th edition) by A. M Lesk, Oxford University Press, 2019
5. BLAST by J. Bedell, I. Korf and M. Yandell; O'Reilly Press, 2003
6. Bioinformatics Vol. 1, Data, sequence analysis & evolution (2nd edition) by J. M. Keith; Humana Press, 2017 .

Semester	Type of Course	Course Code	Name of the Course
II	**Ability Enhancement Course**	**MSCPB02AEC02**	**BIOETHICS AND BIOSAFETY**

Credit			Teaching Hours			Assessment		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
2	-	2	30	-	30	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course bioethics and biosafety is focusing on the core bioethical concerns of the twenty-first century and also provides good practices on biological laboratory safety. This includes the identification, assessment, and control of the broad variety of risks encountered in the lab. Every risk—no matter how small—must be considered, assessed, and properly mitigated. Biological safety and bioethics protocols are essential to the reputation and responsibility of every scientific institution, irrespective of whether research, academic, or industrial.

COURSE OBJECTIVES:

- To describe the ethical issues in biological research.
- To explain the ethical issues in healthcare sector.
- To provide students with biosafety skills and the ability to identify the risks involved.
- To familiarize students with the Biosafety guidelines in India.

COURSE OUTCOMES:

At the end of the course, the student will be able to -

CO1	Explain the ethical issues associated with human genome project

CO2	Explain the ethical issues associated with biological research.
CO3	Explain the different levels of biosafety in biological laboratory
CO4	Explain the biosafety guidelines in India and its management

COURSE CONTENTS:

Module	Description	Teaching Hours
Module 1	1.7 Introduction to Bioethics, need of bioethics, definition of bioethics, application to bioethics, ethical concerns involved with genetic research 1.8 Human genome project and its ethical issue: history of Human Genome Project, five perspectives on genomics, criteria for selection of genomes for sequencing, ethical, legal and social implications (ELSI) of HGP.	**6 hrs**
Module 2	2.1 Ethical aspects of interfering in the natural process, ethical issues associated with ART, prenatal diagnosis, bioethics in animal cloning, ethical issues associated with stem cell research, ethical issues with the use of animal models. 2.6 Evidence-based medicine and bioethics: Utilitarian and Deontological evidence-based medicine approaches, patient autonomy and bias, ethical issues in health care sector in India.	**7 hrs**
Module 3	3.1 Biosafety: Introduction, definition of biosafety, Biosafety Level (BSL) Practices – BSL 1, 2,3 & 4. Hazard levels, Standard microbiological practices, Safety equipment, Laboratory facilities, Biological Safety Cabinets an Overview 3.2 Biohazard Level and Significance- risk assessment of biological hazards, protozoa and helminths, mycotic agents, bacterial pathogens, viral agents of human diseases. Hazards Control-primary barriers, personal respiratory protection, standard	**9 hrs**

	precautions for handling fluids, tissues and cells. Decontamination in the microbiology laboratory, packing and shipping of biological materials.	
Module 4	4.3 Biosafety guidelines in India, Institutional Biosafety Committee: Role & Functioning, Categorization of GE Experiments and Approval requirements in India, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; 4.4 Risk Analysis: Risk Assessment; Risk management and communication. guidelines for research in recombinant DNA research and genetically modified plants. Measuring biosafety program effectiveness. Cartagena Protocol on Biosafety (BSP)-Socio-Economic Impacts.	**8 hrs**

LEARNING RESOURCES

1. Contemporary Issues in Bioethics by Tom L. Beauchamp, LeRoy Walters, 5th edition, Thomson/Wadsworth, 2008
2. Bioethics and Biosafety By M. K. Sateesh, I.K. International Publishing House Pvt. Limited, · 2013
3. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology By Padma Nambisan, Elsevier Science, ·2017
4. Safety, Ethics and Regulations, edited by Achim Rosemann, Phuc Van Pham, Springer International Publishing, 2017
5. Biological Safety Principles and Practices edited by Dawn P. Wooley, Karen B. Byers, Wiley, 2020.

MULTI DISCIPLINARY COURSE

Semester	Type of Course	Course Code	Course Name
III	**Multi-Disciplinary Course**	**MSCPB03MDC01**	**BASICS OF BIOTECHNOLOGY**

Credit			**Teaching Hours**			**Assessment weightage**		
L/T	P/I	Total	L/T	P/I	Total	CE	ESE	Total
4	-	4	60	-	60	40	60	100

Lecture/Tutorials, P/I=Practical/Internship, CE =Continuous Evaluation, ESE = End Semester Evaluation

Course Description

The course Basic Biotechnology was designed to equip the students with the basic techniques of Biotechnology, to explicate the tools required for genetic engineering, to figure out transgenic technology, and to demonstrate the advanced applications of Biotechnology.

COURSE OBJECTIVES:

- To explain the basic concept of Biotechnology.
- To explicate the important steps in genetic engineering.
- To explain the applications of genetic engineering.
- To expound the technology behind transgenic animals.

COURSE OUTCOMES:

On successful completion of the course, students will be able to -

CO1	Explain basic techniques of Biotechnology.
CO2	Apply essential tools required for genetic engineering
CO3	Expound the applications of genetic engineering
CO4	Explicate the applications of transgenic animals and transgenic plants.

COURSE CONTENTS:

Module	Description	Teaching Hours
Module 1	1.1: Biotechnology: Definition, Concept. 1.2: Traditional biotechnology 1.3: Development of modern biotechnology and Genetic engineering 1.4: Historical events that led to recombinant DNA technology.	**12hrs**
Module 2	2.1: Gene cloning, Basic steps in gene cloning. 2.2: Enzymes used in gene cloning 2.3: Vectors used in gene cloning, Selectable marker genes. 2.4: Host cells. 2.5: Various methods for the transfer of foreign genes to host cells, Transformation, Transfection. 2.6: Preparation of gene libraries, Screening of the genomic libraries, Storage of library.	**17hrs**
Module 3	3.1: Various techniques in r DNA technology, PCR, FISH, Chromosome microdissection, DNA finger printing. 3.2: Gene therapy, Somatic cell gene therapy, germline gene therapy, Gene augmentation therapy, Gene inhibition therapy.	**17hrs**
Module 4	4.1: Genetic engineering of animals and Generation of transgenic animals, Transgenic mouse models and its	**14hrs**

	applications. 4.2: Transgenesis of plants, genetically modified crops. 4.3: Genetically modified microbes.	

LEARNING RESOURCES

1. Introduction to Biotechnology (4th Edition) by William J. Thieman, Michael A. Palladino. Global Edition. Pearson Education Limited, 2020.
1. Gene Cloning an introduction (3rd Edition) T.A. Brown. Stanley Thornes (Publishers) Ltd, 1995.
2. DNA and Biotechnology (3rd Edition) by Molly Fitzgerald- Hayes and Frieda Reichsman. Academic press, 2010
3. Biotechnology. Applying the Genetic Revolution. By David P. Clark and Nanette J. Pazdernik. Elsevier Academic Press, 2009.
4. Molecular Biology. Structure and Dynamics of Genomes and Proteomes. By Jordanka Zlatannova and Kensal E. van Holde, Garland Science. Taylor & Francis Group, 2016.
5. Gene cloning an Introduction (3rd Edition) by T.A. Brown, Stanley Thornes (Publishers) Ltd.
6. From Genes to Clones. Introduction to Gene Technology by Ernst Winnacker. Translated by Horst Ibelgaufts. Panima Publishing Corporation. New Delhi.
7. Molecular Biotechnology Principles and Applications of Recombinant DNA (3rd Edition) by Bernard R. Glick and Jack J. Pasternak. ASM Press.
8. Introduction to Biotechnology (4th Edition) by William J. Thieman, Michael A. Palladino. Pearson Education Limited 2020.

Teaching Learning Strategies

ICT enabled classes, Assignments and Seminar presentations

ASSESSMENT RUBRICS

	weightage
End Semester Evaluation	60%
Continuous Evaluation	40%

Sample Questions:

1.What are vectors? (3 marks)

2. Molecular pharming? (3 marks)
3. What is Adapters? (3 marks)
4.Write note on selectable marker gene? (5 marks)
5. M13 phage is a good cloning vector. Explain? (5 marks)

Pattern of Question Papers

Time : 3 Hours Total Weightage: 60

Part A

Answer any five questions. Each question carries a weightage of 3

1.

2.

3.

4.

5.

6.

Part B

Answer any three questions. Each question carries a weightage of 5

7.

8.

9.

10.

11.

Part C

Answer any three questions. Each question carries a weightage of 10

12.

13.

14.

15.

16.