NATIONALEDUCATIONPOLICY-2020

Common Minimum Syllabus for all Uttarakhand State Universities and Colleges

Syllabus Proposed
2023-24

Sri Dev Suman Uttarakhand University
Badshahithol, Tehri (Garhwal)

पाठ्यक्रम निर्माण समिति, उत्तराखण्ड
Curriculum Design Committee, Uttarakhand

क्र0 सं0	नाम एवं पद	
1	**प्रो0 एन0 के0 जोशी** कुलपति, श्रीदेव सुमन उत्तराखण्ड विश्वविद्यालय, टिहरी	**अध्यक्ष**
2	कुलपति, कुमाऊँ विश्वविद्यालय, नैनीताल	**सदस्य**
3	**प्रो0 जगत सिंह बिष्ट** कुलपति, सोबन सिंह जीना विश्वविद्यालय, अल्मोड़ा	**सदस्य**
4	**प्रो0 सुरेखा डंगवाल** कुलपति, दून विश्वविद्यालय, देहरादून	**सदस्य**
5	**प्रो0 ओ0 पी0 एस0 नेगी** कुलपति, उत्तराखण्ड मुक्त विश्वविद्यालय, हल्द्वानी	**सदस्य**
6	**प्रो. एम0 एस0 एम0 रावत** सलाहकार–रूसा, रूसा निदेशालय, देहरादून	**सदस्य**
7	**प्रो0 के0 डी0 पुरोहित** सलाहकार–रूसा, रूसा निदेशालय, देहरादून	**सदस्य**

KUMAUN UNIVERSITY NAINITAL

Common Minimum Syllabus for State Universities and Colleges of Uttarakhand

National Education Policy- 2020

Subject: Biotechnology

PROPOSED STRUCTURE OF PG BIOTECHNOLOGY SYLLABUS

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

SUBJECT: BIOTECHNOLOGY

Syllabus

Developedby:

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Moderated by:

Name	Designation	Affiliation
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Prof. N. K. Singh	Professor	Department of Plant Breeding & Genetics, College of Agriculture, G. B. P. U. A. & T. Pantnagar
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Semester-wise Titles of the Papers in M.Sc. Biotechnology

Year	Sem.	Course Code	Paper Title	Theory/Practical	Credits
Bachelor (Research) in Biotechnology					
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 & 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
		PBT10-(T/P)	Plant Biochemistry and Biotechnology	Theory + practical	4+1
		PBT-E	Elective		4
					Total: 29
Master in Biotechnology					
5	IX	PBT11-(T)	Genomics and Proteomics	Theory	5
		PBT12-(T)	Bioprocess Engineering and technology	Theory	5

		PBT13-(T)	Animal Biotechnology	Theory	5
		PBT14-(T)	Molecular Genetics	Theory	5
		PBT15-(T/P)	Immunology and Immuno-technology	Theory + practical	4+1
					Total : 25
	X	PBT16-(P)	Research		25
					Total: 25

Elective papers offered			
Course Code	**Paper Title**	**Theory/Practical**	**Credits**
PBT-E-01 (T)	Food and beverage biotechnology	Theory	4
PBT-E-02 (T)	Plant Physiology	Theory	4
PBT01- (T/P)	Biochemistry*	Theory + practical	4+1
PBT02-(T/P)	Molecular Biology*	Theory + practical	4+1
PBT03- (T/P)	Plant Biochemistry and Biotechnology*	Theory + practical	4+1

* **Elective for other programs**

Purpose of the Program

Biotechnology uses living cells and cellular material to create different range of products which improve overall quality of life. The purpose of the postgraduate Biotechnology program at the university and college level is critical to develop the understanding of different aspects of Biotechnology in the students so that they are prepared for various job roles as in various industries and research institutions.

Program objectives

To produce high-potential biotechnologists with interdisciplinary knowledge to innovate, plan, and analyze problems related to biotic and abiotic systems. The program further envisages biotech professionals with strong sense of developing innovative strategies for various sustainable goals and objectives related to wellness of different organisms on earth. The professionals will be creative and ethically strong biologists who will serve the nation for its holistic growth.

Program's Outcomes

PO 1. Develop professional skills through scientific attitude and values. Students will have foundation in the fundamentals and applications of the Biotechnology required for different job roles.

PO 2. Demonstrate knowledge for in-depth research to formulate and solve the issues related to Biotechnology 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. Demonstrate skills to use modern analytical tools/ software/ equipment and analyse and solve problems in various courses of biotechnology.

PO 5. Execute their professional roles in society as biotechnology professionals, employers and employees in various industries, researchers and educators.

PO 6. Acquire knowledge and understanding of norms and ethics in the field of biotechnology.

PROGRAM SPECIFIC OUTCOMES (PSOS)	
BACHELOR (RESEARCH) IN BIOTECHNOLOGY	
Fourth Year	This course introduces the foundation of viz., (i) Biochemistry, (ii) Molecular Biology, (iii) Microbiology & Industrial Applications, (iv) Environmental Biochemistry&Biotechnology,(v)geneticengineering,(vi)Analyticaltechniques, (vii) Molecular Virology, (viii) cell &developmental biology, (ix) Plant Biochemistry and Biotechnology along with basics of (x) Biostatistics and Computers. <u>After completion of the course:</u> **PSO1.** Understand the basic concepts of genetics and molecular biology such as Inheritance pattern, DNA replication, transcription and translation. **PSO2.** Understand the basic concepts of Biomolecules such as Carbohydrates, Lipids, Enzymes, Nucleic acid, hormones and Vitamins. The students also develop understanding of coordinated control of metabolism. **PSO3.** Understand the basic concepts of Microbial diversity & systematics, Microbial growth & physiology, microbial interactions & infection and Microbes & environment. **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,cloningmethodologiesandthereapplicationsinIndustryastherapeutics tools.

	PSO6. Understand the basic concepts of analytical techniques such as spectroscopic techniques, Chromatographic techniques, centrifugation techniques for analysis of different samples in different manner for their accurate assessment. **PSO7.** Understand the basic concepts of cell structure, cell organelles, types of cells,
	cell communication, differential and specialized cell like stem cells for better understanding of the basic unit of life i.e. cell. **PSO8.** Perform experiments on Estimation of amino acids, enzymes etc. by using spectroscopic and chromatographic techniques. **PSO9.** Perform experiments on sterilization techniques, media preparation and Characterization of Microorganisms **PSO10.** Perform experiments of Protein purification & estimation, preparation of plasmid DNA and construct formation, DNA isolation, electrophoresis, spectroscopy, PCRetc. **PSO11.** Apply at technical positions in different research laboratories, diagnostic centers and industries. **PSO12.** Understand the basic concepts of Plant Tissue Culture, Protoplast Culture and Somatic Hybridization, Agrobiology, Genetic Transformation, Strategies for Introducing Biotic and Abiotic Stress Resistance, Somaclonal variations, Plants as Biofactories, Principals and applications of cryopreservation, Secondary product formation by cell suspension cultures, and Biosafety and containment practices **PSO13.** 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. **PSO14.** Understand the basic concepts of Molecular Virology, Structure of animal viruses and plant viruses, General Genomic organization of animal viruses, General Genomic organization of plant viruses, Methods to diagnose animal virus infections, and Methods to study plant viruses. **PSO15.** Perform experiments on Plant Tissue Culture such as Preparation of media, Surface sterilization of explants, Micropropagation of plants, Green house and hardening practices.
Fifth Year	**MASTER IN BIOTECHNOLOGY**

	This course introduces the foundation of following courses viz., (i) Genomics and proteomics, (ii) Bioprocess engineering & technology, (iii) Animal Biotechnology, (iv) Molecular genetics, and (v) Immunology &Immunotechnology_ 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 processing and downstream processing, analysis & application of food processing enzymes and microorganisms. **PSO3.** Understand the basic concepts of Animal cell culture, animal health biotechnology, animal reproductive biotechnology & genomics and DNA forensics. **PSO4.** Understand the basic concepts of Bacterial Mutants and mutations, Gene transfer in bacteria, Biology of Bacteriophages and Plasmids, Mendelian Genetics, Gene mapping and human genome project, and Population genetics and evolution. **PSO5.** Understand the basic concepts of Immunology- fundamental concepts and anatomy of the immune system, Immune responses generated by B and T lymphocytes, Antigen-antibody interactions, Vaccine Technology, and Clinical Immunology. **PSO6.** Perform experiments on Immunology such as Preparation of human blood smear and identification of cells, Determination of blood groups and Rh antigen, Estimation of antiserum, Antiserum titer determination by ELISA, Immunization, Collection of Serum, Immunoelectrophoresis and Immunodiagnostics.

Year	Semester	Theory Paper	Units	Practical Paper	Units	Elective credit	Research Project	Total Credits of the semester
4	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. Colorimetric determination ofpKa. 3. Quantitative estimation of Proteins andSugars. 4. Separation techniques-Centrifugation, Chromatography (Gel Permeation, Ion exchange, TLC,etc.)	-	-	5

		Molecular Biology	1.Genomic Organization 2. DNA Structure, Replication, Repair & Recombination 3. Prokaryotic &Eukaryotic Transcription 4.Post Transcriptional Modification 5.Mutaions, Oncogenes and Tumor suppressor gene	Molecular biology	1. Plasmid DNA isolation and DNA quantitation 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	-	-	5

		Microbiology & Industrial application	1. Microbial Diversity &Systematics 2. Microbial Growth & Physiology 3. Microbial Interactions and Infection 4. Microbes and Environment 5. Industrial Applications	Microbiology	1. Sterilization, disinfection, safety in microbiological laboratory. 2. Preparation of media for growth of various microorganisms. 3. Isolation and maintenance of organisms by plating, Streaking and 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. 6. Assay of antibiotics production and demonstration of antibiotic resistance. 7. Isolation and screening			5

					of industrially important microorganisms. 8. Determination of thermal death point and thermal death time of microorganisms			
		Biostatics & Computers	10. Units					5
		Environmental Biochemistry and Biotechnology	1. Introduction 2. Pollution Control, remediation and management 3. Alternate source of energy 4. Environment and health in respect to genetics					5
								Total (VII semester): 25
	VIII	Genetic Engineering	1. Basics Concepts 2. Cloning vectors 3. Cloning methodologies 4. PCR and its applications 5. Sequencing and	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			**5**

			Gene therapy		DNA from *E. coli* DH5α and gel analysis. 4.Restriction digestion of vector (gel analysis) with Restriction endonucleases 5.a. Vector and Insert ligation Transformation in *E. coli* DH5α. 6. Plasmid isolation and confirming recombinant by PCR and RE digestion. 7. Transformation of recombinant plasmid in *E.coli* Laboratory strain. 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 protein by SDS-PAGE.			
		Analytical Techniques	1.Basic Techniques 2.Spectroscopy	Analytical Techniques	1. Paper Chromatography of amino acids. 2. T.L.C of lipids.			5

			Techniques 3.Chromatography Techniques 4. Centrifugation 5.Radioactivity 6.Advanced Techniques		*3.* Isolation of plasmid DNA from *E.coli.* 4. Agarose gel electrophoresis of isolated plasmid DNA. 5. Extraction and purification of protein from plant and animals. 6. SDS PAGE of BSA and extracted proteins			
		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	-	-	-	-	5

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 7. PlantMeristem Organization and Differentiation			5
Plant Biochemistry and Biotechnology	1. Plant Tissue Culture 2. Agrobiology 3.Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance 4.Somaclonal variations, Plants	Plant Biochemistry and Biotechnology	1. SOPs of Plant Tissue Culture laboratory 2. Preparation of media. 3. Surface sterilization of explants 4. Micro propagation of plants 5. Green house and hardening practices 6. Clonal fidelity	5

			as Biofactories 5.Principals and applications of cryopreservation, 6. Secondary product formation by cell suspension cultures		regenerated plants.			
		Total (VIII Semester): 25+4 (elective)=29						
5	IX	Genomics and Proteomics	1. Introduction: Structural organization of genome 2. Genome sequencing projects 3. Proteomics 4. Pharmacogenomics 5.Functional genomics and proteomics					5
		Bioprocess Engineering and Technology	1. Basic principle of Biochemical engineering					5

			2. Concepts of basic mode of fermentation processes 3.Downstream processing 4. Applications of enzymes in food processing 5. Applications of Microbes in food process operations and production					
		Animal Biotechnology	1. Animal cell culture 2. Animal health Biotechnology 3. Animal Reproductive Biotechnology 4. Animal genomics 5. DNA Forensics	-	-	-	-	5

		Molecular Genetics	1. Bacterial Mutants and mutations 2. Bacteriophages and Plasmids 3. Mendelian Genetics 4. Molecular Genetics of Lambda 5. Gene mapping and human genome project	-	-	-	-	5

		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. Immuno electrophoresis. 10.Immuno diagnostics (Demonstration using commercial kits).	-	-	5
								Total (IX Semester): 25
	X	Research Project						**Total (X Semester):** 25

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%

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 Biotechnology	**Year:** Fourth	**Semester:** Seven
Paper-1 Theory Subject: Biotechnology		
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.	9
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	9
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	9

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.	9

Books Recommended:

1. Lehninger: Principles of Biochemistry, 3rd edition, by David L. Nelson and M.M. Cox (2000) Maxmillan/ Worthpublishers.
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,2ndedition,byLaurenceA.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 NewYork.
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-4enzymes-and-metabolism/
6. https://ocw.mit.edu/courses/chemistry/5-07sc-biological-chemistry-i-fall-2013/module-i/session3/

Semester-VII

Practical

Course Title: Biochemistry

Program/Class: Bachelor (Research) in Biotechnology	**Year:** Fourth	**Semester:** Seven
Practical Subject: Biotechnology		
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 Biotechnology	**Year:** Fourth	**Semester:** Seven
		Paper-2 Theory Subject: Biotechnology
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,andgaloperons;Transcriptionalcontrolin 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	**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, NewYork
4. Old, R. W., Primrose, S. B., & Twyman, R. M. (2006). **Principles of Gene Manipulation and Genomics**, 7th Edition: BlackwellPublishing.

5. Brown, T. A. (2018). **Genomes** 4. (4 edition) New York: Garland SciencePub.

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-VII

Practical

Course Title: Molecular Biology

Program/Class: Bachelor (Research) in Biotechnology	**Year:** Fourth	**Semester:** Seven
		Practical Subject: Biotechnology
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 Biotechnology	**Year:** Fourth	**Semester:** Seven
		Paper-3 Theory Subject: Biotechnology
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 bacteria. Ecological impacts of microbes; Symbiosis (Nitrogen fixation and ruminant symbiosis); Microbes and Nutrient cycles; Microbial communication system; Quorum sensing	12
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:

1. Madigan, M. T., Martinko, J. M., & Parker, J. (2003). Brock biology of microorganisms. Upper Saddle River, NJ: Prentice Hall/PearsonEducation.
2. Prescott, and Joanne M. Willey. Prescott's Microbiology. New York: McGraw-Hill, 2011.
3. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (1993). Microbiology: Concepts and applications. New York:McGraw-Hill.
4. Tortora, Gerard J, Berdell R. Funke, and Christine L. Case. Microbiology: An Introduction. , 2004.
5. Mattha, W, Berg C Y, and Black JG. (2005). **Microbiology, Principles and**

Explorations. Boston, MA: John Wiley & Sons.

6. Ananthanarayana R, PanickerCKJ(2020). **Ananthanarayana and Panicker's Textbook of Microbiology**(11edition) Universities Press (India) Pvt.Ltd

Suggested online links:

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

Semester-VII

Practical

Course Title: Microbiology and Industrial Applications

Program/Class: Bachelor (Research) in Biotechnology	**Year:** Fourth	**Semester:** Seven
		Practical Subject: Biotechnology
Course Code: PBT03- (T/P)		**Course Title:** Microbiology and Industrial Applications -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 Biotechnology	**Year:** Fourth	**Semester:** Seven
Paper-4 Theory Subject: Biotechnology		
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:

1. Rosner, B. (2000). **Fundamentals of Biostatistics**. Boston, MA: DuxburyPress.
2. Daniel, W. W. (1987). **Biostatistics, a Foundation for Analysis in the Health Sciences**. New York: Wiley
3. Mariappan P. (2013) **Biostatistics**.Pearson
4. Rastogi VB.(2015). **Biostatistics** (3rd Edition).MedTec
5. Lesk, A. M. (2002). **Introduction to Bioinformatics**. Oxford: Oxford University Press
6. 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:

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-092bioinformatics-and-proteomics-january-iap-2005/lecture-notes/
2. https://ocw.mit.edu/courses/biology/7-91j-foundations-of-computational-and-systems-biologyspring-2014/
3. https://ocw.mit.edu/courses/biology/7-91j-foundations-of-computational-and-systems-biologyspring-2014/lecture-slides/
4. https://ocw.mit.edu/courses/mathematics/18-650-statistics-for-applications-fall-2016/
5. https://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/
6. 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 Biotechnology	**Year:** Fourth	**Semester:** Seventh
Paper-5 Theory Subject: Biotechnology		
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; Role of Biotech in environmental protection; Control and management of biological processes.	12
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:

1. Thakur IS. (2011)Environmental Biotechnology basic concepts and applications. I. K. International Publishing House Pvt. Limited
2. Evans GM and J. C. Furlong (2003). Environmental Biotechnology: Theory and Applications. Wiley Publishers.
3. Ritmann R and McCarty P L (2000). Environmental Biotechnology: Principle & Applications. 2nd Ed., McGraw Hill Science.
4. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
5. Srinivas TR (2008). Environmental Biotechnology. New Age International Pvt. Ltd.

Suggested online links:

1. https://nptel.ac.in/courses/104/103/104103020/
2. https://nptel.ac.in/courses/102/105/102105088/

SEMESTER VIII

Paper 1 (Theory)

Course Title: Genetic Engineering

Program/Class: Bachelor (Research) in Biotechnology	**Year:** Fourth	**Semester:** Eighth
		Paper-1 Theory Subject: Biotechnology
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; Phagedisplay	**12**

4	**PCR and its Applications** Primer design; Fidelity of thermo stable 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	**DNA Sequencing and Silencing** Enzymatic DNA sequencing; Automated DNA sequencing; Chemical Synthesis of oligonucleotides; Introduction of DNA into mammalian cells; Transfection techniques; Gene silencing techniques; RNA interference and siRNA Gene knockouts and Gene Therapy	**12**

Books Recommended:

1. Principles of Gene Manipulation by R.W.Old and S.B.Primrose Third Edition Blackwell ScientificPublication
2. Genes VI by B. Lewin
3. From Genes to Clones by E. L.Winnecker.
4. Brown, T. A. (2006). **Gene Cloning and DNA Analysis: an Introduction.** Oxford: Blackwell Pub.
5. Slater, A., Scott, N. W., & Fowler, M. R. (2003). **Plant Biotechnology: The Genetic Manipulation of Plants**. Oxford: Oxford University Press

Suggested online links:

1. https://ocw.mit.edu/courses/find-by-topic/#cat=science&subcat=biology&spec=stemcells
2. https://ocw.mit.edu/courses/materials-science-and-engineering/3-051j-materials-for-biomedical-applications-spring-2006/lecture-notes/lecture13.pdf
3. https://ocw.mit.edu/courses/biological-engineering/20-109-laboratory-fundamentals-in-biological-engineering-fall-2007/lecture-notes/
4. https://ocw.mit.edu/courses/health-sciences-and-technology/hst-535-principles-and-practice-of-tissue-engineering-fall-2004/
5. 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 Biotechnology	**Year:** Fourth	**Semester:** Eighth
		Practical Subject: Biotechnology
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 Biotechnology	**Year: Fourth**	**Semester:** Eighth
Paper-2 Theory Subject: Biotechnology		
Course Code: PBT07- (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, Spectro fluorometry, 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- Micro centrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Application (Isolation of cell components); Analytical centrifugation.	**12**
4	**Radioactivity** 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	**12**
5	**Advanced Techniques** Protein crystallization; Enzyme and cell immobilization techniques	**12**

Books Recommended:

1. Olaniyan, F. M., (2017) V Edition, Laboratory Instrumentation and Techniques, Create space independent publishing platform
2. Wilson, K., Walker, J. (eds.); Cambridge University Press, Cambridge, 2000, V Edition.
3. 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 Biotechnology	**Year:** Fourth	**Semester:** Eighth
		Practical Subject: Biotechnology
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 proteins 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 Biotechnology	**Year:** Fourth	**Semester:** Eighth
Paper-3 Theory Subject: Biotechnology		
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, agro infection (using Agrobacterium); serological methods, immune electrophoresis in gels, direct double-antibody sandwich method, Dot ELISA, Immuno sorbent 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 Biotechnology	**Year:** Fourth	**Semester:** Eighth
		Paper-4 Theory Subject: Biotechnology
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 Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata	**12**
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:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P.(2014). **Molecular Biology of the Cell** (6th Ed.). New York: Garland Science
2. Cooper, G. M., and Hausman, R. E. (2013). **The Cell: a Molecular Approach** (6th Ed.). Washington: ASM ; Sunderland.
3. Karp, G. **Cell and Molecular Biology. Concepts and experiments**. John Harris, D., Wiley & sons, NewYork

Suggested online links:

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

Semester-VIII

Paper-5 (Theory)

Course Title: Plant Biochemistry and Biotechnology

Program/Class: : Bachelor (Research) in Biotechnology	**Year:** Fourth	**Semester:** Eighth
Paper-5 Theory Subject **Biotechnology**		
Course Code: PBT10- (T/P)	**Course Title:** Plant Biochemistry and Biotechnology	

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

Total Number of Lectures = 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	**Genetic Transformation** Agrobacterium-plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; Disarming the Ti plasmid. Agrobacterium-mediated gene delivery; Co integrate 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 Bio factories** Concept of bio factories; 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 NewYork.
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/

3. https://nptel.ac.in/courses/102/107/102107075/

Semester-VIII

Practical

Course Title: Plant Biochemistry and Biotechnology

Program/Class: : Bachelor (Research) in Biotechnology	**Year:** Fourth	**Semester:** Eighth
		Practical Subject: Biotechnology
Course Code: PBT10- (T/P)	**Course Title:** Plant Biochemistry and Biotechnology-practical	

Credits:1	Compulsory
Max. Marks: 50	Min. Passing Marks:

Total Number of Hours = 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 fidality of regenerated plants.	**10**

Semester-IX

Paper-1 (Theory)

Course Title: Genomics and Proteomics

Program/Class: Master of Biotechnology	**Year:** Fifth	**Semester:** Ninth
		Paper-1 Theory Subject: Biotechnology
Course Code: PBT11-(T)		**Course Title:** Genomics and Proteomics

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

Total Number of Lectures = 60

Course Objectives: To develop a foundation in the fundamental principles of genomics and Proteomics with the biological importance of protein-protein interaction, modeling and protein database, and their clinical relevance by apply different methods available to study DNA and RNA sequence analyses and to evaluate available genomic data to provide new insights in the fields of functional genomics. Study various available data relating to Human Genome Project towards ELSI, with GWAS, SNP and miRNA techniques using specific databases and bioinformatics tools.

Unit	**Content**	**Number of lectures**
1	**Introduction** Structural organization of genome in prokaryotes and eukaryotes; organelle DNA –mitochondrial, chloroplast; DNA sequencing-principles and translation to large scale projects; Recognition of coding and non-coding sequences and gene annotation; Tools for genome analysis-RELP, DNA fingerprinting, RAPD, PCR, physical and genetic mapping.	12
2	**Genome sequencing projects** Microbes, plants and animals; Accessing and retrieving genome project information from web; Comparative genomics (Comparing related sequences retrieved from database(s)), Identification and classification of organisms using molecular markers-16S rRNA typing/sequencing, ESTs and SNPs. -	12

3	**Proteomics** Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing); 2-D electrophoresis of proteins; Micro scale isoelectric focusing in solution, Peptide fingerprinting; LC/MS-MS for identification of proteins and modified proteins; MALDI-TOF; Differential display proteomics, Methods of studying Protein-protein interactions: GST Pull-down assay, Co- immune precipitation, Yeast two-hybrid system.	12
4	**Pharmacogenomics:** High throughput screening in genome for drug discovery; Identification of Drug- targets, Pharmacogenomics and drug development; Gene-therapy.	**12**
5	**Functional genomics and proteomics** Analysis of microarray data; Protein and peptide microarray-based technology; PCR-directed protein in situ arrays; Structural proteomics	**12**

Suggested books:

1. Sangeetha, J. (2015). Genomics and Proteomics: Principles, Technologies, and Applications.
2. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher,2006.
3. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing,1987.
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten,2010.
5. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
6. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science,2001.
7. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics.IX Edition. Benjamin Cummings. 4. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. BenjaminCummings.
8. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press,Washington.
9. Pevsner, J. (2009). Bioinformatics and Functional Genomics.IIEdition.John Wiley & Sons.

Suggested online links:

1. **https://nptel.ac.in/courses/102/101/102101076/**
2. **https://nptel.ac.in/courses/102/101/102101072/**
3. **https://nptel.ac.in/courses/102/104/102104056/**
4. **https://nptel.ac.in/courses/102/103/102103017/**

Semester-IX

Paper-2 (Theory)

Course Title: Bioprocess Engineering and Technology

Program/Class: Master in Biotechnology	**Year:** Fifth	**Semester:** Ninth
		Paper-2 Theory Subject: **Biotechnology**
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
5	**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:

1. Stanbury P F and Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: PergamonPress
2. Shuler M L and Kargi F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: PrenticeHall.
3. Glazier AN and Nikaido H (2007).Microbial Biotechnology – Fundamental & Applied Microbiology – Second Edition. Cambridge UniversityPress.
4. Casida LE (2019) Industrial Microbiology. Second Edition, New Age International Publisher.
5. Bailey J E and Ollis D F. (1986). Biochemical Engineering Fundamentals. New York:McGraw-Hill.

Suggested online links:

1. https://ocw.mit.edu/high-school/biology/exam-prep/cellular-energetics/fermentationcellular-respiration/fermentation/
2. **https://nptel.ac.in/courses/102/106/102106080/**
3. **https://nptel.ac.in/courses/102/106/102106048/**
4. **https://nptel.ac.in/courses/102/106/102106022/**

Semester-IX

Paper-3 (Theory)

Course Title: Animal Biotechnology

Program/Class: Master in Biotechnology	**Year: Fifth**	**Semester:** Ninth
Paper-3 Theory Subject: **Biotechnology**		
Course Code: PBT13-(T)	**Course Title: Animal Biotechnology**	

Credit: 5	**Compulsory**
Max. Marks: 100	**Min. Passing Marks:**
Total No. of Lectures- = 60	

Course Objectives: Learning methods of gene manipulations in animal cells and embryonic stem cells for development of breeding and conservation approaches in animals. Lawfully consideration of the legal and ethical issues related to animal maintenance and experimental uses, that can generate best practices followed during maintenance of cell lines. Apply different recombinant DNA techniques to manipulate the genome of animal cells that can surely formulate ideas for the production of genetically modified organisms. Key understanding of different approaches in reproduction technology which also utilize the concept of molecular techniques involved in animal conservation.

Unit	**Contents**	**Number of Lectures**
1	**Animal cell culture** History of animal cell culture; Basic requirements for animal cell culture; Cell culture media and reagents; Animal cell, tissue and organ cultures; Primary culture, secondary culture; Continuous cell lines; Suspension cultures; Transfection and transformation of cells; Stem cells and their application; Induced Pluripotency, Application of animal cell culture for in vitro testing of drugs; Application of cell culture technology in production of pharmaceuticalproteins.	**12**
2	**Animal health Biotechnology** Recombinant approaches to vaccine production; Hybridoma technology; Phage display technology for production of antibodies; Antigen-antibody based diagnostic assays including radioimmunoassay and ELISA; Immunoblotting; Nucleic acid based diagnostic methods including nucleic acid probe hybridization; PCR, Real time PCR; Branched DNA technology, Nucleic acid sequencing; Animal disease diagnostic kits;Probiotics.	**12**

3	**Animal Reproductive Biotechnology** Cryopreservation of sperms and ova of livestock; Artificial insemination; Super ovulation; in vitro fertilization; Culture of embryos; Cryopreservation of embryos; Embryo transfer; Micromanipulation of animal embryos; Transgenic animal technology and its different applications; Different methods of Transgenic animal production; Targeted gene transfer, Detection of Transgene and transgene function; Animal cloning-basic concepts; Cloning from embryonic cells and adult cells; Ethical, social and moral issues related to cloning; in situ and ex situ preservation of germplasm, Pregnancy diagnostic kits.	**12**
4	**Animal genomics** Introduction to animal genomics; Different methods for characterization of animal genomes, SNP, STR, RFLP, RAPD, proteomics, metobolomics; Genetic basis for disease resistance; Gene knock out technology and animal models for human genetic disorders.	**12**
5	**DNA Forensics** Immunological and nucleic acid based methods for identification of animal species; DNA Barcoding; Detection of adulteration in meat using DNA based methods; Detection of food/feed adulteration with animal protein; Identification of wild animal species using DNA based methods; Microbial forensics; Bioterror agents; Biocrimes and Bioterrorism.	**12**

Books suggested:

1. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: HumanaPress
2. Singh B. Gautam SK (2013). Textbook of animal biotechnology. The Energy and Resources Institute,TERI
3. Gupta PK. (2018) Animal Biotechnology. Rastogi Publications

Suggested online links:

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

6. **https://nptel.ac.in/courses/102/104/102104058/**
7. **https://nptel.ac.in/courses/102/104/102104042/**

Semester-IX

Paper-4 (Theory)

Course Title: Molecular Genetics

Program/Class: Master in Biotechnology	**Year:** Fifth	**Semester:** Ninth
Paper-4 Theory Subject: Biotechnology		
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 generation; Gene mapping; Transposable genetic elements; Insertion sequences; Composite and Complex transposons; Replicative and non-replicative transposition; Genetic analysis using transposons.	12
2	**Bacteriophages and Plasmids** Bacteriophage-structure; Assay; 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; iso disomy; 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:

1. Brown, T. A. (2012). Introduction to genetics: a molecular approach. Garland Science.
2. Lodish, H F. Berk, A. Kaiser, CA, Krieger, M. Bretscher, A. Ploegh, H. Aman,A.
3. Martin, K. (2016). **Molecular Cell Biology** (8th Ed.). New York: W.H.Freeman
4. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). VIII editon Principles of Genetics.WileyIndia.
5. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. XI Edition.BenjaminCummings.
6. Russell, P. J. (2009). iGenetics A Molecular Approach. III Edition. Benjamin Cummings.
7. 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-IX

Paper-5 (Theory)

Course Title: IMMUNOLOGY AND IMMUNOTECHNOLOGY

Program/Class: Master in Biotechnology	**Year:** Fifth	**Semester:** Ninth
		Paper-5 Theory Subject: Biotechnology
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 organizationofimmunoglobulingenes;B-cellreceptor; 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 antigens and super-antigens; Cytokines-properties, receptors and therapeuticuses.	12
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 immunodeficiencies, Acquired or secondary immunodeficiencies	12

Books Recommended:

1. Punt J, Stranford S, Jones P., Owen JA, (2018). Kuby Immunology.(8th edition) New York: W.H.Freeman.
2. Hay FC, Westwood OMR.(2008). Practical Immunology.(4th Edition). Wiley Blackwell
3. Delves P J, Martin SJ, Burton DR, and Roitt IM. (2017). Roitt's Essential

Immunology.(13th edition). Wiley-Blackwell.

4. Hay FC, Westwood OMR.(2008). Practical Immunology.(4th Edition). Wiley Blackwell.
5. Murphy K, and Weaver C, (2016). Janeway's Immunobiology. (9th edition) New York: GarlandScience.

Suggested online links:

1. https://ocw.mit.edu/courses/find-by-topic/#cat=healthandmedicine&subcat=immunology

2.https://nptel.ac.in/courses/102/105/102105083/

3.https://nptel.ac.in/courses/102/103/102103038/

Semester-IX

(Practical)

Course Title: Immunology and Immuno technology

Program/Class: Master of Biotechnology	**Year:** Fifth	**Semester:** Ninth
		Practical Subject: Biotechnology
Course Code: PBT15-(T/P)	**Course Title:** Immunology and Immuno technology-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	Immuno electrophoresis.	**6**
10	Immunodiagnostics (Demonstration using commercial kits).	**6**

Semester-X

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 of Biotechnology	**Year:** Fifth	**Semester:** Tenth
		Subject: Biotechnology
Course Code: PBT16-(T)		**Course Title:** Research project

Credits: 25	Compulsory
	Min. Passing Marks:……

Semester-VIII

Paper-Elective

Course Title: Food and Beverage Biotechnology

Elective Courses For Bachelor (Research) in Biotechnology	
Code: PBT-E-01 (T)	**Course Title: Food and Beverage Biotechnology**
Maximum Marks: 100	

Total Credits = 4, Total Hr.= 60

Course Objective: Demonstrate the basic principles involved in food and beverage technology. Illustrate the chemical and physical properties of food and beverages. Explain the role of microbes in food and beverages. Relate the basic concepts of food technology and the different components of food. Appraise the physical and chemical characteristics of food for application in various food industries. Evaluate the role of regulatory agencies governing food and beverage production and processing.

Unit	Topic	No. of Lectures
I	Type of beverages: fruit & vegetable juices, fermented and non-fermented beverages, synthetic beverages, carbonated and non-carbonated beverages. Tea, Coffee and Cocoa: Production, composition, processing and preparation.	**10**
II	Historical background of Food technology, traditional fermented foods (meat, fish, bread, sauerkraut, soy bean, coffee, cocoa, tea), importance, global trends, codex guidelines, nutritional labelling in India, FSSAI guidelines, improvements through Biotechnology (e.g. Golden Rice, Potato, FlavrSavr Tomato etc.)	**10**
III	Non-carbonated and carbonated synthetic beverages: Ingredients, source of carbon dioxide, chemical and physical properties of carbon dioxide, carbonating process, packaging of carbonating beverages. Alcoholic Beverages: non-distilled beverages: Beer and Wine, distilled beverages: Vodka, Rum, Gin, Whisky, Arack, Toddy,Brandy	**10**
IV	Enzymes in Food Industry: Carbohydrases, Proteases, Lipases; Modification of food using enzymes: Role of endogenous enzymes in food quality, Enzymes use as processing aid and ingredients Food Fermentations: Common fermented foods - Cheese, Butter, Yoghurt, fermented/condensed milk and kefir. Food preservation: Food adulteration and prevailing food standards in India. Source of microorganisms in milk and their types. Microbiological examination of milk (standard plate count, direct microscopic count, reductase and phosphatase test). Dehydration and pasteurization of milk.	**10**

V	Water for beverages: Types of water required for beverages, treatment of water. Additives for beverages: Natural and synthetic sweeteners and colours, acids, emulsifiers, preservatives, flavours and flavour enhancers. Quality control of beverage: Quality standards for beverages, chemical, microbial and sensory evaluation, product shelf life.	**10**
VI	Growth of microorganisms in food: Intrinsic and extrinsic factors. Food Spoilage (microbial and non-microbial), Control mechanisms of food spoilage: Physical and Chemical. Microbial spoilage of food and factors affecting them: Spoilage of various kinds of foods: fish. meat, poultry, sea foods, bread and dairy products). Food adulteration and prevailing food standards in India. Indicator Microorganisms: As an indicator of good quality	**10**

Books Recommended:

1. Foods: Facts and Principles : N. Shankuntala Manny and M. Shadaksharaswamy
2. Ray B and Bhunia A. 2008. Fundamental Food Microbiology, 4th Ed., CRC press, Taylor and Francis Group, USA
3. Martin RA and Maurice OM. 2008. Food Microbiology, 3rd Ed., The Royal Society of Chemistry, Cambridge,UK.
4. Schwartzberg HG, RaoMA. (Eds.) Biotechnology and Food Process Engineering
5. Frazier WC, and Westhoff DC. Food Microbiology. Fourth edition, MacGraw Hillspublication

Suggested online links:

1. https://www.beveragetechnology.in
2. https://ocw.mit.edu/courses/linguistics-and-philosophy/24-03-good-food-ethics-andpolitics-of-food-spring-2017/lecture-notes/MIT24_03S17_lec24.pdf
3. https://www.rug.nl/research/irees/research/edulink-fsba/fsba-course-modules/fsbamodule-2-unit-3-notes-english.pdf
4. https://foodinsight.org/wp-content/uploads/2003/03/Biotech-Guide.pdf

Semester-VIII

Paper-Elective

Course Title: Plant Physiology

Elective Courses For Bachelor (Research) in Biotechnology	
Code: PBT-E-02 (T)	**Course Title:** Plant Physiology
Maximum Marks: 100	

Total Credits = 4, Total Hr.= 60

Course Objectives: Understand the basic concepts central to the study of plant physiology. Comprehensive exposure to the subject of plant physiology. Demonstrate the basics of plant biology and the organization of plants. Relate physiological mechanisms of plant growth, function, and development. Understand the fundamental concepts of plant physiology and mineral nutrition in plants.

Unit	Content	Number of lectures
1	Overview: the organization of plants and plant cells	**10**
2	Water and mineral nutrients. Water in plant cells. Water relations of the whole plant	**10**
3	Essential nutrients. Nutrient uptake	**10**
4	Photosynthesis: light and pigments. Photosynthesis: light reaction. Photosynthesis: carbon assimilation. Photosynthesis: carbon allocation	**10**
5	Regulation of plant growth and development. Cellular basis of growth and development. Plant hormones. Auxin, Gibberellins, Cytokinin, Abscisic acid andEthylene	**10**
6	Photomorphogenesis: responding to light. Plant movements. Photoperiodism. Stress physiology and biotechnology. Plant response to environmental stresses	**10**

Books Recommended:

1. Norman P. A. Hünerand William G. Hopkins, Introduction to Plant Physiology, 3rd. Edition
2. Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy, *Plant Physiology and Development*, 6th Edition
3. F. Salisbury and Cleon W. Ross, Plant Physiology 4th Edition.
4. S K Verma,Mohit Verma, A Textbook of Plant Physiology, Biochemistry andBiotechnology
5. Satish C Bhatla and Manju A. Lal, Plant Physiology, Development andMetabolism
6. Mohammad Pessarakli, Handbook of Plant and Crop Physiology 3rd Edition

7. Victor Sadras, Daniel Calderini, Crop Physiology: Applications for Genetic Improvement and Agronomy

8. Dennis B. Egli, Applied Crop Physiology: Understanding the Fundamentals of Grain Crop Management

Suggested online links:

https://www.esalq.usp.br

2. https://www.biologydiscussion.com
3. https://www.thebiomics.com
4. ScienceXMedia at Global Development BIOPL3420-Plant Physiology-Lecture, You tube Channel

Semester-VIII

Paper-Elective

Course Title: Biochemistry

Elective Courses For Bachelor (Research) in Biotechnology	
Code: PBT01-(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**. (4^{th} 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 Biotechnology	
Code: PBT01-(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 Biotechnology	
Code: PBT02- (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	**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 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	**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;	12

	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	
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:

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/#

Course Title: Molecular Biology-Practical

Elective Courses For Bachelor (Research) in Biotechnology	
Code: PBT02-(T/P)	**Course Title: Molecular Biology-Practical**
Maximum Marks: 100	
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

Elective Courses For Bachelor (Research) in Biotechnology	
Code: PBT10- (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 Biotechnology		
Code: PBT10- (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**