M. Sc. Biotechnology Course Curriculum (2019-2020)

I st SEMESTER (MS1)

S.No.	Subject	L-T-P	Credits
1	General Microbiology	3-0-0	3
2	Molecular Genetics and Genomics	3-0-0	3
3	Biochemistry and Intermediary Metabolism	3-0-0	3
4	Research Methodology and Inferential Statistics	3-0-0	3
5	GLP and Bioinstrumentation	3-0-0	3
6	Introduction to IPR	3-0-0	3
7	General Microbiology lab.	0-0-2	1
8	Molecular Genetics and Genomics lab	0-0-2	1
9	Biochemistry and Intermediary Metabolism lab.	0-0-2	1
	Total	24	21

II nd SEMESTER (MS2)

S.No.	Subject	L-T-P	Credits
1	Immunology and Immunotechnology	3-0-0	3
2	Bioprocess Technology	3-0-0	3
3	Plant and Animal Biotechnology	3-0-0	3
4	Basic Bioinformatics	2-0-0	2
5	**Elective-I** Molecular and Clinical Diagnostics OR Quality Control and Quality Assurance	3-0-0	3
6	Immunology and Immunotechnology lab.	0-0-2	1
7	Bioprocess Technology lab.	0-0-2	1
8	Plant and Animal Biotechnology lab	0-0-2	1
9	Environmental Biotechnology	3-0-0	3
10	Basic Bioinformatics lab.	0-0-2	1
11	Masters Research review seminar	0-0-2	1
	Total	**27**	**22**

III rd SEMESTER (MS3)

S.No.	Subject	L-T-P	Credits
1	Food Biotechnology	3-0-0	3
2	Enzymology and Enzyme Technology	3-0-0	3
3	Recombinant DNA Technology	3-0-0	3
4	**Elective-II** Nanobiotechnology: Principles and Applications OR Cell Signaling	3-0-0	3
5	Food Biotechnology lab.	0-0-2	1
6	Enzymology and Enzyme Technology Lab	0-0-2	1
7	Recombinant DNA Technology Lab.	0-0-2	1
8	Master's Research Thesis Part-I	0-0-8	4
	Total	**26**	**19**

IV th SEMESTER (MS4)

S. No.	Subject	L-T-P	Credits
1	Master's Research Thesis Part-II	0-0-26	13
	Total	**26**	**13**

Total Credit Hours: 75

Electives: Elective courses would be offered from the exiting approved elective courses of the Department

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS

Course Title General Microbiology **(Core Course)**

Course Code

Course Credit 3

L	T	P
3	0	0

Course Coordinator

Course Objectives

To acquaint the students with the development and techniques of microbiology useful in biotechnology industry**.** Scientific evaluation of various characteristics of microorganisms, their metabolism and role in various domains of life.

Course Assessment

Assessment	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	course covered upto T1
T2 Test	25	1.5 hrs.	course covered upto T2, including that covered upto T1
End Term Test	35	2 hrs.	Whole Syllabus
Teacher Assessment (Based on Assignments, quizzes etc.)	25	Entire semester	Information to be provided to the class time to time
Total	**100**		

Course Outcomes

CO I	To acquire the principles of Microbiology and fundamental concepts related to microbial classification and methods
CO II	Scientifically test the hypothesis provided under a given situation involving microbial world and demonstrate practical skills in basic microbiological techniques including growth and control of microorganisms.
CO III	Analyze and interpret the experiments/pathways relevant to Microbes
CO IV	Designate vital role of the microorganisms in the environment and their genetics and association with human beings.
CO V	Retrieve and use cotemporary information and industrial potential related to microbial world.

Topic Covered

S. No.	Unit	Topics Covered	Contact Hrs.

1	**Introduction of Microbiology and Historical Perspective**	Discovery of microbial world, Landmark discoveries relevant to the field of microbiology, Controversy over spontaneous generation, History and pioneers in Microbiology, Nomenclature and classification of microbes, Bacterial metabolism, Sterilization and disinfection, Role of microorganisms in transformation of organic matter and in the diseases	5
2	**Methods in Microbiology**	Isolation, description and identification of bacteria. Microscopy and Morphology of micro-organisms, Pure culture techniques, Theory and practice of sterilization, Principles of microbial nutrition, Enrichment culture techniques for isolat of microorganisms, Growth and nutrition of bacteria,	3
3	**Microbial Taxonomy and Diversity**	Bacteria, Archaea and their broad classification, Eukaryotic microbes: Yeasts, molds and protozoa, Viruses and their classification, Molecular approaches to microbial taxonomy	3
4	**Microbial Growth And Control of microorganisms**	Definition of growth, Growth curve, Mathematical expression of exponential growth phase, Measurement of growth and growth yields, Synchronous growth, Continuous culture, Effect of environmental factors on growth, Effect of physical and chemical agents, Evaluation of effectiveness of antimicrobial agents	7
5	**Microbial Metabolism**	Energetics: redox reactions and electron carriers, An overview of metabolism, Glycolysis, Pentose-phosphate pathway, Entner-Doudoroff pathway, Glyoxalate Pathway, The citric acid cycle, Fermentation, Aerobic and anaerobic respiration, Chemolithotrophy	7
6	**Microbial Diseases**	Human diseases caused by viruses, bacteria, and fungi; The epidemiology, pathogenesis, antigenic characteristics and laboratory diagnosis of disease The nature and Classification of viruses, Morphology virus structure, replication The genetics of viruses The pathogenicity of viruses Epidemiology of viral infections, Vaccines and antiviral drug	5
7	**Microbial Genetics**	Types of mutation, UV and chemical mutagens, Selection of mutants, Ames test for mutagenesis, Bacterial genetic system: transformation, conjugation, transduction, plasmids, transposons, DNA repair, Regulation of gene expression: repression and induction, Operon model, Bacterial genome with special reference to *E. Coli*, Retroviruses	7
8	**Microbial Ecology And Industrial applications**	Thermophiles, Alkaliphiles, Acidophiles, Halophiles, Psychrophies, Radiophiles, Fermented foods and beverages, Biofertilizers, Biopesticides, Biofuels and Bioenergy	5
	Total Number of Lectures		42

Methodology

The course will be covered through lectures. Apart from discussions on topics covered in lectures, assignments and numerical problems will also be given.

TEXT BOOKS

1	Prescott, Harley and Klein: Microbiology, 6th Edition, McGraw Hill 2005.
2	Pelczar, Chan and Krieg: Microbiology by; Tata McGraw Hill.

REFERENCE BOOKS

1	Madigan, M.T., Martinko, J.M., Parker, J: Brock Biology of Microorganisms. 10th Edition.: Publisher: Prentice Hall
2	Gerard J. Tortura, Berdell R. Funke, and Christine L: Microbiology An Introduction: Case. 8th Ed., Pearson/Benjamin Cummings, 2004.
3	Nester : Microbiology Study Guide McGraw Hill.
4	Black : Microbiology : Principles and Applications Prentice Hall
5	Principles of Population Genetics by Daniel L. Hartl and Andrew G. Clark

Molecular genetics and Genomics

COURSE CODE
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: Molecular Biology, Biochemistry, Microbiology

Course Objectives

1. This is an advance course with objective expose students to the advanced topics of Molecular Cell Biology
2. Application of molecular biology and genetics in prognosis, diagnosis and understanding of human diseases

Course Outcomes

S.No.	Course Outcomes	Level of Attainment
CO-1	Students will have a thorough understanding elements of biomolecules (DNA, RNA and protein)	Familiarity
CO-2	The students will know the vast amount of genome information in publically available databases and how to access and best utilize for practical purposes & sequencing, genome annotation, global gene cloning and gene expression technologies, comparative genomics, introduction to pharmacogenomics	Assessment
CO-3	Able to analyze the gene expression data sets to derive the biologically meaning information	Assessment
CO-4	Able to apply the knowledge of function genomics in public health	Usage

Topic Covered

S. No.	Contents	Lecture required.
1	Introduction to Genetics, Genome, Transcriptome, Proteome	3
2	DNA: The Genetic Material. Genome. Replication, Unique aspects of eukaryotic replication, fidelity of replication, DNA damage, repair mechanisms, homologous and site-specific recombination,	6
3	Gene Expression: Transcriptome, Eukaryotic RNA polymerases, RNA synthesis and RNA processing in eukaryotes, RNA editing, splicing, and polyadenylation. Traciptional factors (Crz1, AflR)	6
4	Gene Expression: Proteome. Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post-translational modification of proteins.	6
5	Genomics. Genetic and physical mapping. Understanding of a genome sequence, Prokaryotic and eukaryotic genomes. Organization of human genome. Organellar genome. Genome sequencing- Pyrosequencing & Sequencing by reverse termination. Application of whole of transcripts sequencing.	6
6	Functional and Comparative Genomics. Transcripts/transcriptome analysis-Hybridization and sequencing based approaches. Serial Analysis of Gene Expression-SAGE, DNA- Microarray, Application of DNA Microarray, RT-PCR, etc	6
7	Basics of population Genetics. Single Nucleotide polymorphism. SNP screening platforms & analysis. Haplotyping: Concepts and Applications. Genetics of cancer Biology- role of Tumor proteins p53, tumor suppressor p53, or transformation-related protein 53 (TRP53). p53 isoforms. Association studies of p53 gene in different setting of cancers.	6
8	Biomarker. Pharmacogenomics: Concepts and Applications in healthcare. Role of genotype in drug metabolism. Identification & Utilisation of cancer bio-marker	3
	Total Contact Hours	42

REFERENCE BOOKS

1. Molecular Cell Biology by Lodish
2. Molecular Biology, PS Verma VK Agarwal
3. Principles of genetics / D. Peter Snustad, Michael J. Simmons Snustad, D. Peter

4. Discovering Genomics, proteomics & bioinformatics. Second edition by A Malcolm Campbell, Davidson College; Laurie J. Heyer Davidson College ; With Foreword by Francis S. Collins
5. Molecular Biology of the Gene (1987) Watson J. D., Hopking N., Robast J. and Steiz, J.
6. BIOINFORMATICS: A Practical Guide to the Analysis of Genes and Proteins (Third edition) Andreas D. Baxevanis & B. F. Francis Ouellette

Research and Review Articles:

1. Suggested Reference (s): Ronaghi M. Pyrosequencing sheds light on DNA sequencing. Genome Res. 2001
2. Jan;11(1):3-11. Review. PubMed PMID: 11156611
3. Schulze A, Downward J. Navigating gene expression using microarrays—a technology review. Nat Cell Biol. 2001 Aug;3(8):E190-5. Review. PubMed PMID: 11483980

4. Kim JB, Porreca GJ, Song L, Greenway SC, Gorham JM, Church GM, Seidman CE, Seidman JG. Polony multiplex analysis of gene expression (PMAGE) in mouse hypertrophic cardiomyopathy. Science. 2007 Jun 8;316(5830):1481-4. PubMed PMID: 17556586
5. MacBeath G, Schreiber SL. Printing proteins as microarrays for high-throughput function determination. Science. 2000 Sep 8;289(5485):1760-3. PubMed PMID: 10976071.
6. Shankar J, Wu TD, Clemons KV, Monteiro JP, Mirels LF, et al. (2011) Influence of 17b-Estradiol on Gene Expression of Paracoccidioides during Mycelia-to- Yeast Transition. PLoS ONE 6(12): e28402. doi:10.1371/journal.pone.0028402
7. Mary V. Relling, William E. Evans Nature. Author manuscript; available in PMC 2016 Jan 13.

Evaluation Scheme:

Assessment	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	Syllabus covered upto T-1
T2 Test	25	1.5 hrs.	Syllabus covered upto T-2
End Term Test	35	2 hrs.	Entire Syllabus
Teacher Assessment	25	Entire Sem	Based on Assignments, quizzes etc.

Molecular genetics and Genomics Laboratory

CO I	Students will have a thorough understanding of various genomic technologies SNP,, cDNA-PCR, etc
CO II	The students will know the vast amount of genome information in publically available databases and how to access and best utilize for practical purposes e.g., NCBI. DDBJ, EMBL.
CO III	Able to analyze the gene expression experimental data sets to derive the biologically meaning information
COIV	Identify, formulate, review research literature, and analyze complex

COURSE CODE
COURSE CREDITS: 2
CORE/ELECTIVE: CORE
L-T-P: 0-0-2

Pre-requisite: Molecular Biology, Biochemistry, Microbiology

Course Outcomes:

COV	Able to identify, formulate, review research literature, and analyze complex and asses health, safety, legal and issues

1. The course is intended to provide hand on experiments on comparative and functional genomics. Students will able to carry out both basic bioinformatics work and function genomics work.
2. The course will explore that how different advance molecular biology techniques unravel the understanding of diseases at genetic level

Course Outcomes:

Experiments covered:

Index

S.NO.	TITLE
1	Isolation of Genomic DNA from different organisms (prokaryotes, eukaryotes and higher eukaryotes).
2	Polymerase chain reaction
3	Detection of SNP through RFLP (Restriction Fragment Length Polymorphism).
4	Extraction of Total RNA from eukaryotic species.
5	Preparation of cDNA template from isolated RNA.
6	Pulsed Field Gel Electrophoresis (demonstration)
7	Designing of Primers from a given gene of interest using online tools.
8	Physical restriction mapping of gene of interest (In-silico).
9	Real-Time PCR to quantify expression of gene.

Reference books **& Laboratory Manuals**

1. Methods in Molecular Biology. Starkey, Michael P. Elaswarapu, Ramnath. Genomics Protocols. 2000. Vol. 175. Humana Press
2. Sambrook, J., Fritsch, E. F., Manitiatis, T., Molecular Cloning: A Laboratory Manual, New York: Cold Spring Laboratory Press, 1998, 25—27.
3. Current Protocols in Molecular Biology. Frederick M. Ausubel. John Wiley & Sons Inc. 1988

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Biochemistry and Intermediatery Metabolism
COURSE CODE
COURSE CREDITS: 3

CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: Cell Biology, structural biology, chemistry

Course Objectives

1. This is an advance course with an objectiveto provide an understanding of the various biomolecules and their chemical properties.
2. This course also has an objective to learn the interaction of bio-chemicals and their consequences on maintenance of life supporting processes.

Course Outcomes: In the end of the course, student will be able…..

S.No.	Course Outcomes	Level of Attainment
CO-1	to understand the fundamentals of various basic biomolecules present in organisms and their chemical structures.	Familiarity
CO-2	to understand the structural-functionalrelationship of biomolecules for sustainment of life processes.	Assessment
CO-3	to understand the metabolic pathways ofenergy production in living organism.	Assessment
CO-4	to understand the integration and regulation of various metabolic pathways of organism for maintenance of life supporting processes.	Usage

Topic Covered

	Contents	Lecture required.
1	General aspects of metabolism: Characteristics of metabolic pathways; Strategies used to study metabolic pathways, Laws of thermodynamics; Equilibrium constant and standard free energy change; Biological oxidation-reduction reactions; Standard reduction potential and its relationship with free energy change,	3
2	Carbohydrate Metabolism: Digestion and absorption of carbohydrates; Glycolysis; Entry of other monosaccharaides in glycolytic pathway; Gluconeogenesis; Citric acid cycle; Pentose phosphate pathway; Glucuronate pathway; Biosynthesis of lactose; Biosynthesis of oligosaccharides and glycoproteins; Glycogen metabolism and its regulation; Glycogen storage diseases and other genetic defects in carbohydrate metabolism; Regulation of carbohydrate metabolism; Metabolic adaptation in starvation and diabetes mellitus,	8
3	Mitochondrial ATP Synthesis; Electron carriers and their organization; Sequence of respiratory complexes; ATP synthase and mechanism of ATP synthesis Transport of equivalents of NADH produced in cytoplasm; FADH2 oxidation. Oxidative phosphorylation: Sites of phosphorylation; Inhibitors and uncouplers; Energetics and regulation of oxidative phosphorylation.	6
4	Plant-Specific Metabolic Pathways; General pathways: Photosynthesis and carbon fixation; Glyoxylate pathway	6
5	Lipid Metabolism; Major dietary lipids; Digestion and absorption of dietary lipids; Pathways of fatty acid oxidation; Oxidation of odd carbon number and unsaturated fatty acids; Significance and metabolism of ketone bodies; Biosynthesis of saturated and unsaturated fatty acids; Metabolism of triacylglycerols, glycerolipids, sphingolipids and cholesterol; Role of leptin in the regulation of lipid metabolism.	7
6	Amino Acid and Porphyrin Metabolism; Digestion of dietary proteins; General	6

	reactions in the degradation of amino acids; Essential and nonessential amino acids; Deamination and transamination reactions; Urea cycle; Glucogenic and ketogenic amino acids;	
7	Nucleotide and Xenobiotic Metabolism; Degradation of nucleic acids: deoxyribonucleases and ribonucleases; Biosynthesis and degradation of purine and pyrimidine nucleotides.	6
	Total Contact Hours	42

REFERENCE BOOKS

7. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox
8. Harpers Illustrated Biochemistry by by Victor W. Rodwell, David A Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil
9. Lippincott Illustrated Reviews: Biochemistry by Denise R. Ferrier

EvaluationScheme:

Assessment	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	Syllabus covered upto T-1
T2 Test	25	1.5 hrs.	Syllabus covered upto T-2
End Term Test	35	2 hrs.	Entire Syllabus
Teacher Assessment	25	Entire Sem	Based on Assignments, quizzes etc.

Biochemistry and Metabolism lab.

COURSE CODE
COURSE CREDITS: 2
CORE/ELECTIVE: CORE
L-T-P: 0-0-2

Pre-requisite: Cell Biology, chemistry
Course Outcomes:

1. The course is intended to provide hand on experiments on biochemistry. Students will able to carry out both qualitative and quantitative estimation of basic biomolecules of living organisms.
2. The course will also explore that how different advance biochemistry methods unravel the understanding and diagnosingvarious diseases at molecular level.

Course Outcomes: In the end of the course, student will be able…..

S.No.	Course Outcomes	Level of Attainment
CO I	To familiarize with basic biochemistry laboratory procedures and safety.	Familiarity
CO II	To identify different biochemical molecules using basic biochemical tests and estimate their quantity in standard units.	Assessment
CO III	To quantitate the concentration of a biomolecule in given sample.	Assessment
COIV	To identify and analyze different bio-chemicals in different samples like body fluids, food material etc. and asses their information in relation to human health	Usage

Experiments covered:

S.NO.	TITLE
1	Spectroscopic analysis of various biomolecules and determination of absorption spectrum,
2	Isolation of polysaccharide (starch or glycogen) from the biological material,
3	Quantitative estimation of carbohydrate using biochemical methods,
4	Extraction of lipid/oil from plant material and determination of its saponification value and iodine number,
5	Estimation of phospholipids by Stewart's method,
6	Estimation of protein and sugar content of a glycoprotein;
7	Sub – cellular fraction of and isolation of nuclei and mitochondria from the tissue and identification by the marker enzymes,
8	Determination of molecular weight of proteins by gel filtration,
9	Poly-acraylamide Gel Electrophoresis of serum proteins,
10	Isoelectric focusing and 2D electrophoresis
11	Isolation and quantification of DNA from plant tissue.
12	Isolation and quantification of DNA from animal tissue.

1**Reference books and related material:**

1. Lab manual
2. An Introduction to Practical Biochemistry - David T Plummer
3. Practical Biochemistry, Principles and Techniques - Keith Wilson and John Walker
4. Practical Biochemistry-GeethaDamodaran K
5. E-portal of V-labs by Amrita University (vlab.amrita.edu)

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Research Methodology and Inferential Statistics

COURSE CODE: XXXXXXXX
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-1-0

Pre-requisite: Nil

Course Objectives:

The Objective of the course is to make the student aware of research, planning design and appropriate methodology for research. They will learn statistical treatment, analysis of data, interpretation of results and report writing and assessment.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	The student will aware of ware of the finer nuances and significance of research, selecting, Defining and planning a research problem	Familiarity and Basics
CO-2	The student will learn various types of sampling methods suitable for statistical treatment and drawing valid inferences	Technical and strategies
CO-3	Develop understanding of measure of dispersion, tools and techniques of setting and validating scientific and statistical hypothesis	Technical and application
CO-4	Will learn different type experimental designs and principles of experimental designs	Technical and application
CO-5	Understand the importance scientific communication and technical writing skills	Familiarity and Basics

Course Contents:

Unit	Contents	Lectures required
1	**Fundamentals of Research and Research Process** Meaning and objectives of research, Importance of knowing research methods, Type of research, Basic research process, Criteria of good research, General conditions for a research problem, Selecting a research problem, Necessity and techniques of defining a problem	5
2	**Sampling and Sampling methods** Introduction, Definitions, aim of sampling, Type of populations, Different type of sampling methods	4
3	**Measure of Dispersion** Definition, methods of computation, merits, demerits uses and properties of different measures of central tendency. Definition, Computation, merits, demerits uses and properties of different measures of dispersion. Relative measure of dispersion, coefficient of variation, standard error, Central limit Theorem	5

4	**Testing of Hypothesis** Statistical hypothesis, critical region, level of significance, power of test, degree of freedom, steps in testing a hypothesis, Applications of z, t and Chi square tests for testing hypothesis, chi-square test, Application of chi-square test	**9**
5	**Analysis of Variance** Fundamental principles of analysis of variance, portioning sum of squares and degree of freedom, test of significance, critical difference, method of calculating sum of squares	**6**
6	**Principles of Experimental designs** Basic definitions; Experiment, treatment, replication, Experimental material, Experimental units, Fisher's principles of experimental design; Advantages of replication, randomization, local control; Precision and accuracy. Experimental Designs CRD, RBD & Latin Square	**9**
7	**Report writing, Interpretation and Assessment** Significance of report writing, steps in report writing, layout of research report, Types of reports, Mechanics of writing report, precaution for writing research reports, Technique and precautions in interpretation	**5**
Total lectures		**42**

Suggested Text Book(s):

1. Research Methodology: Methods and Techniques. CR Kothari, New Age International Publishers.
2. Biostaistics A Foundation For Analysis in Health Sciences: Wayne W. Daniel John Willey & Sons, INC
3. A handbook of Agricultural statistics: SRS Chandel Achal Prakashan Mandir

Suggested Reference Book(s):

1. An introduction to biostatistics A manual for students for health Sciences. P.S.S. Sundar Rao and J. Richard. Prentice Hall of India.
2. Introduction to biostatistics A textbook of Biometry. P. K. Banerjee. S Chand and company ltd

Other useful resource(s):

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

COURSE CODE: GLP and Bioinstrumentation

COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: B.Sc./B. Tech 2nd year completed

Course Objectives

3. The Objective of the course is to make the student aware of good laboratory practices and various regulatory guidelines followed in Biotech/Pharmaceutical industry
4. This course covers both theory and practical aspects of modern instrumentation used for analysis in biological research.

Course Outcomes

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand basic guidelines and importance of good laboratory practice	Familiarity
CO-2	To learn various safety aspect related to laboratory research	Assessment
CO-3	To be able to understand documentation and conduct of non clinical studies	Assessment
CO-4	Able to Understand basic instrumental principles involved in the operation of mass spectrometers, infrared spectrometers,and nuclear magnetic resonance spectrometers.	Usage
CO-5	To Develop necessary critical thinking skills in order to do data analysis and interpretation in relation to the research process	Usage
CO-6	To analyze various analytical data	Usage

Topic Covered

S. No.	Contents	Lecture required.
1	Historical background of GLPs (The different organizations that have developed GLPs, Focus of each set of GLPs. Common GLP terms and definitions),	3
2	*Overview,Purpose and Essential elements of GLP :* Safety in the Laboratory: Material safety, Environmental safety, Occupational hazardous safety management, Waste management and disposal, Emergency care, First aid in accidents and poisoning, *Facilities* (Animal care facilities, Separation and isolation of animals, Animal supply facilities, Facilities to handle test articles and control articles, Specimen / data storage.)	6
3	*Testing facilities operation* (Documenting SOPs, Labelling reagents and solutions, Methodologies for test system handling, Quarantine, separation, isolation, and disease control, Clean cages and adequate food and water for test systems, *Conduct of nonclinical studies* (The study protocol and its uses, Correct methods of amending protocols and dealing with deviations, Correct conduct of non-clinical studies)	6
4	Theory, instrumentation and applications of Visible, UV, IR, NMR and MS spectroscopy. Simple spectroscopic problems, Circular Dichroism Spectroscopy	20

5	Chromatography (Ion exchange, Molecular Sieve, Affinity, Thin layer GC and HPLC), Radio isotope techniques: Detection and measurement of radioactivity, Geiger Muller counters, Scintillation counting, Autoradiography and RIA, Electron microscopy,	7
	Total Contact Hours	42

REFERENCE BOOKS

10. GLP Essentials: a Concise Guide to Good Laboratory Practices Milton. A. Anderson (2002)
11. Good Laboratory Practice Regulations / Edited by Sandy Weinberg 4th edition, (2007)
12. Identifications of Organic Compounds by R. M. Silverstein, John Wiley, 8th edition, 2015.
13. Practical Biochemistry, Principles and Techniques - Keith Wilson and John Walker (2009)

Evaluation Scheme:

Assessment	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	Syllabus covered upto T-1
T2 Test	25	1.5 hrs.	Syllabus covered upto T-2
End Term Test	35	2 hrs.	Entire Syllabus
Teacher Assessment	25	Entire Sem	Based on Assignments, quizzes etc.

General Microbiology lab

COURSE CODE:
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
COURSE CORDINATOR: Dr. Ashok Kumar
L-T-P: 0-0-2
Pre-requisite: None
Course Objectives:

1. To gain experience in microbiological techniques used in study of microbes
2. To familiarize the students with basics of methods with experimental analysis

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To familiarize the students with basic microbiology instruments in the lab and basic precautions to be taken.	Familiarity
CO2	To aware the students about basic microbiological techniques to study the microorganisms.	Assessment
CO3	Able to analyze bacterial growth kinetics (homogeneous reaction) in the laboratory	Assessment
CO4	Able to understand the basis of microbial resistance against antibiotics and growth of pathogenic organisms.	Usage
CO5	To develop a strong foundation about microbes and	Usage

	their applications	

List of Experiments

S.No	Description	Hours
1	**Microscopy and Instrumentation** **1.** To study the construction and working of compound microscope. **2.** Study of microbiology-lab instruments. (Operation of autoclave, LAF, hot air oven, Culture room fumigation using formalin).	
2	**Staining techniques** **3.** Gram's staining and test for differentiation of bacteria. **4.** To perform acid fast staining. **5.** To perform Lacto phenol Cotton Blue slide mounts for fungal culture.	
3	**6.** Preparation and sterilization of bacterial and fungal culture media (Nutrient broth, nutrient agar slant, potato dextrose agar)	
4	7. Streaking and plating methods for isolation of axenic culture of bacteria. **8.** Isolation and enumeration of bacteria from soil, water and air using serial dilution technique	
5	**9.** Study of bacterial growth kinetics using Turbidometry, **10.** Cell count using haemocytometer. **11**. Effects of various environmental factors such as the presence or absence of oxygen, temperature and pH on growth of microbes. **12.** Physical and chemical methods used to control the growth of microbes and the growth of microbes on various selective and differential media. **13.** Filter paper disc method for evaluation of antibiotic resistant activity of bacteria. Antimicrobial Sensitivity Testing – The Kirby-Bauer Method	
6	**14.** Preparation of nutrient agar slants and glycerol stocks for preservation. **15.** Lyophilization and Glycerol stock of bacteria for long term preservation	
Total Lab hours		

Suggested/Resources:

1. **TEXT BOOKS**

1 **Introduction to Microbiology : A Case-History Study Approach by John L. Ingraham, Catherine A. Ingraham, Hardcover: 816 pages, Publisher: Brooks Cole**

2 **Microbiology : A Laboratory Manual (7th Edition) by James Cappuccino, Natalie Sherman, Paperback: 544 pages, Publisher: Benjamin Cummings**

3 Microbiology: A Laboratory Experience; Holly Ahern

2.

3. REFERENCE BOOKS

1 Willey, Joanne, Linda Sherwood, Chris Woolverton. Prescott's Microbiology, 8th edition. New York: McGraw Hill, 2011. Print.

2 Willey, Joanne, Linda Sherwood, Chris Woolverton. Lab Excercises in Microbiology, 8th edition. New York: McGraw Hill, 2011. Print

3 James G. Cappuccino and Natalie Sherman. Microbiology: A Laboratory Manual, 7th edition. Benjamin Cummings, 2004. Print.

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Immunology and Imumunotechnology

COURSE CODE: XXXXXXXX
COURSE CREDITS: 4
CORE COURSE
L-T-P: 3-1-0

Prerequisites: Basic Biology.

Course Objective:
The objectives are to familiarize the students with

- Basics of Immunology: types of immunity, T-cells and B-cells, antigen-antibody reaction and major histocompatibility complex (MHC).
- Mechanisms of regulation of immune responses and immunological tolerance.
- Role played by immune response in: infectious diseases, autoimmunity, hypersensitivity reactions, immunodeficiency diseases and vaccines.
- Different technology driven immunological applications in disease and health.

Course Outcome:
Students would gain in-depth knowledge of basic immunology and roles played by immune system in various common diseases, and immunological applications in health and disease. Students with plans to carry out higher studies should be able to relate and apply immunological principles in their research while students inclined towards industrial career should be able to envision themselves as a part of the R &D sector in the area of immunology.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To understand the basic concepts of immunology.	Familiarity
CO-2	To understand the functions of components of the immune system and their role in the diagnostics.	Assessment
CO-3	To understand the roles played by immune response in: infectious diseases, autoimmunity and vaccines.	Assessment
CO-4	To understand the transfer of protective immunity, assessment of immune response and production of antibodies.	Assessment/ Usage

CO-5	To understand the basics of various immunotechnological techniques and their applications.	Assessment/Usage

Course Contents:

Unit	Contents	No. of Lectures = 42
1	**Fundamental concepts:** specificity, memory, discrimination of self from non-self, innate and acquired immunity, immune organs, tissues, cells. development and developmental defects of/in immune system, humoral and cell-mediated immune response, antigen recognition by immune system: recognition of antigens by T and B Cells.	6
2	**Immunoglobins and antigens**: immunoglobins: structure and function, immunoglobin classes, antigens, Immunogenicity, antigenicity, epitopes, haptens, mitogens, antigen-antibody interactions.	3
3	**Interaction of immune system with antigen:** antigen processing and presentation, MHCs, role of MHC molecules in antigen presentation and co-stimulatory signals.	4
4	**Cytokines:** structure and function, cytokine receptors, regulation of immune response, cytokine related diseases, diagnosis and therapeutic application of cytokines.	2
5	**Immune system in diseases:** Immune response and bacterial, parasitic and viral infections, congenital and acquired immunodeficiency; tolerance and autoimmune diseases, transplantation and tumor Immunology, diagnosis and therapeutic approaches.	6
6	**Vaccines:** active immunization: subunit vaccines; recombinant DNA and protein based vaccines, peptide vaccines, conjugate vaccines; passive Immunization: antibody, transfusion of immuno-competent cells, stem cell therapy; cell based vaccines, high throughput identification of pathogen specific potential antigens for vaccine development, Immunoinformatics and vaccine design, methods for evaluation of clinical immune response to vaccines**.**	5
7	**Immune studies *in vivo* animal models and human subjects:** Assessment of protective immunity, transfer of protective immunity, Assessment of immune responses in humans, adoptive transfer of lymphocytes and hematopoietic stem-cell transfers	4
8	**Production and engineering of antibodies:** Production of monoclonal and polyclonal antibodies, hybridoma technology, specific and cross reactivity, anti-immunoglobulin antibodies, antibody engineering, abzymes, antigen-antibody interaction as a basis of precipitation and agglutination reactions, blood typing, RIA, ELISA, Imaging-Immunohistochemistry, Immunoprecipitation and co-immunoprecipitation, Immunoblotting	6
9	**Detection, measurement and characterization of antibodies and their use as research and diagnostic tools: Characterization and analysis of cellular and soluble immune components:** Isolation and enrichment of specific immune cells, ELISPOT, Flow-cytometer and FACS for quantitative/qualitative analysis and sorting of different immune cell subsets, Cell functional assays-lymphoproliferation, Cell cytotoxicity, mixed lymphocyte reaction, apoptosis,	6

Recommended Books:

1. Kindt, T.J., Goldsby, R.A. and Osborne, B.A. (2007). Kuby Immunology .W.H. Freeman and Co., New York, 7th Ed.
2. Kenneth Murphy, Charles A Janeway, Paul Travers and Mark Walport (2007) Immunobiology Garland Science, 8th Ed.
3. Abbas AK, Lichtman AH and Pillai S (2001) Cellular and Molecular Immunology; Elsevier, USA, 7th Ed.
4. Roit, I. (2012). Essential Immunology. Blackwell Scientific Publications, Oxford, 12th Ed.
5. Primrose SB, Twyman RM and Old RW (2002) Principle of gene manipulation. Wiley-Blackwell, UK, 6th Ed.
6. Chakravarty AK (2006) Immunology and Immunotechnology. Oxford University Press, 1st Ed.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

BIOPROCESS TECHNOLOGY

COURSE CODE: XXXXXXXX
COURSE CREDITS: 4
CORE
L-T-P: 3-1-0

Pre-requisite: Microbiology, Biochemistry

Course Objectives:

3. Learn various bioprocess technology related terms and principles
4. Learn about microbial growth kinetics in various mode of fermentation
5. Learn about the principles and application of Sterilization and Fermentation
6. Develop an understanding of important concepts and design aspects of bioreactors and its functioning
7. Learn about the principle of scaling up and scaling down of bioprocesses
8. Learn about the principles and application of various separation techniques involved in bioproducts recovery
9. Learn about the production and recovery of various products through case studies

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Able to use correct biological terms to describe & analyze phenomena/ problems in bioprocesses	Familiarity

CO-2	Able to analyze bacterial growth kinetics (homogeneous reaction) in batch /continuous/ Fed-batch reactor and thermal death kinetics	Assessment
CO-3	Able to describe media formulation, mixing and process scale up and the related basic design calculations	Assessment
CO-4	Able to solve mathematical problems related to bioprocess phenomena including mixing, Mass transfer and sterilization	Assessment
CO-5	To develop a strong foundation about bioreactor designs and their applications	Usage
CO-6	Able to apply principles of various unit operations in designing and optimization of downstream processes	Usage

Course Contents:

S. No.	Unit	Topics Covered	Contact Hrs.
1	Introduction and Basic Concepts	Introduction to Bioprocess Technology, Isolation, screening, preservation and maintenance of industrially important microbes; Strain improvement; Fermentation economics	6
2	Cell Growth Kinetics	Cell number and Cell mass calculations, Media design for growth, Continuous, batch and fed-batch fermentation, Microbial growth kinetics, Kinetic models for cell growth, Substrate and product inhibited growth models, Factors affecting microbial growth, Cell and enzyme immobilization	7
3	Sterilization	Sterilization principles and practices; Thermal death kinetics; Media sterilization; batch and continuous sterilization; Air Sterilization	3
4	Upstream processing	Fermentation media; Media formulation; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process	6
5	Fermentation and Its Concepts	Types of fermentation: Solid substrate, surface and submerged fermentation; and Biotransformation; Application	3
6	Fermenter Designs	Criteria for ideal fermenter; Configuration; Bioreactor designs-mechanically agitated; Pneumatic and hydrodynamic fermenters. Whole Cell Immobilized Fermenters; Stability of microbial reactors.	4
7	Downstream processing	Introduction; Separation of insolubles: Filtration, Centrifugation, Sedimentation; Cell disruption; Liquid-liquid extraction; Precipitation; Purification by chromatographic techniques; Reverse osmosis and ultra filtration; Drying; Crystallization; Storage and packaging; Treatment of effluent and its disposal.	7
8	Case Studies	Industrial Production of Bioproducts: Ethanol, Acids (Citric, acetic, Lactic and gluconic), solvents (glycerol, acetone, butanol), Antibiotics (Penicillin, streptomycin, tetracycline), Semi-synthetic antibiotics, Amino acids (Lysine, glutamic acid), Single Cell Protein.	6
	Total Number of Lectures		**42**

Suggested Text Book(s):

1. Pauline M. Doran, “Bioprocess Engineering Principles”, 8th ed., Academic press, New York, 2003.
2. M.L. Shuler and F. Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall Of India Pvt Ltd (2008).
3. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd. (2007).
4. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991.

Suggested Reference (s):

1. Klaas Van’t Riet, Johannes Tramper, “Basic Bioreactor Design”, 2nd ed., Marcel Dekker, Inc., New York, 1991.
2. JE Bailey and DF Ollis, “Biochemical Engineering Fundamentals”, 2nd ed., McGraw-Hill Book Company, New York, 1986.
3. Mccabe L.Warren, Smith C. Julian and Peter Harriott, “Unit Operations of Chemical Engineering”, 6th ed., McGraw Hill International Edition, New York, 2001.
4. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004.
5. Mansi EMTEL, Bryle CFA. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007.
6. Abhilasha S. Mathuriya, “Industrial Biochnology” 1st ed., Ane Books Pvt. Ltd., New Delhi, 2009.

Other useful resource(s):

1. NPTEL Course Content:

   i) Bioreactors by Prof. Suraish Kumar, IIT Madras
   https://nptel.ac.in/courses/102106053/
   ii) Industrial Biotechnology by Prof. Debabrata Das, IIT Kharagpur….
   https://nptel.ac.in/courses/102105058/
   iii) Aspects of Biochemical Engineering by Prof. Debabrata Das, IIT Kharagpur
   https://nptel.ac.in/courses/102105064/

2. Link to topics related to course:
   i) Mass Transfer by Prof. Bishnupada Mandal, IIT Guwahati
   https://nptel.ac.in/courses/103103034/13#

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Unit 1-2
2	T-2	25	1.5 Hours	Unit 1-6
3.	T-3	35	2 Hours	Whole Syllabus
4.	Teaching Assessment	25	Entire Semester	Inform class time to time (Quizzes, Presentation, Assignments)

Plant and Animal Biotechnology

COURSE CODE: XXXXXXXX
COURSE CREDITS: 3
ELECTIVE/CORE: CORE
L-T-P: 3-0-0

Pre-requisite: Basic Understanding of Biology

Course Objectives:

1. The objective of this course is to introduce the student to basic plant and animal cell and tissue culture techniques and their application.

2. In animal tissue culture component, the course is designed to impart an understanding pertaining to why one needs animal cell cultivation, the basic ATC set-up, the biology of cultured cells, techniques to establish and propagate cell cultures of animal origin.
3. In plant tissue culture component, the course is designed to develop an understanding about the morphology of plant cell and its utilization through different techniques of plant tissue culture for propagation, conservation and production of different plant species and their products

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Able to understand about basics of growing plant and animal cell and tissue under in vitro conditions	Familiarity

CO-2	Basic understanding of techniques and technologies used for growing plant and animal cell	Assessment & Analytical Skills
CO-3	To enable students for applying the knowledge about basic techniques of plant tissue culture for developing products.	Technical Skills
CO-4	Able to learn the methodologies for analyzing, upscaling and commercialization of plant based products.	Assessment & Analytical Skills
CO-5	To understand functional assay at cellular level, cell morphology and survival, immunolabeling in animal cells	Awareness
CO-6	To provide insight about the usage of Plant and Animal biotechnology with ethics and safety for masses and environmental utilization	Usage

Course Contents:

Units	Contents	Lectures required
1	Plant structure, growth and development Introduction, definitions and history of plant cell and tissue culture Organization of tissue culture laboratory Cellular totipotency and cell differentiation, factors affecting differentiation	3
2	Isolation of single plant cells, suspension cultures, types of suspension cultures, Measurement of the growth in suspension cultures, Assessment of Viability of the cultured cells, bioreactors used for plant cell cultures	6
3	Type of cultures and their applications: Direct and indirect methods of culture; seed culture, embryo culture, organ culture, callus culture, somaclonal variation and applications	6
4	Somatic embryogenesis Micro-propagation and its applications, Advances in acclimatization of tissue cultured plants. Haploid and triploid production and applications Protoplast isolation and fusion and application Production of virus free plants through cell and tissue culture	3
5	Secondary metabolite production and bioconversions /biotransformation through plant cell cultures and plant stem cells	3
6	Introduction to human anatomy and Physiology, An overview of different Systems, organs and tissues of human body. Basics terms and definitions, historical background, Importance of animal cell culture technology, laboratory facilities-design, equipments and safety parameters, waste disposal in a cell culture set-up. Aseptic techniques for animal cell cultivation.	7
7	Cell culture technology: Basic requirement for growing animal cells - Cell culture reagents, media, media supplements, media preparation and sterilization, Defined-Undefined media, Complete-Incomplete media, Importance of Serum and Serum free Media, culture conditions. Maintenance of cell culture: Culturing, sub-culturing, passaging.	7
8	Studying biological system using cell culture techniques: Functional assays based on cell culture: Cell morphology, Quantitation, Growth pattern, Cytotoxicity assays, Study of Cell Death: senescence, apoptosis and necrosis, Cell proliferation, Cell viability measurements, FISH. Immunolabeling of cells to study molecular	7

	expression pattern–Microscopy, Flow cytometry, Immunohistochemistry, etc. Application of Cell culture Technology Hybridoma technology for monoclonal antibody production.	
Total Lectures		**42**

Suggested Text Book(s):

1. Michael Butler, "Animal Cell Culture and Technology", BIOS Scientific Publishers
2. John R.W. Masters, " Animal Cell Culture-A Practical Approach", Oxford University Press
3. R. Ian Freshney, "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications".
4. Introduction to Plant biotechnology H S Chawala
5. Plant tissue culture: theory and Practice S.S.Bhojwani and M K Razadan
6. Plant tissue culture S.S.Bhojwani and M K Razadan
7. Elements of Biotechnology P K Gupta
8. Plant cell and tissue culture Narayan Swamy

Suggested Reference Book(s)

1. Molecular Biology of the Cell: by Bruce Alberts, 4th Edition 2002.
2. Lodish, et al. Molecular Cell Biology. 5th ed. New York, NY: W.H. Freeman and Company, 2003.

Other useful resource(s):

1. Link to NPTEL course contents: https://nptel.ac.in/
2. https://nptel.ac.in/courses/102103012/
3. https://nptel.ac.in/courses/102104059/
4. https://nptel.ac.in/courses/102103016/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Plant and Animal Biotechnology Lab

COURSE CODE: XXXXXXXX
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P: 0-0-2

Pre-requisite: Basic Biology

Course Objectives:

10. The objective is to familiarize students with the various plant and animal cell culture techniques.
11. To provide experience in handling plant and animal cells or tissues under in vitro conditions.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To understand, design, analyze and interpret experiments related to plant and animal cell culturing	Familiarity
CO2	To understand, design, analyze and interpret experiments related to Animal cell culture and link practical knowledge to theoretical	Analytical Skills
CO3	To understand, design, analyze and interpret experiments related to Plant tissue Culture and link practical knowledge to theoretical	Analytical Skills
CO4	Able to handle and perform experiments for in vitro growth and development of plant and animal cells	Technical Skills
CO5	To understand team work, ethics and work discipline.	Use

List of Experiments

S.No	Description	Hours
1	Laboratory Safety and Introduction to ATC	2
2	Fluid Transfer using aseptic technique	2
3	Preparation of stock media and filter sterilization	2
4	Handling and Sub culturing of animals cells	2
5	Cryopreservation and Revival of Cell culture	2
6	Assessment of cytotoxicity/Biological screening of herbal/synthetic molecules	2
7	Introduction to various equipments and their working in plant tissue culture lab setup and Preparation of stocks solutions, hormones culture medium	2
8	Establishment of Callus and Suspension cultures and measuring cell growth	2
9	Plant regeneration from callus and somatic embryogenesis	2
10	Microproapagation of different plant species by axillary shooting	2
11	Hardening or Acclimatization of cultured plantlets to field conditions	2
12	Meristem culture for virus elimination. Anther and pollen culture for haploid production	2

13	Protoplast isolation and determining the protoplast viability	2
Total Lab hours		**26**

Suggested/Resources:

1. Lab Manual
2. Plant Cell and Tissue Culture - A Tool in Biotechnology: Basics and Application (Principles and Practice) by: Karl-Hermann Neumann publisher: Springer
3. Tissue Culture for Plant Propagators by R.A. de Fossard
4. Plant Culture Media, Volume 1,Formulations and Uses by E.F. George
5. Micropropagation: Technology and Application by P.C. Debergh and R.H. Zimmerman Kluwer Academic Publishers
6. Virtual Lab. (http://vlab.amrita.edu)

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

M. Sc. Biotechnology

Detailed Syllabus

Course Title: Immunology and Immunotechnology Lab
Course Code:
Credits:

Prerequisites: Basic Biology/ Immunology

Objective:

The objective is to familiarize students with the various immunological techniques that include antigen-antibody interactions, quantitation of antigens or antibody, ELISA, agglutination reactions etc.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To understand, design, analyze and interpret experiments related to immunology and link practical knowledge to theoretical.	Familiarity
CO2	To detect antigen and check quality/quantity of antigen.	Familiarity/Assessment
CO3	To check changes in the number of leucocytes, their isolation from the blood and identify cells secreting cytokines specific to antigens.	Familiarity/Assessment
CO4	To understand team work, ethics and work discipline.	Usage

List of Experiments:

S.No.	Experiments
1	To quantify the concentration of unknown antigen by radial Immunodiffusion (RID).
2	To determine the identity of antigen by double Immunodiffusion (DID).
3	To quantify the concentration of unknown antigen by rocket Immunoelectrophoresis.
4	To characterize the given antibody by Immunoelectrophoresis.
5	To determine the presence of antigen by Dot ELISA method.
6	To check antigen- antibody reaction by performing Direct and Indirect Coombs Test.
7	To quantify the amount of precipitation by Quantitative precipitation assay.
8	To perform latex agglutination test to detect an unknown antigen.
9	To separate mononuclear cells from peripheral blood
10	Assay for cellular apoptosis/proliferation.
11	To estimate the antibody titer using haemagglutination assay.
12	To determine Total Leukocytes Count (TLC) of the given blood sample.
13	To understand and learn the basic concepts of ELISPOT Assay. To learn about the procedure and various reagents involved in performing the assay. (Virtual lab)
14	To learn how to perform fluorescent antibody labelling. To know how to calculate the amount of fluorescent dye bound to protein with a spectrophotometer. (Virtual Lab)

Reference books

1. Lab Manual
2. Hay FC and Westwood OMR (2003) Practical Immunology, 4th Ed., Blackwell Publishing.
3. Barbara Detrick, John L Schmitz and Robert G Hamilton (2016). Manual of Molecular and Clinical Laboratory Immunology.
4. V.Lab (http://vlab.amrita.edu/?sub=3&brch70

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Basic Bioinformatics

COURSE CODE:
COURSE CREDITS: 4
ELECTIVE
L-T-P: 3-0-0

Pre-requisite: Molecular Biology, Biochemistry

Course Objectives:

12. Background and need for bioinformatics
13. Learn sequence analysis techniques.
14. Learn sequence alignment-pairwise and multiple.
15. Apply phylogenetic analysis.
16. Application of bioinformatics in modern day research.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Knowledge of bioinformatics databases and resources	Familiarity
CO-2	Sequence analysis including pairwise sequence alignment	Assessment
CO-3	Sequence analysis using multiple sequence alignment	Assessment
CO-4	Sequence annotation by identifying motifs, domains, conserved regions, predicting secondary structure of protein sequences	Usage
CO-5	Perform phylogenetic analysis of protein sequences and RNA secondary structure prediction	Assessment

Course Contents:

S. No.	Unit	Topics Covered	Contact Hrs.
1	**Introduction**	Bioinformatics and its role in modern biology, Next generation sequencing	3
2	**Pairwise sequence alignment techniques**	Dot plots-word size and stringency method, Alignments (Needleman & Wunsch algorithm, Smith-Waterman algorithm-with advanced scoring systems), semi-global alignment, Statistics of sequence alignment score: E-value and P-value	8
3	**Sequence Alignment**	Sequence Alignment: Dot plots, Alignments (Needleman & Wunsch algorithm, Smith-Waterman algorithm-with simple scoring systems), Multiple sequence alignment, Amino acid distance measures (PAM matrices, Blosum matrices)	8
4	**Database search**	Database searching : FASTA, BLAST	8

5	**Fundamental of sequence alignment**	Sequence similarity: Basic concepts, similarity scores	7
6	**Primer design**	Principles, Programs for Primer Design	4
7	**Distance measures**	Nucleotide distance measures (simple counts method, Jukes-Cantor correction, Kimura 2 parameter correction);	4
8	**Phylogenetic reconstruction**	Introduction, distance method (UPGMA, NJ), parsimony method	7
9	**Gene prediction**	Principles and programs for Gene prediction.	2
10	**Structural alignment of proteins**	Sequence-dependent structure superposition: RMSD, Sequence-independent structure alignment, DALI, VAST, CE, TM-Align	2
11	**Secondary structure and tertiary prediction methods**	Chou-Fasman, PHD, PSIPRED Comparative modeling, threading,	7
12	**RNA secondary structure prediction**	Principles and programs for RNA secondary structure prediction	3
	Total Number of Lectures		**42**

Suggested Text Book(s):

1. Bioinformatics: D.W. Mount
2. Introduction to Bioinformatics by Arthur Lesk
3. Bioinformatics: Databases, tools and Algorithms by Orpita Bosu and Simminder Kaur Thukral
4. Knowledge discovery in Bioinformatics: Xiaouha Hu, Yi Pan

Suggested Reference (s):

1. Sousa et al., Bioinformatics Applications in Life Sciences and Technologies, 2016. PubMed PMID: PMC4870335

Other useful resource(s):

1. https://www.hindawi.com/journals/isrn/2013/615630/
2. https://www.sciencedirect.com/science/article/pii/S0888754317300551

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus

4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Course Outcomes (COs) contribution to the Programme Outcomes(POs)

Basic Bioinformatics Lab

COURSE CODE:
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

17. Understand the importance of bioinformatics
18. Application of various bioinformatics tools
19. Understand the connection of bioinformatics and biotechnology

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Understand the use of various bioinformatics resources (NCBI, Expasy, Pfam)	Usage and familiarity
CO2	Understand tools in NCBI (BLAST types etc.)	Assessment
CO3	Understand various databases and tools in Expasy (Swissprot, PROSITE)	Assessment
CO4	Hands-on of pairwise sequence alignment tools-global and local	Assessment
CO5	Hands-on of multiple sequence alignment tools-global and local	Assessment
CO6	Hands-on of phylogenetic analysis tools and visualization	Assessment

List of Experiments

S.No	Description	Hours
1	NCBI-Exploration of different databases and tools	**2**
2	BLAST program in online page and standalone package	**2**
3	PubChem database, Use of Swiss-Prot, PROSITE and PFAM databases	**2**
4	Multiple sequence alignment (MSA) programs and viewers: ClustalW, Jalview in online mode	**2**
5	Use of MSA programs (ClustalW) as a standalone package	**2**
6	Use of structural databases like PDB and structure visualization using Pymol and Rasmol	**2**
7	EMBOSS, STADEN and STAMP packages for sequence analyses	**2**
8	Gene prediction methods- GENPRED, GenePred	**2**
9	Phylogenetic analysis methods and tree viewers: Phylip and Archaeopteryx	**2**
10	Use of Phylip software as standalone package, MrBayes etc.	**2**

11	KEGG and GO database	**2**
12	Homology modeling in MODELLER, Docking in PatchDock	**2**
13	Prediction of RNA secondary structure	**2**
14	Use of structural classification databases like SCOP, CATH, FSSP	**2**
Total Lab hours		**28**

Suggested/Resources:

4. Pevsner J.:Bioinformatics and Functional Genomics; Cold Spring Harbor Laboratory Press, New York.
5. Baxevanis AD & Oulette BFF: Bioinformatics – A practical guide to the Analysis of Genes and Proteins, Willey International publishers.

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Environmental Biotechnology
COURSE CODE:
COURSE CREDITS: 3
COURSE COORDINATOR: Dr. Ashok Kumar
L-T-P: 3-0-0
Pre-requisite: Environmental pollution: Cause and remediation strategies

Course Objectives:

Environmental Biotechnology is a rapidly developing, increasingly important branch of science that has implications for both the prevention and cleans up of pollution in domestic and industrial waste streams. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature. Such environmental applications of biotechnology include: Bioremediation of pollutants, applications in agriculture, applications in sustainable development in various industries well as in detection and monitoring environmental deterioration.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO I	Students will become aware of concept and scope of environmental biotechnology.	Familiarity
CO II	Students will have knowledge different techniques of bioremediation of pollutants	Assessment
CO III	Students will acquire knowledge about application of biotechnological methods in agriculture to reduce environmental impact.	Assessment

CO IV	Student will have acquaintance use of bioresources and biotechnology in various industries for sustainable development	Usage
CO V	Students will have knowledge about biotechnological methods for detection and monitoring of environmental deterioration	Usage
CO VI	Can analyse case-studies representative of key areas of environmental biotechnology	Assessment

S. No.	Unit	Topics Covered	Contact Hrs.
1	**Environmental Biotechnology**	Concept, Scope, areas and examples on subject matter	2
2	**Bioremediation**	Fundamentals, Methods and strategies In situ and Ex situ bioremediation, (Bio)venting, (Bio)sparging, (Bio)stripping, (Bio)sorption barriers, Biofilters, Bioreactors, Case studies , Phytoremediation: Technical considerations, Types factors case studies	8
3	**Hazardous Waste Management**	Energy Resource Recovery from Hazardous Waste Medical waste, Electronic waste. Characterization of the Harmful Effects of Chemicals and Materials, and Fate of HM in Environment risk Assessment.	8
3	**Environmental Protection Biological waste Treatment**	: Thermochemical conversion of biomass: combustion, pyrolysis, gasification, catalysis. Composting, Vermocomposting, Incineration Landfill Recycling Windrow composting. Liquid waste treatment; Biofilters, activated sludge systems.	4
4	**Environmental Biotechnology and Agriculture**:	Bio fertilizers: Symbiotic systems between plants – microorganisms, Chemical pesticide, Biopesticides, Biological control of pests Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems in application Soil Enzymes – origin and range of enzymes in soil, methods of measurement and extraction of soil enzymes, interactions between agrochemical and soil enzymes.	8
5	**Renewable energy and bio-based products**	Bioconversion of biomass to fuels, liquid and gaseous biofuels production, modelling and economics, Polutry waste biomass, Bio adhesives, Biopolymers, Bio lubricants, Bio plastics, fibers and paper.	8
6	**Detection of Pollutants and Environmental Monitoring**:	Bio-Indicators or Biomarkers, Biosensors for Environmental Monitoring. Toxicity screening of samples using bioluminescence or fluorescence, Water quality monitoring, Atmospheric quality bio-monitoring, and. Soil-contamination bio-monitoring.	4
		Total Number of Lectures	**42**

TEXT BOOKS

1

Environmental Biotechnolgy MH. Fulekar

2 **Environmental Biotechnology (By: Arvind Kumar)**

3 **Textbook of Environmental Biotechnology P.K. Mahapatra**

4. **Introduction To Environmental Biotechnology 3rd Edition (English, Paperback, A. K. Chatterji)**

REFERENCE BOOKS

1 **Environmental Biotechnology: Theory and Application Gareth M. Evans (Author), Judith C. Furlong (Author)**

2 **Environmental Biotechnology" by Bhattacharya B C and Banerjee R**

Other useful resource(s):

https://nptel.ac.in/course.php?disciplineId=102

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Food Biotechnology

COURSE CODE: XXXXXXXX
COURSE CREDITS: 3
CORE
L-T-P: 3-0-0

Pre-requisite: Basic Biology, Introduction to Biochemistry and microbiology

Course Objectives:

1. To understand the concept of food science, technology and safety issues.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Basic understanding of food chemistry and nutrition	Familiarity

CO-2	Able to understand the concept of biotechnology in food science	Assessment
CO-3	Able to apply technology in Processing of food products	Assessment
CO-4	Able to understand the safety issues and emerging technologies in food science	Usage

Course Contents:

S. No.	Topics Covered	Contact Hrs.
1	**Food Components and their role in nutrition:** Carbohydrates, Proteins, fats, anti-nutrients, phytochemicals,	3
2	**Food Quality and hazards:** Perception, organoleptics and relation of nutrition to health, Food hazards: Physical, chemical, microbial (parasitic and viral) and engineered hazards: their threats; methods for detection and documentation.	4
3	**Food fermentation** Nutritional value of fermented food, requirements of fermentation, Benefit of fermentation - nutritive value of fermented food, various substrate used in fermentation and different types of fermentation.	4
4	**Starter culture Technology** Definition, types, propagation of starter cultures, Quality and activity of starter , factors affecting quality of starters, defects, Preservation of starter cultures.	4
5	**Microorganisms in fermented foods** LAB-taxonomy, role in preservation, and basic metabolism, LAB metabolism of carbohydrate and protein, Molds and Yeasts in food fermentation, Microbial changes in fermented foods.	4
6	**Fermented Foods**: Sauerkraut, soy based fermented products,	3
7	**Fermented dairy products** Cultured milk, yoghurt, cheese production and other fermented milk products,	3
8	**Bread fermentation** Baker's yeast importance in bread fermentation, production technology of baker's yeast,	3
9	**Alcoholic beverages** Production of beer, wine and vinegar,	4
10	**Traditional fermented foods** Idli, dosa and other traditional fermented foods.	3
11	**Food safety issues of new biotechnologies** HACCP, GMP, GAP, SPS, TQM, Six sigma, EIA and ISO. Food designing and processes: Advanced and conventional processing and preservation methods Food packaging and labelling (Nutritional claim and health claim),	4
12	**Emerging Technologies used in functional food** Food vehicles, Targeted delivery, Microencapslation and Nanotechnologies, Nutraceuticals	3

	Total Number of Lectures	**42**

Suggested Text Book(s):

1. Biochemistry Stryer 7thEdition Biochemistry by Berg JM, Tymoczko JL, and Stryer L, published by W.H. Freeman and Company
2. Microbiology 5th edition E.C.S. Chan, Michael J. Pelczar, Jr., Noel R. Krieg
3. Prescott's microbiology Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., and Willey, J. M. (2011). New York, McGraw-Hill.
4. Microbiology: An Introduction 12thEdition Gerard J. Tortora, Berdell R. Funke and Christine L. Case
5. Principles of Fermentation Technology 3rd Edition Peter Stanbury Allan Whitaker Stephen Hall
6. Fundamentals of Food Biotechnology Byong H. Lee John Wiley and Sons
7. Food Microbiology M. R. Adams and M. O. Moss
8. Basic Food Microbiology George J. Banwart
9. Fundamental Dairy Microbiology Prajapati, J.B.
10. Lehninger Principles of Biochemistry, 5thEdition David L. Nelson and Michael M Cox.

Other useful resource(s):

https://onlinecourses.nptel.ac.in/noc18_ar10/preview

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Food Biotechnology Lab

COURSE CODE: XXXXXXXX
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P: 0-0-2

Pre-requisite: Basic Biology, Introduction to Biochemistry and microbiology

Course Objectives:

20. The objective is to familiarize students with the technologies and processes in Food Science.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	To understand, design, analyze and interpret experiments related to food science and link practical knowledge to theoretical.	Technical & Analytical Skill

CO2	To understand, design, analyze and interpret experiments related to food microbes and fermented food products	Technical & Analytical Skill
CO3	To understand, design, analyze and interpret experiments related to quality and nutritional value of food commodities	Technical & Analytical Skill
CO4	To understand team work, ethics and work discipline.	Usage

List of Experiments

S.No	Description	Hours
1	Introduction to Food Science and Laboratory Safety	2
2	Isolation of food spoilage microorganisms	2
3	Studies on metabolic activities of starter cultures	2
4	Production of fermented dairy product (Curd)	2
5	Production of Mozzarella cheese using acidification method	2
6	Production of fermented beverages (wine)	2
7	Fermenting power of yeast	2
8	Estimation of saponification value	2
9	Determination of acidity of water	2
10	Determination of alkalinity/ hardness of water	2
11	Determination of gelatinization temperature range of different starches and effect of additives	2
12	Determination of proteins in food commodities	2
13	Determination of fats in food commodities	2
Total Lab hours		**26**

Suggested/Resources:

1. **Laboratory Manual of Food Microbiology** Neelima Garg, K L Garg and K.G. Mukerji

2. **Protein measurementwith the Folin phenol reagent** Lowry, O.H., Rosebrough, N.J., Farr, A.L., and Randall, R.J. (1951) J.Biol.Chem 193: 265.
3. **Standard Methods for the Examination of Water and Wastewater** AWWA, WEF, APHA, 1998,(Methods: 4500 B. Electrometric Method; 2320 B. Titration Method)
4. **Chemistry for Environmental Engineering4th Edition** Sawyer, C.N., McCarty, P.L., and Parkin, G.F. 2000, Tata McGraw-Hill Publishing Company Limited.
5. **Measurement of the gassing power of Bakers' Yeast:Correlation between the dough volume and the incubationtime** Walter Borzani, Vol.47, pp. 213-217
6. **An Introduction to Practical Biochemistry, 3rd edition** David T Plummer, McGraw-Hill, c. McGraw-Hill Book Company (U.K.) Ltd.,London. 1987.
7. **"Experimental Biochemistry"** Beedusashidharrao, Vijay Deshpande, I K International Pvt.ltd; ISBN 81-88237-41-8.
8. **Laboratory Manual in Biochemistry** Jayaraman J; Wiley Eastern Limited. 2.
9. **Test Method for Acidity, Saponification value, Ester value, Iodine value and Hydroxy value of Chemical products and Unsaponifiables.** JIS K 0070-1992
10. **Determination of Fat** United States Department of Agriculture Food Safety and Inspection Service, Office of Public Health Science
11. **The Anthrone Method for the Determination of Carbohydrates in Foods and in Oral Rinsing** Thomas G. Ludwig and Hyman J.V. Goldberg1956
12. **Manufacture cheese of mozzarella by direct acidification withreduced amounts of rennet and pepsin 1** R. Mickettsand N. F. Olson
13. **Manual of methods of analysis of foods** Food safety and standards authority of India, Ministry of Health and Family Welfare Government of India,New Delhi,2015

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

ENZYMOLOGY AND ENZYME TECHNOLOGY

COURSE CODE: XXXXXXXX
COURSE CREDITS: 3
CORE
L-T-P: 3-0-0

Pre-requisite: Biochemistry

Course Objectives:

21. Learn about basic aspects of enzymes and their function and structure
22. Learn about mechanisms of various enzyme catalyzed reactions
23. Learn about the important aspects of enzyme kinetics
24. Learn about the regulatory mechanism of enzymes
25. Learn about the potential applications of enzymes

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Able to understand basic concepts of enzymes	Familiarity
CO-2	Able to understand the mechanism of action in various enzyme catalyzed reactions	Assessment
CO-3	Able to understand kinetics of enzymes	Assessment

CO-4	Able to solve mathematical problems related to enzyme kinetics and inhibition	Assessment
CO-5	Able to understand about various regulatory mechanism of enzymes	Assessment
CO-6	Able to understand the present potential of enzyme in industrial and clinical application and improved activity of the enzyme using various molecular biology techniques.	Usage

Course Contents:

S. No.	Unit	Topics Covered	Contact Hrs.
1	**Introduction to Enzymes**	Basic concepts, classification of enzymes, Unit of activity, Criteria of purity of enzymes- Specific activity, Role of coenzymes. Protein and non-protein enzymes: Isozyme, Synzyme, Abzymes, Ribozymes and DNAzymes, Metallozymes, Metal activated enzymes, Coenzymes and Cofactors, Prosthetic group,	8
2	**Characteristics of enzymes and their reactions**	Enzyme structure hierarchy: Primary, Secondary, tertiary and quaternary. Active sites and allosteric sites. Nature of active site, identification of functional groups at active site, enzyme-substrate complex. Enzymes Specificity, Types of specificity	6
3	**Enzyme Catalysis**	Hypothesis of enzymatic reactions, lock and key hypothesis induced fit hypothesis, Mechanism of enzyme action: acid-base catalysis, covalent catalysis, metal ion catalysis, proximity and orientation effects, nucleophilic and electrophilic catalysis. Mechanism: Chymotrypsin, Lysozyme, Carboxypeptidase A, Ribonuclase, Zymogens.	8
4	**Enzyme Kinetics**	Kinetics of Enzyme Catalysed Reactions: Michaelis-Menten hypothesis, transformations of Michaelis-Menten equation and determination of Km & V_{max}, substrate inhibition and activation, multireactant enzymes, King and Altman method of deriving steady-state velocity equations, Kinetics of Enzyme inhibition, Kinetics of Allosteric enzymes	8
5	**Regulation of Enzyme Activity**	Brief account of enzyme induction and repression, Feedback Regulation, Allosteric regulation, covalent modification, Proteolytic activation, Effect of temperature and pH on rate of enzyme catalysed reaction. Mechanism of enzyme degradation. Application of enzymes in various synthetic reactions	7
6	**Industrial and clinical applications of enzymes**	Industrial Enzymes: Thermophilic enzymes, amylases, lipases, proteolytic enzymes. Cellulose degdrading enzymes, Enzymes in food, leather, meat industries. Clinical enzymes: Enzymes as thrombolytic agents, anti-inflamatory agents, Streptokinase, Asparaginase, Transaminases, Cholinesterases, Phosphatases, ELISA, Biosensors. Enzyme engineering.	5
	Total Number of Lectures		**42**

Suggested Text Book(s):

1. Devasena, T., "Enzymology", 1st ed., Oxford University Press, 2010.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L., "*Biochemistry*", 5th ed., W.H. Freeman and Company, New York, 2002
3. Nelson D.L., Cox M.M., "Lehninger Principles of Biochemistry", 5th ed., W.H. Freeman and Company, New York, 2008.

Suggested Reference (s):

7. Pye, E.K. and Wingard, L.B., "*Enzyme Engineering II*", Plenum Press, 1974.
8. Illanes A, "Enzyme Biocatalysis", Springer Science, 2008**.**

Other useful resource(s):

2. NPTEL Course Content:

iv) Enzyme Science and Engineering by Prof. Subhash Chand, IIT Delhi
https://nptel.ac.in/courses/102102033/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Unit 1-2
2	T-2	25	1.5 Hours	Unit 1-4
3.	T-3	35	2 Hours	Whole Syllabus
4.	Teaching Assessment	25	Entire Semester	Inform class time to time (Quizzes, Presentation, Assignments)

ENZYMOLOGY AND ENZYME TECHNOLOGY LAB

COURSE CODE: XXXXXXXX
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P: 0-0-2
Pre-requisite: Biochemistry Lab
Course Objectives:

26. Provide exposure to the students with hands on experience on various practices in Enzymology and Enzyme Technology.
27. Enable students to link the theoretical knowledge of Enzymology and Enzyme Technology with the experiments.
28. Enable to Learn how to carry out enzyme assays
29. Learn how to determine various Michaelis Menten's Kinetics parameter
30. Learn how to characterize an purified enzyme practically
31. Learn about the influence of various physicochemical characteristics upon enzyme activity

Course Outcomes:

S. No.	Course Outcomes	Level of Attainment
CO-1	Able to apply practical knowledge to understand the various important aspects of enzymes usage in biotechnology industries	Familiarity
CO-2	Able to design experiments and to analyze various data related to various practices in enzymology and enzyme technology and its interpretation and their documentation	Assessment
CO-3	Able to understand and determine various kinetics parameters of an enzyme	Usage
CO-4	Able to plot graphs and its interpretation	Assessment and Usage
CO-5	Able to perform immobilization of enzyme	Assessment and Usage
CO-6	Able to work in a team to accomplish the experiments and to document the experiments properly in lab note books	Assessment

List of Experiments

S. No.	Description	Hours
1	Introduction of Lab and lab safety	**2**
2	Determination of enzyme activity and specific activity of purified amylase enzyme	**2**
3	To analyze the effect of temperature on the enzyme activity	**2**
4	To analyze the effect of pH on the enzyme activity	**2**
5	To analyze the effect of metal ions on enzyme activity	**2**
6	To determine the thermostablity of the given enzyme	**2**
7	To determine the energy of activation of amylase enzyme	**2**
8	To determine Michaelis Menten's kinetics parameters of amylase enzyme	**2**
9	Determination of molecular weight using SDS-PAGE	**2**
10	Fractionation of enzyme by using ammonium sulphate precipitation	**2**
11	Preparation of Immobilized enzymes using calcium alginate beads and its characterization in term of activity and stability	**4**
Total Lab hours		**24**

Suggested/Resources:

6. Devasena, T., "Enzymology", 1st ed., Oxford University Press, 2010.
7. Lab Manual
8. Berg, J.M., Tymoczko, J.L. and Stryer, L., "*Biochemistry*", 5th ed., W.H. Freeman and Company, New York, 2002
9. Nelson D.L., Cox M.M., "Lehninger Principles of Biochemistry", 5th ed., W.H. Freeman and Company, New York, 2008.
10. Nicholas C. Price and Lewis Stevens, "Fundamental of Enzymology", Oxford University Press, Oxford. ISBN: 9780198502296.
11. Sawney S.K., Singh R. "Introductory Practical Biochemistry", Narosa Publisher, 2000. ISBN 9788173193026.

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

Recombinant DNA Technology

COURSE CODE: XXXXXXXX
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-1-0

Pre-requisite: Genetics, Molecular Biology

Course Objectives:

32. Familiarize the students with the basic concepts in recombinant DNA technology
33. Acquaint the students to versatile tools and techniques employed in genetic engineering and recombinant DNA technology
34. Apprise students about applications recombinant DNA technology and genetic engineering

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	Students will become aware of concept of recombinant DNA technology and genetic engineering and its applications	Familiarity and Basics
CO-2	Students will have knowledge of tools and strategies used in recombinant DNA technology	Technical and strategies
CO-3	Student will acquire knowledge about gene libraries and isolation of genes, DNA and genome sequencing technologies	Technical and application
CO-4	Student will have acquaintance about protein expression hosts and genetic manipulation of plants and animals	Familiarity and Basics
CO-5	Understand application of recombinant DNA technology and genetic engineering in problem solving in academic and industrial perspective	Application

Course Contents:

Unit	Contents	Lectures required
1	**Introduction:** Genetic engineering, Recombinant DNA technology: gene cloning - concept and basic steps - rDNA Glossary	2
2	**DNA modifying enzymes and cloning techniques:** Restriction Endonucleases, DNA Ligation Enzymes and, DNA, Gene cloning methods and strategies: Cloning of PCR products, TA and TOPO TA cloning, Gateway cloning, DNA Modifying Enzymes: Nucleases, Kinases, phosphatases, Reverse transcriptase, RFLP and AFLP	8
3	**Cloning and Expression Vectors:** Plasmid Vectors, Vectors based on Lambda Bacteriophage, Cosmids, M13 Vectors, Vectors for Cloning Large DNA Molecules, Expression Vectors, Transcriptional & Translational Fusions, Adding Tags and Signals overproducing Proteins.	10
4	**Construction & Screening of genomic libraries:** Genomic library, cDNA library, Growing & Storing Libraries, cDNA Cloning (5'&3' RACE)	5
5	**Identification and isolation of genes:** Screening Libraries with Gene Probes, Screening Expression Libraries with Antibodies, Susbtacrtive hybridization, DDRT-PCR, Positional Gene Cloning, Functional Complementation	4
6	**DNA and Genome Sequencing:** Basics of DNA Sequencing, Next generation sequencing technologies, Whole genome sequencing	6

7	**Gene Expression in Microbial and Eukaryotic Systems:** Microbial, Yeast *Saccharomyces Cerevisiae* and Other Fungi as heterologoues protein expression platforms	**3**
8	**Genetic Manipulation of Plants and Animals:** Gene transfer methods, Application of Genetically Engineered Strains of Plants and Animals	**4**
Total lectures		**42**

Suggested Text Book(s):

1. Principles of Gene Manipulation and Genomics SEVENTH EDITION S.B. Primrose and R.M. Twyman.
2. Recombinant DNA: A Short Course by JD Watson, J. Tooze and DT Kurtz.
3. Genetic Engineering : Amita Rastogi and Neelam Pathak

Suggested Reference Book(s):

1. From Genes to Genomes: Concepts and Applications of DNA Technology by JW Dale and M Schantz
2. Molecular Biotechnology: Principles & Applications of Recombinant DNA Glick BR and Pasternak JJ
3. Genetic Engineering : Amita Rastogi and Neelam Pathak

Other useful resource(s):

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

Recombinant DNA Technology Lab

COURSE CODE: XXXXXXXX
COURSE CREDITS: 1
CORE/ELECTIVE: CORE
L-T-P: 0-0-2

Pre-requisite: None

Course Objectives:

The objective of the course is to give practical exposure to student about basic tools and techniques employed in recombinant DNA technology and genetic engineering.

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO1	Students will be able to isolate and analyze plasmid vectors.	Technical
CO2	Students will be cut and ligate DNA fragments/vectors with help of restriction enzymes and ligase.	Technical
CO3	The students will be able to prepare competent cells and demonstrate bacterial transformation with given vectors	Technical
CO4	The students will be able to amplify specific DNA fragment and cloning it in T vectors demonstrate bacterial transformation.	Technical
CO5	Student will acquire proficiency in designing and conducting experiments involving genetic manipulation.	Strategies and Application

List of Experiments

S.No	Description	Hours
Lab-I	Introduction to rDNA laboratory, w.r.t. working bench, types of instruments and their handling, lab. Preparation of stock solutions of buffers for use in gel running, gel loading, their autoclaving; preparation of working buffers, antibiotic stocks, and storage of buffers required in rDNA practicals with detailed methodology. (Theory and Virtual)	**4**
Lab 2-3	Plasmid DNA Preparation: Preparation of LB medium with and without antibiotics for the growth of bacterial cultures, Growth of *E. coli*, Isolation of Plasmid DNA, Electrtrophoresis of Plasmid DNA and Interpretation of results	**4**
Lab 4	Restriction of given plasmid or λ DNA with the restriction enzyme *Eco*RI and HindIII or any other Restriction Enzymes,	**4**
Lab 4 -5	To perform ligation of λ/*Eco*R I digest using T4 DNA Ligase Electrophoresis of the uncut and digested DNA and Interpretation of the results Electrophoresis of ligated samples by agarose gel electrophoresis, Interpretation of the results	**4**
Lab 6	Setting up a PCR reaction to amplify a gene or a DNA fragment using gene specific primers	**2**
Lab 7	Preparation of competent cells of *E. coli* transformation	**4**
Lab 8	To insert the PCR product into T vector by TA-cloning, and confirmation	**4**
Lab 9-10	Transformation of E.coli. DH5 α cells with Empty puc/ pcambia1301/and Confirmation of transformed cells by scoring the expression of LacZ gene.	**4**
Lab 10-11	Transformation of E.coli. DH5 α cells with Recombinant T- vector/puc vector Confirmation of transformed cells by scoring the expression of LacZ gene.	**4**
Lab 12-13	RNA isolation and to synthesize cDNA from total RNA preparation using reverse transcriptase and oligod T primer (Virtual)	**2**
Lab 12-14	Mini Project for lab evaluation and Exam	**4**
Total Lab hours Total Contact Hours (Students are required to devote some extra time for some experiments		

Suggested/Resources:

1. Lab Manual
2. Molecular Cloning: A Laboratory Manual 2nd Edition Cold Spring Harbour Laboratory Press

3. Virtual Lab

Evaluation Scheme:

1	Mid Sem. Evaluation	20 Marks
2	End Sem. Evaluation	20 Marks
3	Lab Assessment	60 Marks
	Total	100 marks

SYLLABI OF ELECTIVES FOR M.Sc - BIOTECHNOLOGY

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS

Molecular and Clinical Diagnostics

COURSE CODE: XXXXXXXX
COURSE CREDITS: 3
COURSE : ELECTIVE
: 3-0-0

Prerequisites: Basic Biology Course

Objective:

This course aims to familiarize the students with the principles & applications of the latest state-of-the-art bio-molecular technologies with specific reference to Nucleic Acids and Proteins used in Health, Medical Research, various and clinical settings and Forensic laboratories the world over. This course covers both theory and practical aspects of modern instrumentation used for analysis in biological research

Course Outcomes:

S.No.	Course Outcomes	Level of Attainment
CO-1	To understand the basic concepts of diagnostics in research and clinical settings.	Familiarity
CO-2	To learn the basics of various DNA based diagnostic methods, quality control and applications.	Usage
CO-3	Able to Understand basic instrumental principles involved in the operation of mass spectrometers, infrared spectrometers, and nuclear magnetic resonance spectrometers.	Usage
CO-4	To learn the basics of various Antigen – Antibody based diagnostic methods, with their comparative advantage and limitations.	Usage
CO-5	To understand and learn various label based diagnostic methods, their applications in research and pathological settings.	Usage

Course Contents:

Unit	Contents	No. of Lectures
1	**Introduction to Clinical Diagnostics:** Philosophy and general approach to clinical specimens, Sample collection (Blood, urine, spinal fluid, synovial fluid, amniotic fluid) - method of collection, preservation, transport and processing of samples. Diagnosis – disease altered state, prognosis, direct and indirect, concept of antigen and antibody.	**3**

2	**PCR based Clinical Diagnostics:** Nucleic acid extraction from clinical samples, quantization, digestion, hybridization, Amplification by PCR (Inverse PCR, Multiplex PCR, Nested PCR, Hot-start, applications and limitations). Validation and quality control of polymerase chain reaction methods used for the diagnosis of infectious diseases.	**5**
3	**Antigen-Antibody Interaction based Diagnostic Techniques:** Hybridoma technology, Concept of monoclonal vs polyclonal antibodies, specific, Theories of antigen-antibody interaction. Precipitation based diagnostic methods – radial diffusion, double diffusion, immunoelectrophoresis, rocket Immunoelectrophoresis, 2-D Immunoelectrophoresis, Immunoprecipitation. Agglutination - principle,	**7**
	ABO blood typing, latex agglutination, agglutination inhibition.	
4	**Radio labeling Techniques for Diagnostics:** Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines. Imaging based Techniques – MRI, PET.	**7**
5	**Biophysical Methods for Diagnostics:** Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy. Molecular structure determination using X- ray diffraction and NMR, Types of mass spectrometry and surface plasma resonance methods.	**8**
6	**Microscopic techniques for visualization and localization of cells and antigens:** Visulization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze- fracture methods for EM.	**4**
7	**Label Based Diagnostic Methods** - Radioimmuno Assay, western blot, ELISPOT, ELISA – types, designing, Immunohistochemistry, In situ localization by techniques - FISH and GISH, Immunofluorescence, Flow Cytometry – Principle, components, and applications. FACS.	**8**

Recommended Books:

1. Kindt, T.J., Goldsby, R.A. and Osborne, B.A. (2007). Kuby Immunology .W.H. Freeman and Co., New York, 7th Ed.
2. Kenneth Murphy, Charles A Janeway, Paul Travers and Mark Walport (2007) Immunobiology Garland Science, 8th Ed.
3. Abbas AK, Lichtman AH and Pillai S (2001) Cellular and Molecular Immunology; Elsevier, USA, 7th Ed.
4. Roit, I. (2012). Essential Immunology. Blackwell Scientific Publications, Oxford, 12th Ed.
5. Primrose SB, Twyman RM and Old RW (2002) Principle of gene manipulation. Wiley-Blackwell, UK, 6th Ed.
6. Chakravarty AK (2006) Immunology and Immunotechnology. Oxford University Press, 1st Ed.
7. Practical Biochemistry, Principles and Techniques - Keith Wilson and John Walker (2009)

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS

Course Title **Quality Control and Quality Assurance** **(Elective Course)**

Course Code xxxxxxxx

L	T	P
3	0	0

Course Credit 3

Course Coordinator Dr. Gopal Singh Bisht

Course Objectives

The Objective of the course is to make the student aware of quality control techniques and process for routine analysis of various biotech and pharmaceutical products. They will learn design of QC laboratory for chemical, instrumental and microbiological analysis.

Course Assessment

Assessment	Max. marks	Duration	Course Covered
T1 Test	15	1 hr.	Unit 1-2
T2 Test	25	1.5 hrs.	Unit 1,2,3,4
End Term Test	35	2 hrs.	Whole Syllabus
Teacher Assessment (Based on Assignments, quizzes etc.)	25	Whole Semester	Inform class time to time
Total	**100**		

Course Outcomes

CO I	To understand concept of quality control & importance of quality control of various biotechnological products
CO II	Able to design and prepare quality sheets for various process
CO III	Able to learn quality control guidelines for maintaining various equipment and process used in biotech industry
CO IV	To understand various validation process involved in R& D industry
CO V	To be able to use quality tools to prepare process control chart

Unit no.	Topics Covered	Contact Hrs.
1	Introduction of Quality Control & Quality Assurance, Evaluation of quality control, Using Quality Assurance for the Best Results; The Role of Inspection in Quality Control, Collecting Your Quality Data	4

2	Quality Models in business, Six Sigma Concept, Six Sigma tools, Continuous improvements and its applications, Ten Steps for Incorporating Quality into a New Product and/or Process; Quality Management: Practices, Tools, and Standards Stability Studies, ICH Guidelines, WHO Guidelines Good Practices in QC laboratory, Schedule L1, standardization of reagents, labeling of reagents, control, QA Lot release, non-conforming material review, failure review QC Lot	18
	release testing –chemical assays & bioassays ,validation for quality control QC Raw material testing, in-process testing, validation support QA Audit procedures and vendor certification Handling out-of-specification results	
3	Good Practices in QC laboratory, Schedule L1, standardization of reagents, labeling of reagents, control, Design of QC laboratory for chemical, instrumental and microbiological analysis. Quality Control techniques for routine analysis with HPLC: Quality control aspects of Pharmaceuticals and Food products, Quality control aspects of Bioactive natural products, QC Monoclonal antibody products QC rDNA products ,	12
4	Statistics Process control: control chart for variable and attributes, P charts C charts,Quality control laboratory: Environmental monitoring, setting of limits and its evaluation. Control of contamination and cross contamination. Contract manufacturing and analysis	8
	Total	42

TEXT BOOKS

1	Fundamentals of Quality control and improvement by Ämitav Mitra A John Wiley & Sons, Inc., Publication
2	Good Manufacturing Practices for Pharmaceuticals by Sidney H Willig, Marcel and Dekker
3	Quality Assurance in Environmental Monitoring by P. Quevauviller, Wiley VCH
4	Bioactive Natural Products: Quality Control & Standardization by V.K.Gupta, s.c. Taneja and B.D. Gupta, Studium Press LLC, U.S.A.

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS

Nanobiotechnology: Principles and Applications

Course Code:
Course Credits: 3
Core / Elective: Elective
L-T-P: 3-0-0

Pre-requisite: Basic of Physics, Chemistry and Biology

Course Objectives:

- Introduction to Nanomaterial and various material used for obtaining nano-materials
- Learn various approaches or methods used for nanomaterial synthesis.
- To learn various analytical techniques used for nanomaterial characterization.
- Learn various applications of nanomaterial in health care, agriculture and environmental monitoring

Course Outcomes

S. No.	Course Outcomes	Level of Attainment
CO I	Introduction to nano-biotechnology and develop an understanding of the fundamental properties of matter at nanoscale.	Familiarity
CO II	Identify the principles of processing and manufacturing of nanomaterials.	Assessment & Technical
CO III	Fundamental understanding and characterization of nanomaterials.	Assessment & Technical
CO IV	Fundamental understanding of biologically inspired nanomaterial and application.	Usage
CO V	Identify the applications of nanomaterial in biomedical sciences.	Usage

Course Contents:

Unit		Contents	Lectures
1	Introduction to Nano-Biotechnology	Characteristic length scales. Concepts of nanomaterials and nanostructures .Definition of nano-biotechnology. One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, etc. physical-chemical properties.	4
2	Types of nanomaterials and properties of nanomaterials	Quantum effect, structural and fundamental principles of nano-biotechnology. Stability criteria of nanomaterials for biological applications.	3
3	Method of Preparation and characterization	Nanomaterial synthesis using chemical, Physical and Biological methods. Basic characterization technique e.g. electron microscopy (SEM, TEM), Atomic Force microscopy, Dynamic Light Scattering, Nuclear Magnetic Resonance and Spectroscopic technique	9

4	Biologically Inspired Nanomaterial for Biomedical Applications	Structurally Inspired Materials like, Liposomes, Virosomes, Polymerosome and functionally inspired nanomaterial such as muscle adhesive protein	7
5	Nanostructure in Biological Detections	Use of nanomaterials (quantum dot, gold nanoparticles, silver nanoparticles) in fluorescence detection, surface Plasmon based detection and electrochemical detection	9
6	Applications	Use of nanomaterials in drug delivery, Tissue engineering and environmental protection	10
	Total Number of Lectures		**42**

Methodology

The course will be covered through lectures. Apart from discussions on topics covered in lectures, assignments and analytical will also be given

TEXT BOOKS

1	C. N. R. Rao, A. Muller, A. K. Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH Verlag Gmbh & Co, Weinheim, 2004.
2	P. Boisseau, P. Houdy, M. Lahmani, Nanoscience: Nanobiotechnology and Nanobiology
3	Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007
4	G.Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, 2004.

REFERENCE BOOKS

1	C. A. Mirkin and C. M. Niemeyer. Nanobiotechnology - II more concepts and applications. (2007) -Wiley VCH.
2	D.A Phoenix, W. Ahmed, Nanobiotechnology, One Central Press Ltd, UK
3	L. Filipponi, D. Sutherland, Nanotechnologies: Principles, Applications, Implications and Hands-on Activities.Directorate- European commission

Other useful resource(s): Link to NPTEL course contents

- https://nptel.ac.in/courses/118107015/
- https://onlinecourses.nptel.ac.in/noc17_bt17/preview
- http://videos.gitam.edu/nptel/nano.html

Evaluation Scheme:

S. No.	Exam	Marks	Duration	Coverage/Scope of Examination

1	T-1	15	1 Hour	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3	T-3	35	2 Hours	Entire Syllabus
4	Teaching Assessment	25	Entire Semester	Quiz-1 -10 Quiz-2 -10 Attendance -5

DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS

Cell Signaling

COURSE CODE:
COURSE CREDITS:
3

CORE/ELECTIVE: ELECTIVE

: 3-0-0

Pre-requisite: Cell Biology, Molecular Biology, Biochemistry

Course Objective:

Objective of this course is to enable the students to have the understanding of the basics of the cellular signaling. This course will impart knowledge regarding the communication between the cells and how the signaling process is involved in the various basic processes of the cells. The course will also impart knowledge to the students about signaling processes in the normal physiology and various pathological conditions. The Course would be extremely beneficial to the students if they want to further pursue a career in higher studies/research.

Topics include the pathways by which cells respond to extracellular signals such as growth factors and the mechanisms by which extracellular signals are translated into alterations in the cell cycle, morphology, differentiation state, and motility of the responding cells. Stress pathways regarding how the cells respond to survive the stress or induce their own death.

Course Outcomes

S. No.	Course Outcomes	Level of Attainment
CO-1	The students will have basic knowledge about the signaling pathways.	Familiarity
CO-2	The students will understand the need of the signaling molecules and the consequences on their absence.	Assessment
CO-3	Students will understand the function of specific anabolic and catabolic pathways and how these pathways are controlled and interrelated. They will understand various signaling pathways and signaling molecules.	Assessment
CO-4	Students will be able to apply the knowledge of signal transduction in normal physiology as well as in pathophysiological conditions.	Usage

Unit	Contents	No. of Lectures
1	Regulation of transcription and translation. Signal transduction: definition, signals, ligands and receptors. Endocrine, paracrine and autocrine signaling. Cyclic nucleotides and G proteins, G protein signaling, Second Messengers and Protein Kinases.	4

2	Receptors and signaling pathways: cell signaling, cell surface receptors. G Protein coupled receptors-structure, mechanism of signal transmission, regulatory GTPases. Cytokines and chemokines. Signal transmission via Ras-Erk and other MAPKs, Jak-STAT, Hedgehog; Wnt, NF-kB, etc.	8
3	Reactive oxygen species, Nitric oxide, free radicals, etc. Programmed Cell Death: intrinsic and extrinsic triggers and the pathway involved	5
4	Signal Transduction by Ions: Functional role of ions such as Calcium, Zinc, etc their channels and transporters and intracellular signaling.	6
5	Signaling at Synapses: Nerve impulse transmission –Nerve cells, synapses, reflex arc structure, Resting membrane potential, action potential. Neurotransmitters and Their Receptors. Photochemical reaction and regulation of rhodopsin.	8
8	Signal transduction in Health and Disease: Cancer, Neurodegeneration, Diabetes, etc. eg. Insulin and the signal transduction cascades it invokes in normal and pathological condition.	6
9	Techniques used to study/elucidate/intervene cell signaling	5
		42

Suggested Text Book(s):

1) Molecular biology- David Freifelder, Narosa Publishing House Pvt. Limited, 2005
2) Biochemistry of Signal Transduction and Regulation. 3rd Edition. Gerhard Krauss, 2003 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim ISBN: 3-527-30591-2
3) Molecular Biology of the Cell, 4th edition, Bruce Alberts. New York: Garland Science; 2002. ISBN-10: 0-8153-3218-1ISBN-10: 0-8153-4072-9
4) Molecular Cell Biology, 4th edition**,** Harvey Lodish.New York: W. H. Freeman; 2000. ISBN-10: 0-7167-3136-3
5) Principles of cell and molecular biology- Lewis Kleinsmith, 2nd edition, illustrated, HarperCollins, 1995.

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3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment, Quizzes & Attendance

CO-PO mapping:

CO/PO	PO1	PO2	PO3	PO4	PO5	PSO1	PSO2
CO1	3	3	3	2	2	3	3
CO2	3	3	3	2	2	3	2
CO3	3	3	3	2	3	3	2
CO4	3	2	2	2	2	3	3
Average	**3**	**2.75**	**2.75**	**2**	**2.25**	**3**	**2.5**