KUMAUN UNIVERSITY NAINITAL

Common Minimum Syllabus for State Universities and Colleges of Uttarakhand

National Education Policy- 2020

Subject: Microbiology

PROPOSED STRUCTURE OF PG MICROBIOLOGY SYLLABUS

National Education Policy-2020
Common Minimum Syllabus for all Uttarakhand State Universities/Colleges

SUBJECT: Microbiology

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Semester-Wise Titles of the Papers in M.Sc. Microbiology

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Bachelor (Research) in Microbiology					
4	VII	PBT01-(T/P)	Biochemistry	Theory + Practical	4 + 1
		PBT02-(T/P)	Molecular Biology	Theory + Practical	4 + 1
		PBT03-(T/P)	Microbiology and Industrial Applications	Theory + Practical	4 + 1
		PBT04-(T)	Biostatistics and Computer Applications	Theory	5
		PBT05-(T)	Environmental Biochemistry and Biotechnology	Theory	5
					Total : 25
	VIII	PBT06-(T/P)	Genetic Engineering	Theory + Practical	4 + 1
		PBT07-(T/P)	Analytical Techniques	Theory + Practical	4 + 1
		PBT08-(T)	Molecular Virology	Theory	5
		PBT09-(T)	Cell and Developmental Biology	Theory	5
		PMB01-(T/P)	Microbiological Techniques	Theory + Practical	4+1
		PMB-E	Elective		4
					Total : 29
Masters in Microbiology					
5	IX	PMB02-(T)	Applied Microbiology	Theory	5
		PBT12 (T)	Bioprocess Engineering and Technology	Theory	5
		PMB03 (T)	Bacterial Metabolism	Theory	5
		PBT14-(T)	Molecular Genetics	Theory	5
		PBT15-(T/P)	Immunology and Immunotechnology	Theory + Practical	4 + 1
					Total : 25
	X	PMB16	**Research Project**		25
					Total : 25

Elective papers offered			
Course Code	**Paper Title**	**Theory/Practical**	**Credits**
PMB-E-01 (T)	Agriculture and Environmental Microbiology	Theory	4
PMB-E-02 (T)	Industrial Microbiology	Theory	4
PBT01- (T/P)	Biochemistry*	Theory + Practical	4+1
PBT02- (T/P)	Molecular Biology*	Theory + Practical	4+1
PBT10- (T/P)	Plant Biochemistry and Biotechnology*	Theory + Practical	4+1

***Elective for other programs**

Purpose of the Program

Microbiology is a classical science and has found application in diverse areas of studies and research. The purpose of the postgraduate Microbiology program at the University and College level is to prepare our students for all those fields where knowledge of Microbiology is required for Research and Development and academic professionals in various industries, research institutions and Universities/Colleges.

Program Objectives (POs)

Students will be practitioner microbiologists and researchers; they will function in their field with ethical awareness and responsibility. They will interact with their peers in an interdisciplinary way in their work place and society and contribute to sustainable growth of the country. They will pursue higher studies and choose their career paths in teaching or research.

Program's Outcomes

PO 1. Students will develop professional skills through scientific attitude and values. Students will have foundation in the fundamentals and applications of the Microbiological applications required for different jobs.

PO 2. They will be able to demonstrate knowledge for in-depth research to formulate and solve the issues related to Microbiological research.

PO 3. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.

PO 4. Students will be able to explore new areas of research in both Microbiology, Biotechnology and allied fields of science and technology.

PO 5. Students will be able to demonstrate skills they will acquire during their study to use modern analytical tools/software/equipment and analyze and solve problems in various courses of Microbiology.

PO 6. Students will be able to apply their knowledge of bacterial metabolism and microbiological techniques to solve water, soil air pollution through bioremediation.

PO 7. Students will be able to function as a member of an interdisciplinary problem-solving team.

PROGRAM SPECIFIC OUTCOMES (PSOS)	
BACHELOR (RESEARCH) IN MICROBIOLOGY	
Fourth Year	This course introduces the foundation of Biochemistry, Molecular Biology, Microbiology and Industrial Applications, Genetic Engineering, Analytical Techniques, Applied Microbiology and Cell & Developmental Biology along with basics of Biostatistics and Computer Applications. After completion of the course: **PSO1.** Understand the basic concepts of Genetics and Molecular Biology such as inheritance pattern, DNA replication, transcription and translation. **PSO2.** Understand the basic structure and concepts of Biomolecules such as Carbohydrates, Lipids, Enzymes, Nucleic acids, Hormones and Vitamins. The students will also develop understanding of coordinated control of metabolism. **PSO3.** Understand the basic concepts of Microbial Diversity & Systematics, Microbial Growth & Physiology, Microbial Interactions and Infections. **PSO4.** Understand the basic concepts of Biostatistics tools for recording and analyzing experimental data. **PSO5.** Understand the basic concepts of Genetic Engineering such as cloning vectors, cloning methodologies and their applications in industry as therapeutics tools. **PSO6.** Understand the basic concepts of analytical techniques such as Spectroscopy, Chromatography, Centrifugation for sample analysis and their accurate assessment. **PSO7.** Understand the basic concept of environmental rearrangement to enhance quality surroundings with reference to air, water and soil to mitigate social problems. **PSO8.** Understand the basic concepts of cell structure, cell organelles, type of cells, cell communication, differential and specialized cells like stem cells for better understanding of the basic unit of life i.e., cell. **PSO9.** Perform experiments of estimation of amino acids, enzymes etc., by using spectroscopic and chromatographic techniques. **PSO10.** Perform experiments on sterilization techniques, media preparation and characterization of microorganisms. **PSO11.** Perform experiments of protein purification and estimation, isolation of plasmid DNA and formation of construct, genomic DNA isolation, electrophoresis, spectroscopy, PCR etc. **PSO12.** Apply at technical positions in different research laboratories, diagnostic centers and industries.
	MASTER IN MICROBIOLOGY
Fifth Year	This course introduces the foundation of Genomics and Proteomics, Bioprocess Engineering and Technology, Molecular Genetics, Bacterial Metabolism, Microbiological Techniques, Environmental Biochemistry and Biotechnology, Immunology and Immunotechnology and Molecular Virology. After completion of the course: **PSO1.** Understand the basic concepts of structural organization of genome, genome sequencing projects, protein analysis methods, pharmacogenomics and functional genomics.

	PSO2. Understand the basic concepts of Bioprocess Engineering such as large scale culture as fermentation and protein generation, upstream and downstream processing, analysis and application of food processing enzymes and microorganisms. **PSO3.** Understand the basic concepts of bacterial mutants and mutations, gene transfer in bacteria, regulation of bacteriophage life cycle, Mendelian Genetics, gene mapping and human genome project population genetics and evolution.. **PSO4.** Understand the basic concepts of environmental biochemistry and biotechnology, such as environmental pollution, control, remediation and management, bioaugmentation, alternate source of energy, environment and health in respect to genetics and human biomonitoring. **PSO5.** Understand the concepts of immunology, immune system and response, B and T cell regulation, antigen-antibody interactions, vaccine and vaccine technology and clinical immunology. **PSO6.** Understand the concepts of Molecular Virology, structure of animal and plant viruses, general organization of animal and plant viruses, methods to diagnose animal and plant virus infections. **PSO7.** Perform experiments on Immunology such as preparation of human blood smear and identification of cells, determination of blood groups and Rh factor, estimation of antiserum, antiserum titer determination by different types of ELISA, Immunoelectrophoresis and Immunodiagnostics. **PSO8.** Study of metabolic pathways involved in release and dissimilation of substrates by hetero and autotrophs with emphasis on the reactions of industrial and environmental concern. **PSO9.** Fermentation of lactic-acid bacteria, ethanol fermenting organisms, propionic acid bacteria, enterobacteriacea and clostridia. **PSO10.** Bacterial nitrogen fixation and regulation, biochemistry of methanogenesis and its regulation. **PSO11.** Identification and characterization of microorganisms especially of human interest, introduction to terms and equipments used in microbiological laboratory, microscopy, cell cytometry. **PSO12.** BIOLOG plant method, carbohydrate fermentation, IMVIC test, genus level identification of bacteria, isolation of halophiles, thermophiles, psychrophiles and acidophiles.

Subject: Microbiology							
Year	**Semester**	**Theory Paper**	**Units**	**Practical Paper**	**Units**	**Research Project**	**Total Credits of the Year**
Fourth Year	VII	Biochemistry	1. Chemical Basis of Life 2. Proteins 3. Enzymes 4. Carbohydrates 5. Lipids 6. Nucleic Acids 7. Bioenergetics	Biochemistry	1. Titration of Amino Acids 2. Colorometric determination of pKa 3. Quantitaive estimation of proteins and Sugars 4. Seperation techniques-Centrifugation, Chromatography (Gel Permeation, Ion Exchange, TLC etc.)		5+5+5+5+5=**25** 5+5+5+5+4= **29** **Grand total =54**
		Molecular Biology	1. Genome Organization 2. DNA Structure: Replication, Repair & Recombination 3. Prokaryotic & Eukaryotic Transcription 4. Post Transcriptional Modification, Translation & Transport 5. Mutation; Oncogenes and Tumor suppressor gene	Molecular Biology	1. Plasmid DNA isolation and DNA quantification 2. Restriction digestion 3. Preparation of competent cells 4. Agarose gel electrophoresis 5. Restriction Enzyme digestion of DNA 6. Purification of DNA from an agarose gel 7. DNA ligation 8. Transformation of *E. coli.* With standard plasmids, calculation of transformation efficiency 9. Restriction mapping of recombinant plasmid 10. Polymerase chain reaction 11. RFLP analysis of the PCR product		
		Microbiology and Industrial Applications	1. Microbial Diversity & Systematics 2. Microbial Growth & Physiology 3. Microbial Interactions and Infection 4. Microbes and Environment 5. Industrial Applications	Microbiology	1. Standardization, disinfection, safety in microbiological laboratory 2. Preparation of media for growth of various microorganisms 3. Isolation and maintenance of organisms by plating, straking, serial dilution methods-slants and stab cultures. Storage of microorganisms 4. Gram staining and enumeration of microorganisms		

					5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen		
		Biostatistics and Computer Applications	1. Brief description and Tabulation of data and its graphical representation 2. Measure of central tendency and description 3. Simple linear regression and Correlation 4. Introduction of digital computers 5. Flow charts and Programming techniques 6. Introduction to data structures and data base concepts, Introduction to internet and its applications 7. Introduction to MS-office software 8. Introduction to Harvard graphics/Sigma plotter 9. Computer oriented statistical techniques 10. Bio-informatics				
		Environmental Biochemistry and Biotechnology	1. Introduction 2. Pollution 3. Control, remediation and management 4. Alternate source of energy 5. Environment and health in respect to genetics				

	VIII	Genetic Engineering	1. Basics Concepts 2. Cloning Vectors 3. Cloning Methodologies 4. PCR and Its Applications 5. Sequencing methods	Genetic Engineering	1. Isolation of genomic DNA from *E. coli.* 2. PCR amplification of bacterial/plant/animal-cell genomic region and analysis by agarose gel electrophoresis 3. Preparation of plasmid DNA from *E. coli* DH5ά and gel analysis 4. Restriction digestion of vector (gel analysis) with restriction endonucleases 5. A. Vector and insert ligation B. Transformation in E.coli DH5ά 6. Plasmid isolation and confirming recombinant by PCR and RE digestion. 7. Transformation of recombinant with IPTG and analysis on SDS-PAGE. 8. Induction of recombinant protein with IPTG and analysis on SDS-PAGE. 9. Purification of protein on Ni-NTA/Glutathione/Mannose column and analysis of purified by SDS-PAGE.	Elective	
		Analytical Techniques	1. Basic Techniques 2. Spectroscopy Techniques 3. Chromatography Techniques, Electrophoretic Techniques 4. Centrifugation 5. Radioactivity 6. Advanced Techniques	Analytical Techniques	1. Paper chromatography of amino acids **2**. TLC of lipids 3. Isolation of plasmid DNA from *E. coli* 4. Agarose gel electrophoresis of isolated plasmid DNA 5. Extraction and purification of protein from plants and animals 6. SDS-PAGE of BSA and extracted protein		
		Molecular Virology	1. Structure of animal viruses and plant viruses 2. General Genomic organization of animal viruses				

			3. General Genomic organization of plant viruses 4. Methods to diagnose animal virus infections 5. Methods to study plant viruses				
		Cell and Developmental Biology	1. Cell Theory and Methods of Study 2. Membrane Structure and Function 3. Organelles 4. Endo-membrane System and Cellular Motility 5. Cell Communication 6. Differentiation of Specialized Cells, Plant Meristem organization and Differentiation				
		Microbiological techniques	1. Experiments designed to familiarize students with the handling, identification and characterization of microorganisms 2. Introduction to terms and equipments used in Microbiological laboratory, safety precautions, Microscopy 3. Preparation of culture media-nutritional needs of microbes-dehydrated-selective-differentialautotrophic-heterotrophic 4. Isolation of pure microbial flora from natural and extreme environments Biochemical characterization of bacteria-BIOLOG plant method	Microbiological Techniques	1. Preparation of culture media-nutritional needs of microbes-dehydrated-selective-differential-autotrophic-heterotrophic, adjustment of pH, buffers, pure culture techniques, preparation of slants, sub-culturing. 2. Isolation of pure microbial flora from natural and extreme environments, serial dilution, Microbial growth measurement, standard plate count, haemocytometry. 3. Staining: Dye preparation, staining techniques, their applications, Motility (Hanging drop method). Microscopy: Microscope and its operations, components, type. Preservation of microorganisms. Biochemical characterization of bacteria-BIOLOG plate method,		

					carbohydrate fermentation, catalase, peroxidase, indole, methyl red, vogus-prausker, citrate utilization test (IMVIC), Nitrate Reduction Test etc.		
Master in Microbiology							
5	IX	Applied Microbiology	1. Study of microflora with special reference to silage, agro industrial waste, environment, soil fertility and management 2. Scope and importance of microbiology as applied to environment and industry 3. Environmental quality 4. Microbial deterioration of cotton, jute, coir, wool, leather and wood and methods of preservation, Microbiology of biogas generation, utilization of alternate sources of energy, Utilization of agroindustrial waste for microbial biomass and protein 5. Soil fertility and management of agricultural soil			Research Project	5+5+5+5+5+25= **50**
		Bioprocess Engineering and technology	1. Basic Principle of Biochemical Engineering 2. Concepts of Basic Mode of Fermentation Process 3. Downstream Processing 4. Applications of Enzymes in Food Processing				

			5. Applications of Microbes in Food process Operations and Production				
		Bacterial metabolism	1. Metabolic pathways involved in the release and dissimilation of substrates by heterotrophs and autotrophs 2. Thermodynamic considerations of biological reactions 3. Fermentation 4. Biochemistry of xenobiotics degradation 5. Fixation of molecular nitrogen and regulation				
		Molecular Genetics	1. Bacterial Mutants and mutations, Gene transfer in bacteria 2. Bacteriophages and Plasmids 3. Mendelian Genetics, Non-Mendelian inheritance patterns 4. Molecular Genetics of Lambda 5. Gene mapping and human genome project, Population genetics and evolution				
		Immunology and Immunotechnology	1. Immunology- fundamental concepts and anatomy of the immune system 2. Immune responses generated by B and T lymphocytes 3. Antigen-antibody interactions 4. Vaccine Technology 5. Clinical Immunology	Immunology and Immunotechnology	1. Preparation of human blood smear and identification of cells. 2. Determination of blood groups. 3. Determination of Rh antigen. 4. Estimation of antiserum by		

					Mancini method. 5. Estimation of antiserum by Ouchterlony method. 6. Antiserum titer determination by ELISA. 7. DOT ELISA for the presence of specific antigen. 8. Immunization, Collection of Serum. 9. Immunoelectrophoresis. 10. Immunodiagnostics (Demonstration using commercial kits).		

Pattern of examination theory papers

A. Theory

*Each theory paper shall consist two sections **A** and **B**.*
***Section A**: (Short answers type with reasoning); 25 marks, eight questions of five marks each, any five have to be attempted).*
***Section B**: (Long answers type); 50 marks, one question of ten marks each. Five questions are compulsory (each question from each unit) with internal choice.*

B. Internal assessment

For each theory paper internal assessment shall be conducted periodically (in the form of class tests and/or assignments/ group discussion/ oral presentation/ overall performance) during the semester period. Total marks allotted to internal assessment shall be 25. The evaluated answer sheets/assignments have to be retained by the Professor In-Charge for the period of six months and can be shown to the students if students want to see the evaluated answer sheets. The marks obtained by the students shall be submitted to the Head of concerned department/the Principal of the College for uploading onto the University examination portal.

C. Practical

*The laboratory work of the students has to be evaluated periodically. The breakup of marks for practical examination for **each semester** would be as follows:*
Practical exam: 20% marks
Viva voce: 20% marks
Lab record: 20% marks
Spotting: 30% marks
Attendance: 10% marks
Total: 150 marks (each semester)

Marks obtained in the practical examination have to be submitted to the Head of the department/ Principal of the College. The Head of the Department/Principal of the College will make necessary arrangement for uploading the marks onto the University exam portal. The hard copy of the award list from portal has to be submitted to the Controller of Examination, Kumaun University, Nainital.

Semester-VII
Paper-1 (Theory)
Course Title: Biochemistry

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Seven
Paper 1 Theory Subject: Microbiology		
Course Code: PBT01-(T/P)	**Course Title:** Biochemistry	
Credits: 4	Compulsory	
Max. Marks: 100	Min. Passing Marks:……	

Total Number of Lectures = 60

Course Objectives: To develop a clear understanding of the concepts related to structures and functions of biomolecules for better understanding of energetics and regulation of metabolic pathways. To develop hands-on-ability in young minds to plan and execute different biochemical experiments in the laboratory.

Unit	**Content**	**Number of lectures**
1	**Chemical Basis of Life:** Composition of living matter; Water-properties, pH, pKa, Titration curves of weak acids, Buffers, Handerson-Hasselbach equations, ionization and hydrophobicity; Emergent properties of biomolecules in water; Water as a reactant.	8
2	**Proteins:** Amino acids as building blocks of proteins and their chemical properties, pI and pKa values, Primary, Secondary, Tertiary and Higher order structure of Proteins, Protein Sequencing, Ramchandran Plot, Conjugated proteins-Glycoproteins, Lipoproteins, Heamproteins.	10
3	**Enzymes**: General principles of catalysis, Quantitation of enzyme activity and efficiency, Enzyme characterization and Michaelis-Menten kinetics, Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; Single substrate enzymes	10
4	**Carbohydrates:** Mono- Di- and Polysaccharides, Optical isomerism, Structure of Carbohydrates, Glycolysis, Gluconeogenesis, Pentose phosphate pathways, Citric acid cycle.	8
5	**Lipids:** Classification and structural analysis of fatty acids, Glycerols, Waxes, Glycolipids, Phospholipids, Sphingolipids, Sterols, Lipoproteins, β-oxidation, Biosynthesis of Cholesterol and Fatty acids	10
6	**Nucleic acids:** Biosynthetic pathways of purines and pyrimidines, degradation pathways	6
7	**Bioenergetics-** Basic principles; Equilibria and concept of free energy; Group transfer, concept of Entropy, Enthalpy and free energy, Oxidation and Reduction reactions, Electron Transport Chain, Oxidative phosphorylation; photosynthesis.	8

Books Recommended:

(i) David L. Nelson, Michael Cox, Lehninger Principles of Biochemistry: International Edition
(ii) Victor W. Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil, Harper's Illustrated Biochemistry Thirty-First Edition (A & L LANGE SERIES), 31st Edition
(iii) Jeremy M. Berg, Lubert Stryer, John Tymoczko, Gregory Gatto, Biochemistry, 9th Edition
(iv) Donald Voet, Judith G. Voet, Charlotte W. Pratt, Fundamentals of Biochemistry: Life at the Molecular Level, 5th Edition
(v) U Satyanarayana, Biochemistry

Suggested online links:
https://www.youtube.com/channel/UCv_PnJwd_q7mAv7nGHw7XHQ, Fundamentals of Biochemistry
https://www.youtube.com/watch?v=CHJsaq2lNjU, Introduction to Biochemistry
https://www.biochemistry.org
https://www.organic-chemistry.org, Biochemistry Links - Organic Chemistry Portal
https://www.csulb.edu

Semester-VII

Practical

Course Title: Biochemistry

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Seven
		Practical Subject: Microbiology
Course Code: PBT01-(T/P)		**Course Title:** Biochemistry-Practical
Credits:1		Compulsory
Max. Marks: 50		Min. Passing Marks:……

Total Number of hours = 60

Unit	**Contents**	**Number of hours**
1	Titration of Amino Acids.	**15**
2	Colorimetric determination of pKa.	**15**
3	Quantitative estimation of Proteins and Sugars.	**15**
4	Separation techniques- Centrifugation, Chromatography (Gel Permeation, Ion exchange, TLC, etc.)	**15**

Semester-VII
Paper-2 (Theory)
Course Title: Molecular Biology

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Seven
		Paper-2 Theory Subject: Microbiology
Course Code: PBT02-(T/P)		**Course Title:** Molecular Biology
Credits: 4		Compulsory
Max. Marks: 100		Min. Passing Marks:……

Total Number of Lectures = 60

Course Objectives: To illustrate the molecular concepts of life, through learning the organization and functions of DNA, RNA, and proteins, that can describe and demonstrate the regulation of various biological processes. To develop clear understanding of established concepts and perceive recent scientific developments in the field of molecular biology.

Unit	**Contents**	**Number of Lectures**
1	**Genome Organization** Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive region; DNA methylation & Imprinting	12
2	**DNA Structure; Replication; Repair & Recombination** Structure of DNA-A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes; Gene disruption; FLP/FRT and Cre/Lox recombination.	12
3	**Prokaryotic & Eukaryotic Transcription** Prokaryotic Transcription; Transcription unit; Promoters-Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept- lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA	12

	Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing	
4	**Post Transcriptional Modification** Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA. **Translation & Transport** Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co-and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation	12
5	**Mutation; Oncogenes and Tumor suppressor gene** Nonsense, missense and point mutations; Intragenic and Intergenic suppression; Frameshift mutations; Physical, chemical and biological mutagens; Transposition- Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators.	12

Books Recommended:

(i) David P. Clark, Nanette J. Pazdernik and Michelle R. McGehee, Molecular Biology, 3rd Edition

(ii) Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter, Molecular Biology of the Cell, Sixth Edition

(iii) Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Lewin's GENES XII, 12th Edition

(iv) Watson, J. D. Baker TA, Bell, SP Gann, A. Levine, M. Losick R. (2008). Molecular Biology of the Gene (5th ed.). Pearson

(v) Lodish, H F. Berk, A. Kaiser, CA, Krieger, M. Bretscher, A. Ploegh, H. Aman, A. Martin, K. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman

(vi) Karp, G. Cell and Molecular Biology. Concepts and experiments. John Harris, D., Wiley & sons, New York

(vii) Old, R. W., Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics, 7th Edition: Blackwell Publishing.

(viii) Brown, T. A. (2018). Genomes 4. (4th edition) New York: Garland Science Pub.

Suggested online links:

https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/molecularbiology/
https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/molecularbiology/transcription-translation/
https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/molecularbiology/gene-regulation-and-the-lac-operon/
https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinantdna/
https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinantdna/agarose-gel-electrophoresis-dna-sequencing-pcr/
https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinantdna/basic-mechanics-of-cloning/

Semester-VII

Practical

Course Title: Molecular Biology

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Seven
Practical Subject: Microbiology		
Course Code: PBT02-(T/P)	**Course Title:** Molecular Biology-Practical	
Credits:1	Compulsory	
Max. Marks: 50	Min. Passing Marks:……	

Total Number of Hours = 60

Unit	Contents	Number of Hours
1	Plasmid DNA isolation and DNA quantitation	**5**
2	Restriction digestion	**5**
3	Preparation of competent cells	**5**
4	Agarose gel electrophoresis	**5**
5	Restriction Enzyme digestion of DNA	**5**
6	Purification of DNA from an agarose gel	**5**
7	DNA Ligation	**5**
8	Transformation of *E. coli* with standard plasmids, Calculation of transformation efficiency	**10**
9	Restriction mapping of recombinant plasmid.	**5**
10	Polymerase Chain reaction	**5**
11	RFLP analysis of the PCR product	**5**

Semester-VII
Paper-3 (Theory)
Course Title: Microbiology and Industrial Applications

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Seven
		Paper-3 Theory Subject: Microbiology
Course Code: PBT03-(T/P)	**Course Title:** Microbiology and Industrial Applications	
Credits: 4		Compulsory
Max. Marks: 100		Min. Passing Marks:……

Total Number of Lectures = 60

Course Objectives: To develop understanding of the basic concepts on Microbial growth and physiology, Microbial diversity and systematics. To develop understanding on the microbes and their relations to environment.

Unit	**Contents**	**Number of Lectures**
1	**Microbial Diversity & Systematics.** The Milestones in Microbiology: The discovery of microbial world by Antony van Leeuwenhocek, The controversy over spontaneous generation, Golden age of Microbiology. Criteria for classification of microorganism; Classification of Bacteria according to Bergey's manual; Molecular methods such as Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Amplified rDNA Restriction Analysis and Terminal Restriction Fragment Length Polymorphism (T-RFLP) in assessing microbial diversity; 16S rDNA sequencing and Ribosomal Database Project.	12
2	**Microbial Growth & Physiology** Cell Structure and Functions: Prokaryote cell, size, shape and arrangement of bacterial cells, Cell wall, External and Internal structures to the cell wall of Eubacteria. Ultrastructure of Archaea (Methanococcus); Unicellular Eukaryotes (Yeast). Microbial growth: Batch, fed-batch, continuous kinetics, synchronous growth, methods of growth estimation, stringent response, thermal death of a bacterial cell. Methods in Microbiology: Pure culture techniques, The theory and practice of sterilization, Principles of microbial nutrition, Construction of culture media, Enrichment of culture techniques, Pure culture and its maintenance	12
3	**Microbial Interactions and Infection** Host-pathogen interactions; Microbes infecting animals and plants; Disease reservoirs, Epidemiological terminologies, Infectious diseases transmission, Pathogenicity islands and their role in bacterial virulence	12
4	**Microbes and Environment** Salient features of extremophiles (halophiles, thermophiles, psychrophiles) archaeabacteria. aerobic and anaerobic bacteria, phototrophic and gliding bacteria, prosthecate and budding	12

	bacteria. Ecological impacts of microbes; Symbiosis (Nitrogen fixation and ruminant symbiosis); Microbes and Nutrient cycles; Microbial communication system; Quorum sensing	
5	**Industrial Applications** Role of microorganisms in natural system and artificial system. Scope and importance of Microbiology in Biotechnology. Microbial fuel cells; Prebiotics and Probiotics; Vaccines. Microbial processes-production, optimization, screening, strain improvement, for the production of ethanol, organic acids, antibiotics etc. Basic principles in bioprocess technology; Media Formulation; Sterilization; Batch and continuous sterilization systems; Bioprocess control and monitoring variables such as temperature, agitation, pressure, pH.	12

Books Recommended:

(i) Madigan, M. T., Martinko, J. M., & Parker, J. (2003). Brock biology of microorganisms. Upper Saddle River, NJ: Prentice Hall/Pearson Education.
(ii) Prescott, and Joanne M. Willey. Prescott's Microbiology. New York: McGraw-Hill, 2011.
(iii) Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (1993). Microbiology: Concepts and applications. New York: McGraw-Hill.
(iv) Tortora, Gerard J, Berdell R. Funke, and Christine L. Case (2004). Microbiology: An Introduction.
(v) W. Mattha, C. Y. Berg, and J. G. Black. (2005). Microbiology, Principles and Explorations. Boston, MA: John Wiley & Sons.
(vi) Ananthanarayana R, Panicker CKJ (2020). Ananthanarayana and Panicker's Textbook of Microbiology(11edition) Universities Press (India) Pvt. Ltd

Suggested online links:

https://microbeonline.com
https://ocw.mit.edu/courses/find-by topic/#cat=science&subcat=biology&spec=microbiology
https://nptel.ac.in/courses/102/103/102103015/

Semester-VII

Practical

Course Title: Microbiology and Industrial Application

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Seven
		Practical Subject: Microbiology
Course Code: PBT03-(T)	**Course Title:** Microbiology and Industrial Application - Practical	
Credits:1		Compulsory
Max. Marks: 50		Min. Passing Marks:……

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	Sterilization, disinfection, safety in microbiological laboratory.	**7**
2	Preparation of media for growth of various microorganisms.	**7**
3	Isolation and maintenance of organisms by plating, Streaking and Serial dilution methods- slants and stab cultures, Storage of microorganisms.	8
4	Gram Staining and enumeration of microorganisms.	**7**
5	Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.	**7**
6	Assay of antibiotics production and demonstration of antibiotic resistance.	**7**
7	Isolation and screening of industrially important microorganisms.	9
8	Determination of thermal death point and thermal death time of microorganisms.	8

Semester-VII
Paper-4 (Theory)
Course Title: Biostatistics and Computer Applications

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Seven
Paper-4 Theory Subject: Microbiology		
Course Code: PBT04-(T)	**Course Title: Biostatistics and Computer Applications**	
Credits: 5	Compulsory	
Max. Marks: 100	Min. Passing Marks:……	

Total Number of Lectures = 60

Course Objectives: To gain understanding on fundamentals of computers and biostatistics for managing and analyzing the scientific data generated.

Unit	**Contents**	**Number of Lectures**
1	Brief description and Tabulation of data and its graphical representation.	6
2	Measure of central tendency and description: Mean, Mode, Median, Range, Standard deviation, Variance, Idea of two types of errors and level of significance, Tests of significance (F and T test), Chi-Square tests.	8
3	Simple linear regression and Correlation.	4
4	Introduction of digital computers: Organizations, Low-level and High-level languages, Binary systems.	6
5	Flow charts and Programming techniques.	4
6	Introduction to data structures and data base concepts, Introduction to internet and its applications.	6
7	Introduction to MS-office software covering word processing, spread sheets and presentation software.	6
8	Introduction to Harvard graphics/Sigma plotter.	4
9	Computer oriented statistical techniques: Frequency table of single discrete variable. Bubble sort, Computation of mean, Variance and standard deviations, T-test, Correlation coefficient.	8
10	Bio-informatics- Internet access and using web search engines to access biological databases, sequence, structure and strain database, Secondary and sequence analysis of DNA, RNA and proteins.	8

Books Recommended:

(i) Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press.
(ii) Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley
(iii) Mariappan P. (2013) Biostatistics. Pearson
(iv) Rastogi VB. (2015). Biostatistics (3rd Edition). MedTec
(v) Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press
(vi) Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience

Suggested online links:

https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-092bioinformatics-and-proteomics-january-iap-2005/lecture-notes/
https://ocw.mit.edu/courses/biology/7-91j-foundations-of-computational-and-systems-biologyspring-2014/
https://ocw.mit.edu/courses/biology/7-91j-foundations-of-computational-and-systems-biologyspring-2014/lecture-slides/
https://ocw.mit.edu/courses/mathematics/18-650-statistics-for-applications-fall-2016/
https://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/
https://ocw.mit.edu/courses/mathematics/18-443-statistics-for-applications-fall-2003/lecture-notes/

Semester-VII
Paper-5 (Theory)
Course Title: Environmental Biochemistry and Biotechnology

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Seventh
Paper-5 Theory Subject: Microbiology		
Course Code: PBT05-(T)	**Course Title: Environmental Biochemistry and Biotechnology**	
Credits:5	Compulsory	
Max. Marks: 100	Min. Passing Marks:……	

Total Number of Lectures = 60

Course Objectives: The course is aimed at to make students understand and appreciate the importance of environmental biotechnology so as to develop remediation techniques for environmental degradation. To inspire the students to find ways to contribute personally and professionally for sustainable development of environment friendly societal development.

Unit	**Contents**	**Number of Lectures**
1	**Introduction** Environment; Basic concepts; Resources; Eco system: plants, animals, microbes; Ecosystem management; Renewable resources; Sustainability; Microbiology of degradation and decay;	12

	Role of Biotech in environmental protection; Control and management of biological processes.	
2	**Pollution** Environmental pollution; Source of pollution; Air, water as a source of natural resource; Hydrocarbons, substituted hydro carbons; Oil pollution; Surfactants; Pesticides; Measurement of pollution; Water pollution; Biofilm; Soil pollution; Radioactive pollution; Radiation; Ozone depletion; Green house effect; Impact of pollutants; Measurement techniques; Pollution of milk and aquatic animals.	12
3	**Control, remediation and management** Waste water collection; control and management; Waste water treatment; Sewage treatment through chemical, microbial and biotech techniques; Anaerobic processes; Anaerobic filters; Anaerobic sludge blanket reactors; Bioremediation of organic pollutants and odorous compounds; Use of bacteria, fungi, plants, enzymes, and GE organisms; Plasmid borne metabolic treatment; Bioaugmentation; Bioremediation of contaminated soils and waste land; Bioremediation of contaminated ground water; Macrophytes in water treatment; Phytoremediation of soil metals; Treatment for waste water from dairy, distillery, tannery, sugar and antibiotic industries.	12
4	**Alternate source of energy** Biomass as source of energy; Bioreactors; Rural biotechnology; Biocomposting; Biofertilizers; Vermiculture; Organic farming; Bio-mineralization; Biofuels; Bioethanol and biohydrogen; Solid waste management.	12
5	**Environment and health in respect to genetics** Gene and environment; Effect of carbon and other nanoparticles upon health; Gene mutation; Genetic testing; Genetic sensors; Environmental pollution and children; Human biomonitoring.	12

Books Recommended:

(i) Thakur I. S. (2011) Environmental Biotechnology basic concepts and applications. I. K. International Publishing House Pvt. Limited

(ii) Evans G M and J. C. Furlong (2003). Environmental Biotechnology: Theory and Applications. Wiley Publishers.

(iii)Ritmann R and McCarty P L (2000). Environmental Biotechnology: Principle & Applications. 2nd Ed., McGraw Hill Science.

(iv)Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.

(v) Srinivas TR (2008). Environmental Biotechnology. New Age International Pvt. Ltd.

Suggested online links:

https://nptel.ac.in/courses/104/103/104103020/

https://nptel.ac.in/courses/102/105/102105088/

SEMESTER VIII
Paper 1 (Theory)
Course Title: Genetic Engineering

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Eighth
Paper-1 Theory Subject: Microbiology		
Course Code: PBT06-(T/P)	**Course Title: Genetic Engineering**	
Credits: 4	Compulsory	
Max. Marks: 100	Min. Passing Marks:……	

Total Number of Lectures = 60

Course Objectives: The objectives of course include development of theoretical and practical knowledge on concepts of genetic engineering such as cloning vectors, PCR, restriction enzymes and DNA sequencing.

Unit	**Contents**	**Number of Lectures**
1	**Basics Concepts** DNA structure and properties; Restriction enzymes; DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphate, cohesive and blunt end ligation; Linkers; Adaptors; Homopolymer tailing, Labeling of DNA, Hybridization technique: Northern, southern and colony hybridization, fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA Protein Interactions; electrophoretic shift assay.	**12**
2	**Cloning Vectors** Plasmids; M13 mp vector; PUC19 and Bluescript vectors, Phagemids, Lambda vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Mammalian expression vectors & retroviral vectors; Prokaryotic Expression vectors with GST-, His- and MBP-tags; Affinity purification of recombinant fusion proteins; Inclusion bodies; Methodologies to reduce formation of inclusion bodies.	**12**
3	**Cloning Methodologies** Bacterial Transformation; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Expression cloning; Phage display	**12**
4	**PCR and Its Applications** Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR- reverse transcriptase, real time PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Proof reading enzymes; PCR in site specific mutagenesis; PCR in molecular diagnostics; Viral and bacterial detection.	**12**
5	Enzymatic DNA sequencing; Automated DNA sequencing; Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing	**12**

	techniques; RNA interference and siRNA Gene knockouts and Gene Therapy	

Books Recommended:

(i) Principles of Gene Manipulation by R.W. Old and S.B. Primrose Third Edition Blackwell Scientific Publication
(ii) Genes VI by B. Lewin
(iii) From Genes to Clones by E. L. Whittecker.
(iv) Brown, T. A. (2006). Gene Cloning and DNA Analysis: an Introduction. Oxford: Blackwell Pub.
(v) Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford: Oxford University Press

Suggested online links:

https://ocw.mit.edu/courses/find-by-topic/#cat=science&subcat=biology&spec=stemcells
https://ocw.mit.edu/courses/materials-science-and-engineering/3-051j-materials-for-biomedical-applications-spring-2006/lecture-notes/lecture13.pdf
https://ocw.mit.edu/courses/biological-engineering/20-109-laboratory-fundamentals-in-biological-engineering-fall-2007/lecture-notes/
https://ocw.mit.edu/courses/health-sciences-and-technology/hst-535-principles-and-practice-of-tissue-engineering-fall-2004/
https://ocw.mit.edu/courses/biological-engineering/20-109-laboratory-fundamentals-in-biological-engineering-fall-2007/labs/mod1_3/

Semester-VIII

(Practical)

Course Title: Genetic Engineering

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Eighth
		Practical Subject: Microbiology
Course Code: PBT06-(T/P)	**Course Title:** Genetic Engineering-practical	
Credits: 1	Compulsory	
Max. Marks: 50	Min. Passing Marks:……	

Total Number of Hours: 60

Unit	**Contents**	**Number of Hours**
1	Isolation of genomic DNA from *E. coli*	**6**
2	PCR amplification of bacterial/plant/animal-cell genomic region and analysis by agarose gel electrophoresis.	**6**

3	Preparation of plasmid DNA from *E. coli* DH5α and gel analysis.	**6**
4	Restriction digestion of vector (gel analysis) with Restriction endonucleases	**6**
5	Vector and Insert ligation	**6**
6	Transformation in *E. coli* DH5α.	**6**
7	Plasmid isolation and confirming recombinant by PCR and RE digestion.	**6**
8	Transformation of recombinant plasmid in *E. coli* Laboratory strain.	**6**
9	Induction of recombinant protein with IPTG and analysis on SDS-PAGE	**6**
10	Purification of protein on Ni-NTA/Glutathione/Mannose column and analysis of purified protein by SDS- PAGE.	**6**

SEMESTER VIII
Paper-2 (Theory)
Course Title: Analytical Techniques

Program/Class: Bachelor (Research) in Microbiology	**Year: Fourth**	**Semester:** Eighth
Paper-2 Theory Subject: Microbiology		
Course Code: PBT(07)-(T/P)	**Course Title: Analytical Techniques**	
Credits: 4	Compulsory	
Max. Marks: 100	Min. Passing Marks:……	

Total Number of Lectures = 60

Course Objectives: The course envisages conceptual and hands on learning of various analytical techniques. This course will enable students to perform spectroscopy techniques, enzyme assays, chromatography techniques etc.

Unit	**Contents**	**Number of Lectures**
1	**Basic Techniques** Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membrane proteins; Dialysis, Ultrafiltration and other membrane techniques. **Spectroscopy Techniques** Basic Principle, Instrumentation and Biological applications of: UV and Visible light absorption spectroscopy, Spectrofluorometry, CD and ORD, Atomic spectroscopy (Absorption and emission). Infrared spectroscopy, Raman Scattering, Application of FT-IR in the study of biomolecules, Nuclear Magnetic Resonance (NMR) spectroscopy, and EPR; Mass spectroscopy and mass analyzers like ion trap, quadrupole, magnetic sector, time of flight (ToF).	**12**
2	**Chromatography Techniques** TLC and Paper Chromatography; Column chromatography Chromatographic methods for macromolecule separation-Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC. **Electrophoretic Techniques** Theory and application of Polyacrylamide and Agarose gel electrophoresis; Native and SDS-PAGE electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis	**12**
3	**Centrifugation** Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge- Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Application (Isolation of cell components); Analytical centrifugation.	**12**
4	**Radioactivity**	**12**

	Radioactive & stable isotopes; Radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Autoradiography; Applications of isotopes in biochemistry, Clinical application; Radioimmunoassay	
5	**Advanced Techniques** Protein crystallization; Enzyme and cell immobilization techniques	**12**

Books Recommended:

(i) Olaniyan, F. M., (2017) V Edition, Laboratory Instrumentation and Techniques, Createspace independent publishing platform

(ii) Wilson, K., Walker, J. (eds.); Cambridge University Press, Cambridge, 2000, V Edition.

(iii)Willard, M. H., (2004), VII Edition, Instrumental Methods of Analysis, CBS Publisher and distributor Private Limited.

Suggested online links:

https://nptel.ac.in/courses/102/103/102103044/

Semester-VIII

(Practical)

Course Title: Analytical techniques

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Eighth
Practical Subject: Microbiology		
Course Code: PBT07-(T/P)	**Course Title:** Analytical Techniques-Practical	
Credits: 1	Compulsory	
Max. Marks: 50	Min. Passing Marks:……	

Total Number of Hours:60

Unit	Contents	Number of Hours
1	Paper chromatography of amino acids	**10**
2	TLC of lipids	**10**
3	Isolation of plasmid DNA from Ecoli	**10**
4	Agarose gel electrophoresis of plasmid DNA from Ecoli	**10**
5	Extraction and purification of protiens from plant and animal	**10**

6	SDS PAGE of BSA and extracted proteins	**10**

Semester- VIII

Paper-3 (Theory)

Course Title: Molecular Virology

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Eighth
Paper-3 Theory Subject: Microbiology		
Course Code: PBT08-(T)	**Course Title: Molecular Virology**	
Credits: 5	Compulsory	
Max. Marks: 100	Min. Passing Marks…	

Total Number of Lectures = 60

Course Objectives: The course objectives include learning of structural and genomic organization of different animal and plant viruses. The learning will enable students to take up research in challenging and evolving areas of virology, such as effective diagnostic and treatment of viral infections in plants and animals.

Unit	**Contents**	**Number of Lectures**
1	Structure of animal viruses and plant viruses; Classification of animal and plant viruses; Satellite viruses; Viroids; Virusoids, Prions etc.; Transmission of Viruses; Vectors for Virus transmission, Cell to cell and systemic movement of viruses. Impact of Viruses on Health and Economy: (Diseases causes by animal viruses and plant viruses; Economic loss due to important viruses); Bacterial Viruses: Lysogenic and Lytic Phages, Bacteriophage Typing.	12
2	General Genomic organization of animal viruses; Replication and Life cycle of: Poliovirus, Human Immunodeficiency virus (HIV), Influenza Virus, Rabies Virus, Poxvirus, Herpesvirus and Hepatitis viruses; Introduction to Cancer causing viruses and their mechanism of host-cell transformation.	12
3	General Genomic organization of plant viruses; Replication and Life cycle of plant viruses: Cauliflower Mosaic Virus (CMV), Tobacco Mosaic Virus (TMV), Rice Dwarf Virus, Citrus triesteza Virus.	12
4	Methods to diagnose animal virus infections: Electron microscopy, Tissue culture growth of viruses and Cytopathic effects, Virus quantitation assays, Viral serology: ELISA, neutralization assays; Molecular methods: hybridization, Real-time PCR, antiviral assays.	12

5	Methods to study plant viruses; Infectivity assays – Sap transmission, insect vector transmission, agroinfection (using Agrobacterium); serological methods, immunelectrophoresis in gels, direct double-antibody sandwich method, Dot ELISA, Immunosorbent electron microscopy (ISEM), Polymerase chain reaction; Gene silencing, and viral suppressors of gene silencing.	12

Books Recommended:

1. Acheson, N. H. (2011). Fundamentals of Molecular Virology (No. Ed. 2). John Wiley & Sons, Inc.

Suggested online links:

https://nptel.ac.in/courses/102/103/102103039/

SEMESTER VIII

Paper-4 (Theory)

Course Title: Cell and Developmental Biology

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Eighth
Paper-4 Theory Subject: Microbiology		
Course Code: PBT09-(T)	**Course Title:** Cell and Developmental Biology	
Credits:5	Compulsory	
Max. Marks: 100	Min. Passing Marks:……	

Total Number of Lectures = 60

Course Objectives: Produce a basic understanding of the unit of life i.e., cell by theoretical and pictorial learning of the organization and function of different cell organelles and developmental biology. Learning critical concepts, facts, and theories relevant to cellular mechanisms also understand the functions of different organelles of the cell and their interrelationships. Perceive recent developments in the field.

Unit	Contents	Number of Lectures
1	**Cell Theory and Methods of Study** Microscope and its modifications- Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy, etc. **Membrane Structure and Function** Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and	**12**

	Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata	
2	Cellular compartments and intracellular sorting of proteins, ER & Lysosomes, peroxisomes, synthesis and sorting of proteins (lysosomal proteins, membrane proteins, secretory proteins). Nuclear transport.	**12**
3	**Endo-membrane System and Cellular Motility** Organization of nucleus and nuclear membrane, structure and organization of chromatin. Cytoskeleton: Actin filaments and cell cortex, cilliary movements and cytoplasmic microtubules and intermediate filaments.	**12**
4	**Cell Communication** General principle, Signal Molecules, Signaling through GPCRs, Second Messengers, Molecular Switches, Cells Sensitivity to a signal, IP3, Jak-STAT pathways, Cam Kinase-II, Receptor Tyrosine Kinase, Signaling in Plants	**12**
5	**Differentiation of specialized cells** Stem cell differentiation. Differentiation of cancerous cells and role of proto-oncogenes **Plant Meristem Organization and Differentiation** Organization of shoot Apical Meristem (SAM); Organization of Root Apical Meristem (RAM); Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixes.	**12**

Books Recommended:

(i) Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). **Molecular Biology of the Cell** (6th Ed.). New York: Garland Science

(ii) Cooper, G. M., and Hausman, R. E. (2013). **The Cell: a Molecular Approach** (6th Ed.). Washington: ASM ; Sunderland.

(iii) Karp, G. **Cell and Molecular Biology. Concepts and experiments**. John Harris, D., Wiley & sons, New York

Suggested online links:

https://nptel.ac.in/courses/102/103/102103012/
https://nptel.ac.in/courses/102/106/102106084/
https://nptel.ac.in/courses/102/107/102107075/

Semester-VIII
Paper-5 (Theory + Practical)
Course Title: Microbiological Techniques

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Eighth
Paper-5 Theory Subject: Microbiology		
Course Code: PMB01-(T/P)	**Course Title:** Microbiological Techniques	
Credits: 4	Compulsory	
Max. Marks: 100	Min. Passing Marks:……	

Total Number of Lectures = 60

Course Objectives: To understand the interdependency of microbiology and biological systems such as the relationship between structure of microorganisms and their biological activity. To introduce students to biochemical and molecular techniques essential for microbiologists.

Unit	Content	Number of lectures
1	Experiments designed to familiarize students with the handling, identification and characterization of microorganisms and their activities particularly those of interest to man from different habitats.	**10**
2	Introduction to terms and equipments used in Microbiological laboratory, safety precautions, Microscopy: Microscope and its operations, components, types. Staining: types of dyes, preparation, staining techniques, their applications, Motility (Hanging drop method), Cell cytometry	**15**
3	Preparation of culture media-nutritional needs of microbes-dehydrated-selective-differential-autotrophic-heterotrophic, Culture techniques-adjustment of pH, buffers, pure culture techniques, prepartion of slants, sub-culturing, Preservation of microorganisms-slants, mineral oil, paraffin, Norris-bead method, lyophilization etc.	**15**
4	Isolation of pure microbial flora from natural and extreme environments-air, soil, water, food, Halophilic, thermophilic, psychrophilic and Acidophilic, Microbial growth measurements-Direct and indirect methods-cell count, turbidity measurement, percentage transmission, optical density, serial dilution, standard plate count, haemocytometry	**10**
5	Biochemical characterization of bacteria-BIOLOG plant method, carbohydrate fermentation, catalase, peroxidase, indole, methyl red, vogus-prausker, citrate utilization test (IMViC) etc. Assignment: Identification of unknown isolated pure culture upto genus level.	**10**

Books Recommended:

(i) Brock Biology of Microorganisms, 14th edition
(ii) Prescott`s Microbiology, 10th edition
(iii) R. Anathanarayan and Panikar, Text Book of Microbiology, 10th edition
(iv) Gerard J. Tortora. Microbiology: An Introduction.
(v) Tortora, Funke and Case, Mirobiology: An Introduction
(vi) Michael J. Leboffe and Burton E. Pierce, Microbiology Laboratory Theory and Application, 3rd edition

Suggested online links:

https://microbeonline.com
https://bio.libretexts.org
http://britannica.com09/ET/1456899566CHE_P3_M5_etext.pdf
http://phaostech.com
https://keyence.com
https://courses.lumenlearning.com

Semester-VIII

(Practical)

Course Title: Microbiological Techniques

Program/Class: Bachelor (Research) in Microbiology	**Year:** Fourth	**Semester:** Eighth
		Practical Subject: Microbiology
Course Code: PMB01-(T/P)	**Course Title:** Analytical Techniques-Practical	
Credits: 1	Compulsory	
Max. Marks: 50	Min. Passing Marks:……	

Total Number of Hours:60

Unit	**Content (Practical)**	**Number of Hrs.**
1	Preparation of culture media-nutritional needs of microbes-dehydrated-selective-differential-autotrophic-heterotrophic, adjustment of pH, buffers, pure culture techniques, preparation of slants, sub-culturing.	15
2	Isolation of pure microbial flora from natural and extreme environments, serial dilution, Microbial growth measurement, standard plate count, haemocytometry.	15
3	Staining: Dye preparation, staining techniques, their applications, Motility (Hanging drop method). Microscopy: Microscope and its operations, components, type. Preservation of microorganisms.	15
4	Biochemical characterization of bacteria-BIOLOG plate method, carbohydrate fermentation, catalase, peroxidase, indole, methyl red, vogus-prausker, citrate utilization test (IMViC), Nitrate Reduction Test etc.	15

SEMESTER IX
Paper-1 (Theory)
Course Title: Applied Microbiology

Program/Class: Master in Microbiology	**Year:** Fifth	**Semester:** Ninth
		Paper-1 Theory Subject: Microbiology
Course Code: PMB02-(T)	**Course Title:** Applied Microbiology	

Credits: 5	Compulsory
Max. Marks: 100	Min. Passing Marks:……

Total Number of Lectures = 60

Course Objectives: Students will get expertise in the applications of microbial functioning at the advanced level. They will make use of tools, technologies, and microbiological methods to independently carry out research and development work to solve the practical problems.

Unit	**Contents**	**Number of Lectures**
1	Study of microflora with special reference to silage, agroindustrial waste, environment, soil fertility and management.	**12**
2	Scope and importance of microbiology as applied to environment and industry, Petroleum and mining microbiology, Biopesticides and Microbiology of paints, films, pharmaceuticals and other stored products, fermented food products and Biotransformation of steroids	**12**
3	Environmental quality; Biodegradation of waste and pollutants; (i) solid waste disposal, sanitary, landfills and composting (ii) Treatment of liquid waste, sewage treatment, (iii) treatment and safety of water supply, Role of microbes in bioremediation, genetic engineering and biotechnology, Microbial degradation of pesticides and hydrocarbons	**12**
4	Microbial deterioration of cotton, jute, coir, wool, leather and wood and methods of preservation, Microbiology of biogas generation, utilization of alternate sources of energy, Utilization of agroindustrial waste for microbial biomass and protein	**12**
5	Soil fertility and management of agricultural soil: soil microflora and organic matter decomposition, rhizosphere, Soil-plant-microbe interactions and Biofertilizers.	**12**

Semester-IX
Paper-2 (Theory)
Course Title: Bioprocess Engineering and Technology

Program/Class: Master in Microbiology	**Year:** Fifth	**Semester:** Ninth
		Paper-2 Theory Subject: Microbiology
Course Code: PBT12(T)	**Course Title: Bioprocess Engineering and Technology**	
Credits: 5	**Compulsory**	
Max. Marks: 100	Min. Passing Marks:	

Total No. of Lectures- = 60

Course Objectives: To learn the basics of different types of fermentors and its accessories. Learning sterilization procedures, practical aspects of microbial growth kinetics, production kinetics, and inhibition models, types of bioreactor, its configurations and operation modes

based upon the nature of natural products. To solve problems and seek practical solutions for large scale implementation.

Unit	Contents	Number of Lectures
1	**Basic principle of Biochemical engineering** Isolation, screening and maintenance of industrially important microbes; Microbial growth (an example from each group, particularly with reference to industrially useful microorganisms); Strain improvement for increased yield and other desirable characteristics.	12
2	**Concepts of basic mode of fermentation processes** Bioreactor designs; Types of fermentation and fermenters; Concepts of basic modes of fermentation – Batch, fed batch and continuous; Conventional fermentation v/s biotransformation; Solid substrate, surface and submerged fermentation; Fermentation media; Measurement and control of bioprocess parameters; Scale up and scale down process.	12
3	**Downstream processing** Bioseparation- filtration, centrifugation, sedimentation, flocculation; Cell disruption; Storage and packaging; Treatment of effluent and its disposal.	12
4	**Applications of enzymes in food processing** Mechanism of enzyme function and reactions in process techniques; Enzymic bioconversions e.g. starch and sugar conversion processes; High-Fructose Corn Syrup; Production, recovery and scaling up of enzymes and their role in food and other industries; Immobilization of enzymes and their industrial applications	12
6	**Applications of Microbes in food process operations and production** Fermented foods and beverages; Food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; Microbes and their use in pickling, producing colors and flavors, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; Bacteriocins from lactic acid bacteria – Production and applications in food preservation.	12

Books recommended:

(i) Stanbury P F and Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press

(ii) Shuler M L and Kargi F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.

(iii) Glazier AN and Nikaido H (2007).Microbial Biotechnology – Fundamental & Applied Microbiology – Second Edition. Cambridge University Press.

(iv) Casida LE (2019) Industrial Microbiology. Second Edition,New Age International Publisher.

(v) Bailey J E and Ollis D F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.

Suggested online links:

https://ocw.mit.edu/high-school/biology/exam-prep/cellular-energetics/fermentationcellular-respiration/fermentation/

https://nptel.ac.in/courses/102/106/102106080/

https://nptel.ac.in/courses/102/106/102106048/

https://nptel.ac.in/courses/102/106/102106022/

Semester-IX
Paper-3 (Theory)
Course Title: Bacterial Metabolism

Program/Class: Master in Microbiology	**Year:** Fifth	**Semester:** Ninth
Paper-3 Theory Subject: Microbiology		
Course Code: PMB03(T)	**Course Title:** Bacterial Metabolism	
Credits: 5	Compulsory	
Max. Marks: 100	Min. Passing Marks:……	

Total Number of Lectures = 90

Course Objectives: To make students understand the basics of bacterial metabolism. Outline the metabolic pathways and function of pathways like fermentation, xenobiotic degradation, nitrogen fixation and methanogenesis etc., by bacterial system.

Unit	**Content**	**Number of lectures**
1	Detailed study of metabolic pathways involved in the release and dissimilation of substrates by heterotrophs and autotrophs with emphasis on the reactions of industrial and environmental concern.	**20**
2	Thermodynamic considerations of biological reactions, mechanisms of ATP synthesis, Photosynthesis and photometabolism in eubacteria, Respiration: aerobic and anaerobic, electron transport chain and Metabolism of secondary metabolites	**20**
3	Fermentation of lactic acid bacteria, ethanol fermenting organisms, propionic acid bacteria, butane-diol, butyric acid bacteria, enterobacteriaceae and clostridia	**20**
4	Biochemistry of xenobiotics degradation; aliphatic, aromatic and polycyclic compounds and Heavy metal toxicity: biochemical and genetic basis, resistance	**15**
5	Fixation of molecular nitrogen and regulation, Biochemistry of methanogenesis and Regulation: enzyme synthesis and enzyme activity.	**15**

Books Recommended:

(i) Monika Rustogi, Bacterial Metabolism, Ist edition
(ii) G. Gottschalk, Bacterial Metabolism, 2nd edition
(iii) B. D. Singh and R. P. Singh, Microbial Metabolism and Molecular Biology.
(iv) Brock Biology of Microorganisms, 14th edition
(v) Prescott`s Microbiology, 10th edition

Suggested online links:

https://ncbi.nlm.nih.gov
https://springer.com
https://frontierin.org
https://nature.com
https://cell press
https://microbeonline.com
Regulation of Metabolism in Bacteria-Global Regulation, by Dr Paustio`s Microbiology, You Tube Video dated 19-June-2020

Semester-IX
Paper-4 (Theory)
Course Title: Molecular Genetics

Program/Class: Master in Microbiology	**Year: Fifth**	**Semester:** Ninth
		Paper-4 Theory Subject: Microbiology
Course Code: PBT14-(T)		**Course Title:** Molecular Genetics

Credit: 5	**Compulsory**
Max. Marks: 100	**Min. Passing Marks:**

Total No. of Lectures- = 60

Course Objectives: To learn basic concepts in molecular genetics. Explain genetic inheritance, discuss chromosome organization and sex determination so that students are able to relate genetic makeup of different organisms. Understanding the relationship between mutation and evolution.

Unit	**Contents**	**Number of Lectures**
1	**Bacterial Mutants and mutations** Isolation; Useful phenotypes (auxotrophic, conditional, lethal, resistant); Mutation rate; Types of mutations (base pair changes; frameshift; insertions; deletion; tandem duplication); Reversion vs. suppression; Mutagenic agents; Molecular Mechanisms of mutagenesis; Assay of mutagenic agents (Ames test) **Gene transfer in bacteria** History; Transduction- generalized and specialized; Conjugation- F, F', HFr; F transfer; Hfr- mediated chromosome transfer; Transformation- natural and artificial transformation; Merodiploid	12

	generation; Gene mapping; Transposable genetic elements; Insertion sequences; Composite and Complex transposons; Replicative and non-replicative transposition; Genetic analysis using transposons.	
2	**Bacteriophages and Plasmids** Bacteriophage-structure; Lambda phage – genetic map, lysogenic and lytic cycles; Gene regulation; Filamentous phages such as M13; Plasmids – natural plasmids; their properties and phenotypes; Plasmid biology – copy number and its control; Incompatibility; Plasmid survival strategies; Antibiotic resistance markers on plasmids (mechanism of action and resistance); Genetic analysis using phage and plasmid	12
3	**Mendelian Genetics** Introduction to human genetics; Background and history; Types of genetic diseases; Role of genetics in medicine; Human pedigrees; Patterns of single gene inheritance-autosomal recessive; Autosomal dominant; X linked inheritance; Complicating factors – incomplete penetrance; variable expression; Multiple alleles; Co dominance; Sex influenced expression; Hemoglobinopathies – Genetic disorders of hemoglobin and their diseases. **Non-Mendelian inheritance patterns** Mitochondrial inheritance; Genomic imprinting; Lyon hypothesis; isodisomy; Complex inheritance-genetic and environmental variation; Heritability; Twin studies; Behavioral traits; Analysis of quantitative and qualitative traits.	12
4	**Molecular Genetics of Lambda** The genome packaging, replication and recombination, Regulation of Lytic and Lysogenic Cycles	12
5	**Gene mapping and human genome project** Physical mapping; linkage and association **Population genetics and evolution** Phenotype; Genotype; Gene frequency; Hardy Weinberg law; Factors distinguishing; Hardy Weinberg equilibrium; Mutation selection; Migration; Gene flow; Genetic drift;	12

Books Recommended:

(i) Brown, T. A. (2012). Introduction to genetics: a molecular approach. Garland Science.
(ii) Lodish, H F. Berk, A. Kaiser, CA, Krieger, M. Bretscher, A. Ploegh, H. Aman, A.
(iii) Martin, K. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman
(iv) Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). VIII editon Principles of Genetics.Wiley India.
(v) Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. XI edition. Benjamin Cummings.
(vi) Russell, P. J. (2009). Genetics: A Molecular Approach. III edition. Benjamin Cummings.
(vii) Pierce, B. A. (2008). Genetics A Conceptual Approach. W. H. Freeman& co. NY

Suggested online link:

https://nptel.ac.in/courses/102/104/102104052/

Semester-X
Paper-5 (Theory)
Course Title: Immunology and Immunotechnology

Program/Class: Master in Microbiology	**Year:** Fifth	**Semester:** Tenth
		Paper-5 Theory Subject: Microbiology
Course Code: PBT15-(T/P)	**Course Title:** Immunology and Immunotechnology	

Credits: 4	Compulsory
Max. Marks: 100	Min. Passing Marks:……

Total Number of Lectures = 60

Course Objectives: To understand the basics of immunology and facilitate the application of core immunology for healthy and diseases free nation. Evaluation of molecular and cellular basis of the development and function of the immune system in states of health and diseases. Correlate the theoretical immunology with clinical decision-making cancer diagnosis and treatment. Understanding the mechanisms of disease and therapeutic implications of vaccines and its development.

Unit	**Contents**	**Number of Lectures**
1	**Immunology- fundamental concepts and anatomy of the immune system** Components of innate and acquired immunity; Phagocytosis; Complement and Inflammatory responses; haematopoesis; Organs and cells of the immune system- primary and secondary lymphoid organs; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue. (MALT & CALT); Mucosal Immunity; Antigens and antigenicity – immunogens and immunogenicity, Immune modulators: Adjuvants, hapten- carrier system; Toxins and Toxoids. Major Histocompatibility Complex – MHC genes, MHC and immune responsiveness and disease susceptibility.	12
2	**Immune responses generated by B and T lymphocytes** Immunoglobulins- basic structure, classes & subclasses of immunoglobulins, antigenic determinants (Epitopes); Antigen-Antibody interaction, affinity, cross reactivity, specificity, Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Basis of self –non-self-discrimination; Generation of antibody diversity; T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC Antigen processing and presentation-endogenous antigens, exogenous antigens, non-peptide bacterial	12

	antigens and super-antigens; Cytokines-properties, receptors and therapeutic uses.	
3	**Antigen-antibody interactions** Precipitation, agglutination and complement mediated immune reactions; Antibodies as in-vitro and in-vivo probes; Advanced immunological techniques – RIA, ELISA, Western blotting, ELISPOT assay, Flow cytometry: Instrumentation and Applications; Identification of Immune Cells; Surface Plasmon resonance, Biosenor assays for assessing ligand–receptor interaction, CMI techniques- lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis.	12
4	**Vaccine Technology** Principles of Immunization, Techniques for analysis of immune response. General Idea of Active and passive immunization; Live, killed, attenuated, sub unit vaccines; recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Hybridoma, antibody engineering - chimeric and hybrid monoclonal antibodies; Transfusion of Immuno-competent cells; stem cell therapy; Cell based vaccines.	12
5	**Clinical Immunology** Immunity to Infection: Bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases; Treatment of autoimmune diseases; Transplantation – Immunological basis of graft rejection; General Idea of Tumor immunology, Cancer immunotherapy; Immunodeficiency- Primary immunodeficiency's, Acquired or secondary immunodeficiency's	12

Books Recommended:

(i) Punt J, Stranford S, Jones P., Owen JA, (2018). Kuby Immunology. (8th edition) New York: W.H. Freeman.

(ii) Hay FC, Westwood OMR. (2008). Practical Immunology. (4th Edition). Wiley Blackwell

(iii) Delves P J, Martin SJ, Burton DR, and Roitt IM. (2017). Roitt's Essential Immunology. (13th edition). Wiley-Blackwell.

(iv) Hay FC, Westwood OMR. (2008). Practical Immunology. (4th Edition). Wiley Blackwell.

(v) Murphy K, and Weaver C, (2016). Janeway's Immunobiology. (9th edition) New York: Garland Science.

Suggested online links:

https://ocw.mit.edu/courses/find-by-topic/#cat=healthandmedicine&subcat=immunology
https://nptel.ac.in/courses/102/105/102105083/
https://nptel.ac.in/courses/102/103/102103038/

Semester-X,

(Practical)

Course Title: Immunology and Immunotechnology

Program/Class: Master in Microbiology	**Year:** Fifth	**Semester:** Tenth
		Practical Subject: Microbiology
Course Code: PBT15-(T/P)	**Course Title:** Immunology and Immunotechnology-practical	
Credits:1		Compulsory
Max. Marks: 150		Min. Passing Marks:……

Total Number of Hours = 60

Unit	**Contents**	**Number of Hours**
1	Preparation of human blood smear and identification of cells.	**6**
2	Determination of blood groups	**6**
3	Determination of Rh antigen.	**6**
4	Estimation of antiserum by Mancini method	**6**
5	Estimation of antiserum by Ouchterlony method	**6**
6	Antiserum titer determination by ELISA.	**6**
7	DOT ELISA for the presence of specific antigen	**6**
8	Immunization, Collection of Serum	**6**
9	Immunoelectrophoresis.	**6**
10	Immunodiagnostics (Demonstration using commercial kits).	**6**

Semester-X
Course Title: Research Project

Course Objective: To provide sufficient hands-on learning experience related to the area of specialization with a focus on research orientation. To take up specific research problem statements with reasonable assumptions and constraints. Perform a literature search and/or patent search in the area of interest. Design and Conduct experiments. Synthesize the results and arrive at scientific conclusions. Document the results in the form of technical report/presentation

Program/Class: Master in Microbiology	**Year:** Fifth	**Semester:** Tenth
Course Code: PMB16	**Course Title:** Research Project	

Credits: 25	Compulsory

Semester-VIII

Paper-Elective

Course Title: Agriculture and Environmental Microbiology

Course Objectives: To make students understand and appreciate the microbiome in all its forms and the implications of microflora on the environment and agriculture. To broaden the understanding of global climate changes and the importance of microbiology in solid waste management etc. To give students a basic understanding of the major causes of environmental degradation on the planet, with specific reference to the Indian situation and how microflora can provide sustainable solutions to agricultural productivity and environmental degradation.

Elective Courses for Bachelor (Research) in Microbiology		
Code: PMB-E-01 (T)	**Course Title: Agriculture and Environmental Microbiology**	
Maximum Marks: 100		
Total Credits = 4, Total Hr.= 60		
Unit	**Topic**	**No. of Lectures**
I	**Microorganisms and their habitats** Structure and function of ecosystem; Terrestrial environment: soil profile and soil microflora; Aquatic Environment: microflora of fresh water and marine habitats; Atmosphere: Aeromicroflora and dispersion of microbes; Animal Environment: Microbes in/on human body (microbiomes) & animal (Ruminants) body; Extreme habitats: Extremophiles: Microbes thriving at high & low temperature, pH. High hydrostatic & osmotic pressures, salinity and low nutrient level; Microbial succession in decomposition of plant organic matter.	**10**
II	**Microbial Interactions Microbe interactions:** Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation; Microbe-Plant interaction: positive-negative interaction; Microbe-Animal interaction: positive-negative interaction; Microorganism of rhizosphere, rhizoplane and phylloplane, mycorrhiza (types and its applications).	**10**
III	**Biogeochemical cycling Carbon cycle**: Microbial degradation of cellulose, hemicellulase, lignin and chitin; Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction; Phosphorous cycle: Phosphate Immobilisation and solubilisation; Sulphur cycle: Microbes involved in sulphur cycle.	**10**

IV	**Waste management Solid waste management:** Source and type of solid waste, method of solid waste disposal (composting and sanitary landfill), Liquid waste management: composition and strength of sewage (BOD & COD), primary, secondary, (oxidation pond, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.	**10**
V	**Microbial Bioremediation** Principle and degradation of common pesticides, organic (hydrocarbon, oil spills) and inorganic matter, biosurfactants.	**10**
VI	**Biofertilizer and Biopesticides** Definition, Types- Bacterial, Fungal, Phosphate solubilizer, BGA & associative; Mode of application; Advantages and Disadvantages. Introduction and definition; Types of biopesticides; Integrated pest management (IPM); Mode of action; Factor influencing; Applications, advantages& disadvantages.	**10**

Suggested Readings:

1. Alexander M., Introduction to soil microbiology, Wiley Eastern limited, New Delhi.
2. Alexopoulas C.J. and MIMS C.W., Introductory Mycology, New age international, New Delhi.
3. Aneja K.R., Experiments in Microbiology, plant pathology, Tissue culture and Mushroom cultivation, New Age International, New Delhi
4. Hurst, C.J., Environmental Microbiology, ASM press, Washington D.C.
5. Mehrotra A.S., Plant Pathology, Tata Mcgraw Hill Publications limited, New Delhi.
6. Pelczar M.J., Chan E.C.S and Kreig N.R., Microbiology, Mcgraw-Hill Book Company, New York.
7. Prescott Lansing M., Harley John P. and Klein Donald A., Microbiology, WCB Mcgraw- Hill, New York.
8. Salle A.J., Fundamental Principles of Bacteriology, Tata Mcgraw-Hill Publishing Company Limited, New Delhi.
9. Stacey R.H. and Evans H.J., Biological Nitrogen Fixation, Chapman and Hall limited, London.
10. Stanier R.Y., Ingraham J.L., General Microbiology, Prentice Hall of India Private Limited, New Delhi.

Suggestive digital platforms web links-

1. https://www.classcentral.com/tag/microbiology
2. https://www.mooc-list.com/tags/biotechnology
3. https://asm.org/articles/2020/december/virtual-resources-to-teach-microbiology-techniques
4. https://www.futuredirections.org.au/publication/living-soils-role-microorganisms-soil-health
5. https://collegelearners.com/ebooks/agricultural-microbiology-pdf-free-download

Semester-VIII

Paper-Elective

Course Title: Industrial Microbiology

Course Objectives: Recall knowledge on medium formulation and strain improvement for enhanced production of bioproducts. Develop fundamental knowledge to explore microbes for the production of industrially relevant primary and secondary metabolites. Extend knowledge on the industrial method of fermentation processes for the production of bioproducts.

Elective Courses for Bachelor (Research) in Microbiology		
Code: PMB-E-02 (T)	**Course Title: Industrial Microbiology**	
Maximum Marks: 100		
Total Credits = 4, Total Hr.= 60		
Unit	**Topic**	**No. of Lectures**
I	History & Multidisciplinary nature of Industrial microbiology. A typical Bio process: Introduction, advantages & limitations. Patents and intellectual property rights.	**10**
II	Taxonomic diversity of industrially useful bacteria & fungi. Important characteristics of microbes used in Industrial Microbiology, Isolation techniques. Concept & examples of microorganisms classified as Generally Regarded as Safe (GRAS).	**10**
III	Exploitation of microorganism and their products, Screening, Strain development strategies, Immobilization methods.	**5**
IV	Fermentation: Media, Raw material, Antifoaming agents, Buffers. Equipments, Fermenter design. Types of fermentation – Single, Batch, Continuous fermentation process. Down-stream processing steps: Detection and assay of the product, Recovery (intercellular and extracellular product). Purification (solvent extraction & chromatography)	**15**
V	Production of Alcohol (industrial alcohol, wine, beer, whiskey), Organic acid (Citric acid), Antibiotic (Penicillin). Production of Vitamin (B12), Enzyme (Amylase), Amino acid (Glutamic acid), Hormones (Insulin), Vaccine (Hepatitis B).	**10**
VI	Biofuel (Methane), Production of Biofertilizers & Biopesticides, Biotransformation of steroids.	**10**

Suggested Readings:

1. Industrial Microbiology (2000) by AH Patel, Macmillan Publishers India

2. Biology of Industrial microorganism (1981) by Arnold L. Domain, Bejamin/ cummings Pub. Co.
3. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
4. Industrial Microbiology by Casida LE, New Age International (P) Ltd.

Suggestive digital platforms web links:

1. http://foodhaccp.com/foodsafetymicro/onlineindex.html
2. http://www.cpe.rutgers.ed/courses/current/If0401wa.html

Semester-VIII

Paper-Elective

Course Title: Biochemistry

Elective Courses For Bachelor (research) in Microbiology	
Code: PBT01-E- (T/P)	**Course Title:** Biochemistry
Maximum Marks: 100	
Total Credits = 4, Total Hr.= 60	
Course Objectives: To develop a clear understanding of the concepts related to structures and functions of biomolecules for better understanding of energetics and regulation of metabolic pathways. To develop hands-on-ability in young minds to plan and execute different biochemical experiments in the laboratory.	

Unit	Content	Number of lectures
1	**Chemical basis of life:** Composition of living matter; Water-properties, pH, pKa, Titration curves of weak acids, Buffers, Handerson-Hasselbach equations, ionization and hydrophobicity; Emergent properties of biomolecules in water; Water as a reactant.	8
2	**Proteins:** Amino acids as building blocks of proteins and their chemical properties,pI and pKa values, Primary, Secondary, Tertiary and Higher order structure of Proteins, Protein Sequencing, Ramchandran Plot, Conjugated proteins-Glycoproteins, Lipoproteins, Heamproteins.	8
3	**Enzymes**: General principles of catalysis, Quantitation of enzyme activity and efficiency, Enzyme characterization and Michaelis-Menten kinetics, Relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; Single substrate enzymes	8

4	**Carbohydrates:** Mono- Di- and Polysaccharides, Optical isomerism, Structure of Carbohydrates, Glycolysis, Gluconeogenesis, Pentose phosphate pathways, Citric acid cycle.	8
5	**Lipids:** Classification and structural analysis of fatty acids, Glycerols, Waxes, Glycolipids, Phospholipids, Sphingolipids, Sterols, Lipoproteins, β-oxidation, Biosynthesis of Cholesterol and Fatty acids	8
6	**Nucleic acids:** Biosynthetic pathways of purines and pyrimidines, degradation pathways	8
7	**Bioenergetics-** Basic principles; Equilibria and concept of free energy; Group transfer, concept of Entropy, Enthalpy and free energy , Oxidation and Reduction reactions, Electron Transport Chain, Oxidative phosphorylation; photosynthesis.	12

Books Recommended:

1. Lehninger: Principles of Biochemistry, 3rd edition, by David L. Nelson and M.M. Cox (2000) Maxmillan/ Worth publishers.
2. Fundamentals of Biochemistry by Donald Voet and Judith G Voet (1999). John Wiley & Sons, NY
3. Biochemistry, 2nd edition, by R.H. Garrett and C.M. Grisham (1999). Saunders College Publishing, NY.
4. Outlines of Biochemistry by E.E.Conn, P.K.Stumpf, G. Bruenimg and Ray H.Doi (1987). John Wiley & Sons, NY
5. Biochemistry, 2nd edition, by Laurence A. Moran, K.G. Scrimgeour, H. R. Horton, R.S. Ochs and J. David Rawn (1994), Neil Patterson Publishers Prentice Hall.
6. Berg, JM Tymoczko, JL. Gatto, GJ., Stryer, L. (2015). **Biochemistry.** (8th ed.) W H Freeman and Company New York.
7. Satyanarayana U. Chakrapani U. (2013). **Biochemistry**. (4th edition). Elsevier and Books and Allied (P) Ltd

Suggested online links:

1. https://nptel.ac.in/courses/104/105/104105076/
2. https://nptel.ac.in/courses/102/106/102106087/
3. https://ocw.mit.edu/courses/find-by-topic/#cat=healthandmedicine&subcat=spectroscopy
4. https://ocw.mit.edu/courses/chemistry/5-07sc-biological-chemistry-i-fall-2013/module-i/session4/
5. https://ocw.mit.edu/courses/biology/7-016-introductory-biology-fall-2018/lecturevideos/lecture-4 enzymes-and-metabolism/
6. https://ocw.mit.edu/courses/chemistry/5-07sc-biological-chemistry-i-fall-2013/module-i/session3/

Semester-VIII

Paper-Elective

Course Title: Biochemistry-Practical

Elective Courses For Bachelor (research) in Microbiology	
Code: PBT01-E-(T/P)	**Course Title:** Biochemistry-Practical
Maximum Marks: 50	
Total Credits = 1, Total Hr.= 60	

Unit	Contents	Number of hours
1	Titration of Amino Acids.	**15**
2	Colorimetric determination of pKa.	**15**
3	Quantitative estimation of Proteins and Sugars.	**15**
4	Separation techniques- Centrifugation, Chromatography (Gel Permeation, Ion exchange, TLC, etc.)	**15**

Semester-VIII

Paper-Elective

Course Title: Molecular Biology

Elective Courses For Bachelor (research) in Microbiology	
Code: PBT02-E- (T/P)	**Course Title: Molecular Biology**
Maximum Marks: 100	
Total Credits = 4, Total Hr.= 60 **Course Objectives:** To illustrate the molecular concepts of life, through learning the organization and functions of DNA, RNA, and proteins, that can describe and demonstrate the regulation of various biological processes. To develop clear understanding of established concepts and perceive recent scientific developments in the field of molecular biology.	

Unit	Contents	Number of Lectures
1	**Unit-I Genome Organization**	12

	Organization of bacterial genome; Structure of eukaryotic chromosomes; Role of nuclear matrix in chromosome organization and function; Matrix binding proteins; Heterochromatin and Euchromatin; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNA melting and buoyant density; Nucleosome phasing; DNase I hypersensitive region; DNA methylation & Imprinting	
2	**Unit-II DNA Structure; Replication; Repair & Recombination** Structure of DNA-A-,B-, Z- and triplex DNA; Measurement of properties-Spectrophotometric, CD, AFM and Electron microscope analysis of DNA structure; Replication initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA; Gene stability and DNA repair- enzymes; Photoreactivation; Nucleotide excision repair; Mismatch correction; SOS repair; Recombination: Homologous and non-homologous; Site specific recombination; Chi sequences in prokaryotes; Gene disruption; FLP/FRT and Cre/Lox recombination.	12
3	**Unit III Prokaryotic & Eukaryotic Transcription** Prokaryotic Transcription; Transcription unit; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Anti-termination; Transcriptional regulation-Positive and negative; Operon concept- lac, trp, ara, his, and gal operons; Transcriptional control in lambda phage; Transcript processing; Processing of tRNA and rRNA Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); Activators and repressors; Transcriptional and post-transcriptional gene silencing	12
4	**Unit-IV Post Transcriptional Modification** Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA. **Translation & Transport** Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co-and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation	12

5	**Unit-V Mutation; Oncogenes and Tumor suppressor gene** Nonsense, missense and point mutations; Intragenic and Intergenic suppression; Frameshift mutations; Physical, chemical and biological mutagens; Transposition- Transposable genetic elements in prokaryotes and eukaryotes; Mechanisms of transposition; Role of transposons in mutation; Viral and cellular oncogenes; Tumor suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins; Activation of oncogenes and dominant negative effect; Suppression of tumor suppressor genes; Oncogenes as transcriptional activators.	12

Books Recommended:

1. Watson, J. D. Baker TA, Bell, SP Gann, A. Levine, M. Losick R. (2008). **Molecular Biology of the Gene** (5th ed.). Pearson
2. Lodish, H F. Berk, A. Kaiser, CA, Krieger, M. Bretscher, A. Ploegh, H. Aman, A. Martin, K. (2016). **Molecular Cell Biology** (8th Ed.). New York: W.H. Freeman
3. Karp, G. **Cell and Molecular Biology. Concepts and experiments**. John Harris, D., Wiley & sons, New York
4. Old, R. W., Primrose, S. B., & Twyman, R. M. (2006). **Principles of Gene Manipulation and Genomics**, 7th Edition: Blackwell Publishing.
5. Brown, T. A. (2018). **Genomes** 4.(4 edition) New York: Garland Science Pub.

Suggested online links:

1. https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/molecularbiology/
2. https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/molecularbiology/transcription-translation/
3. https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/molecularbiology/gene-regulation-and-the-lac-operon/
4. https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinantdna/
5. https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinantdna/agarose-gel-electrophoresis-dna-sequencing-pcr/
6. https://ocw.mit.edu/courses/biology/7-01sc-fundamentals-of-biology-fall-2011/recombinantdna/basic-mechanics-of-cloning/
7. https://ocw.mit.edu/courses/biological-engineering/20-109-laboratory-fundamentals-inbiological-engineering-fall-2007/labs/mod1_3/
8. https://nptel.ac.in/courses/102/103/102103045/#

Semester-VIII

Paper-Elective

Course Title: Molecular Biology-Practical

Elective Courses For Bachelor (research) in Microbiology	
Code: PBT02-E-(T/P)	**Course Title: Molecular Biology-Practical**
Maximum Marks: 50	
Total Credits = 1, Total Hr.= 60	

Unit	Contents	Number of Hours
1	Plasmid DNA isolation and DNA quantitation	**5**
2	Restriction digestion	**5**
3	Preparation of competent cells	**5**
4	Agarose gel electrophoresis	**5**
5	Restriction Enzyme digestion of DNA	**5**
6	Purification of DNA from an agarose gel	**5**
7	DNA Ligation	**5**
8	Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency	**10**
9	Restriction mapping of recombinant plasmid.	**5**
10	Polymerase Chain reaction	**5**
11	RFLP analysis of the PCR product	**5**

Semester-VIII

Paper-Elective

Course Title: Plant Biochemistry and Biotechnology

E Elective Courses For Bachelor (research) in Microbiology	
Code: PBT10-E- (T/P)	**Course Title: Plant Biochemistry and Biotechnology**
Maximum Marks: 100	
Total Credits = 4, Total Hr.= 60	

Course Objectives: Describe the developmental processes operating in plants, hands on training of plant tissue culture & micropropagation methods. Evaluate and

perform biotechnological tools for genetically modified plants generation in agriculture and industry. Understands the basics of sterilization and culture preparation methods and highlights the importance and fundamentals of plant tissue culture. To develop basic understanding of need of vectors for plant transformation. Create awareness for the suitability of transgenics, in the society, industrialists, and environment. To emphasize the interest in young mind for startup through biotechnology-based industry.

Unit	Contents	Number of Lectures
1	**Plant Tissue Culture** Historical perspective; Totipotency; Organogenesis; Somatic embryogenesis; Regulation and applications; Artificial seed production; Micropropagation; Somaclonal variation; Androgenesis and its applications in genetics and plant breeding; Germplasm conservation and cryopreservation. **Protoplast Culture and Somatic Hybridization** Protoplast isolation; Culture and usage; Somatic hybridization – methods and applications; Cybrids and somatic cell genetics.	12
2	**Agrobacterium-Plant interaction**; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid. **Genetic Transformation** Agrobacterium-mediated gene delivery; Cointegrate and binary vectors and their utility; Direct gene transfer- PEG-mediated, electroporation, particle bombardment and alternative methods; Screenable and selectable markers; Characterization of transgenics; Chloroplast transformation; Marker-free methodologies; Gene targeting.	12
3	**Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance** Bacterial resistance; Viral resistance; Fungal resistance; Insects and pathogens resistance; Herbicide resistance; Drought, salinity, thermal stress, flooding and submergence tolerance	12
4	**Somaclonal variations, Plants as Biofactories** Concept of biofactories; Fermentation and production of industrial enzymes, vitamins and antibiotics and other biomolecules; Cell cultures for secondary metabolite production; Production of pharmaceutically important compounds; Bioenergy generation.	12

5	**Principals and applications of cryopreservation** **Secondary product formation by cell suspension cultures** Culture media and environmental conditions supporting secondary product formation, Biotransformation of terpenoids, alkaloids and steroids by suspension and immobilized plant cell cultures. **Biosafety and containment practices**	12

Books Recommended:

1. Berg, JM Tymoczko, JL. Gatto, GJ., Stryer, L. (2015). Biochemistry. (8th ed.) W H Freeman and Company New York.
2. Nelson DL. Cox MM. (2017) Lehninger Principles of Biochemistry (7th ed.). W H Freeman New York.
3. Boyer RF. (2012) Biochemistry laboratory : modern theory and techniques(2nd Edition). Pearson Education, Inc
4. Jain JL. Jain S. Jain N. (2005). Fundamentals of Biochemistry. (6th edition). S Chand and Company Ltd.
5. Satyanarayana U. Chakrapani U. (2013). Biochemistry (4th edition). Elsevier and Books and Allied (P) Ltd
6. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science
7. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
8. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
9. Dubey RC. (2014) A Textbook of Biotechnology (5th edition) S Chand and Company Ltd
10. Singh BD. (2015). Biotechnology: Expanding Horizons (4th edition). Kalyani Publishers

Suggested online links:

1. https://nptel.ac.in/courses/102/106/102106080/
2. **https://nptel.ac.in/courses/102/103/102103016/**

Semester-VIII

Practical

Course Title: Plant Biochemistry and Biotechnology

Elective Courses For Bachelor (research) in Microbiology	
Code: PBT10-E- (T/P)	**Course Title: Plant Biochemistry and Biotechnology-Practical**
Maximum Marks: 50	
Total Credits = 1, Total Hr.= 60	

Unit	Contents	Number of Hours
1	SOPs of Plant Tissue Culture laboratory	**10**
2	Preparation of media.	**10**
3	Surface sterilization of explants	**10**
4	Micropropagation of plants	**10**
5	Green house and hardening practices	**10**
6	Clonal fidelity of regenerated plants.	**10**