CHOICE BASED CREDIT SYSTEM – REGULATION & CURRICULUM (2023-25)

(With effect from the Academic year 2023-2024)

M. Sc. Biotechnology

Semester - I

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:	**L**	**T**	**P**	**C**	
PABTC101	**Cell and Molecular Biology**	4	0	0	4	
Year and Semester	I Year (I Semester)	Contact hours per week (4Hrs)				
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**		
			✓			
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**		

Course Objectives	• To acquaint students with the concepts in Cell and Molecular Biology. • To appraise on cellular and genomic processes and regulation • To understand the basics of molecular biology and gene expression.		
Course Outcomes	At the end of the course the student will be able to:		BTL
	1.	Exhibit a knowledge base in cell structure, organelles and their functions	K2
	2.	Outline the process that control cell cycle, and cell death	K2
	3.	Understand the process of replication, transcription and translation	K2
	4.	Appraise the post-synthesis modifications for transcription and translation	K1
	5.	Comprehend the role of genetic code, chromatin, operons and cis/trans elements in gene regulation	K3
	6.	Relate the Cell communications and signaling pathways	K3

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Cell organelles and organization: Chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

Unit 2 **12 Hrs**

Cellular Processes: Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and trans-membrane signaling; cell motility and migration; cell death: different modes of cell death and their regulation.

Unit 3 **12 Hrs**

Genome Organization: Genome organization in prokaryotes and eukaryotes, Molecular structure of DNA and RNA, Forms of DNA and RNA; Bacterial Recombination: Transformation, Transduction –types and Conjugation. DNA Replication – Prokaryotes, Enzymes in replication, regulation of replication, DNA Replication – Eukaryotes and Mutations - Mutation: types, DNA repair systems - methylation, mismatch repair, Photo reactivation repair, SOS repair, recombination repair.

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Unit 4	**12 Hrs**
Transcription, Genetic Code and Translation: RNA polymerase, features of promoters and enhancers, transcription factors, Prokaryotic and eukaryotic transcription, post-transcriptional modification - RNA splicing and RNA editing, Inhibitors, Elucidation of genetic code - salient features, Process of translation in prokaryotes and eukaryotes, Post translational modifications, Inhibitors, Regulation of gene expression: In prokaryotes – lac and trp operons. Regulation in eukaryotes – cis and trans-elements, chromatin re-organization in gene regulation.	
Unit 5	**12 Hrs**
Current Trends in Cell and Molecular Biology: Stem cells and progress in stem cell therapy. Cell imaging techniques: Fluorescence microscopy and confocal microscopy, FACS.	

References

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science.
2. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM; Sunderland.
3. Gupta, H.L and Jangir, H.L. (2010) Cell biology: Fundamentals and Applications, Agrobios, Jodhpur, India.
4. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings.
5. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.
6. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.
7. Sambrook, J and Russes D. Molecular Cloning. 3 volumes. Cold Spring Harbor Laboratory Press
8. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.

Text Book, if any.

1. Ajoy, P. (2009) Textbook of Cell and Molecular Biology, Second edition, Books and Allied Publication, Mumbai.
2. Veerbala Rastogi. Fundamentals of Molecular Biology. ANE Books India.

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTC102**	Course Name: **Microbiology and Virology**		**L** 4	**T** 0	**P** 0	**C** 4
Year and Semester	I Year (I Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**		
			✓			
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**		

Course Objectives

- To highlight the functions and characteristics of microorganisms
- To study the cultivation and purification of viruses
- To evaluate explicitly, the metabolic pathways, role of microbes in public health; insight into the physical and chemical control of microorganisms

Course Outcomes

	At the end of the course the student will be able to:	BTL
1	Recall the basic knowledge on the development of microbiology	K2
2	Recognize the fundamental concepts pertaining to the structure and functions of microbes	K2
3	Apply appropriate physical and chemical methods to control the growth of microbes	K2
4	Compare and categorize the interactions of microorganisms with plants and animals	K1
5	Appraise the importance and classification of the viruses	K3
6	Infer about the virology studies and analytical approaches	K2

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POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Microbial Diversity: Introduction to microbiology and microbes, history & scope of microbiology, Microbial taxonomy and the evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; eukaryota: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

Unit 2 **12 Hrs**

Microbial Characteristics: Ultrastructure of Archaea (Methanococcus, Eubacteria (*E. coli*); Unicellular Eukaryotes -Yeast and Algae (*Chlorella*), morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction, and conjugation; antimicrobial resistance.

Unit 3 **12 Hrs**

Control of Microorganisms: Sterilization, disinfection, and antisepsis: physical and chemical methods for control of microorganisms, Beneficial microbes; Host–Pathogen interactions; Microbes infecting humans, veterinary animals and plants; Pathogenicity islands and their role in bacterial virulence, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Unit 4 **12 Hrs**

Virology: History and principles of virology, molecular biology of bacterial virus, viral classification, nomenclature, taxonomy; viral strategies for attachment and entry, different strategies for viral replication - the Baltimore Classification System; Basic immune response to viral infection, general virus pathogenesis; virus structure and morphology.

Unit 5 **12 Hrs**

Virological Methods: Cultivation and purification of viruses: Different *in vivo*, *in vitro* and *in ovo* growth systems for bacterial, plant and animal viruses, determination of yields; Purification of viruses using various techniques.

References

1. Lita M. Proctor. Marine Virus Ecology, Springer, pp 113-130. 1998.
2. Matthai, W., Berg, C. Y., & Black, J. G. (2005). *Microbiology, Principles and Explorations*. Boston, MA: John Wiley & Sons.
3. Tewari. Advances in Microbial Technology. APH, New Delhi, pp. 567. 2000.
4. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology*. New York: McGraw-Hill.

Text Book, if any

1. Pelczar, M.J., Chan, E.C. and Krieg, N.R. (2006) Microbiology, 6th Edition, Tata McGraw Hill Publishing Company Ltd, New Delhi.

PROGRAM	M. Sc., Biotechnology				
Course Code **PABTC103**	Course Name: **Biochemistry and Biophysics**	**L**	**T**	**P**	**C**
		4	0	0	4
Year and Semester	I Year (I Semester)	Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**	
			✓		
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**	

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Course Objectives	• To facilitate strong knowledge on metabolic pathways and their regulations • To articulate the importance of bioenergetics • To gain knowledge on the structures of biomolecules at different levels		
Course Outcomes	At the end of the course the student will be able to:		BTL
	1	Acquire knowledge on the metabolic pathways	K2
	2	Summarize the biosynthesis and degradation pathways of biomolecules	K2
	3	Explain the importance of bioenergetics and energy rich compounds	K2
	4	Understand various biophysical methods and their applications	K1
	5	Articulate the significance of the biomolecules and to apply these fundamentals in biotechnology	K3
	6	Explain the application of analytical instrumentation in macromolecular structure	K2

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Introduction: Biomolecules -Principles of Bioenergetics-Glycolysis and catabolism of hexoses- The citric acid Cycle. Oxidation of fatty acids-Oxidation of amino acids-Oxidative phosphorylation - Photophosphorylation – Biological membranes and transport

Unit 2 **12 Hrs**

Biosynthesis: Carbohydrate Biosynthesis-Lipid biosynthesis- Biosynthesis of amino acids, nucleotide and related molecules-Chemical synthesis of peptides and oligosaccharides, Prostaglandins, leukotrienes, thrombaxanes – Interferons and interleukins, Antibiotics, alkaloids – Animal pigments – Cytoskeletal organization.

Unit 3 **12 Hrs**

Scope and methods of Biophysics: Thermodynamics: Thermodynamic system, Equilibrium, Thermodynamic Laws and their Applications. Different type of processes of Heat Transfer; Thermodynamic variable; entropy, enthalpy, free energy, Thermodynamic Potentials and relations, Maxwell equation, Fundamental Equation of Heat flow.

Unit 4 **12 Hrs**

Measurement of pH, Radioactive labelling and counting, Autoradiography. Bragg`s Equation, Reciprocal Lattice, Miller Indices, Unit cell, Concept of different crystal structure, determination of crystal structure, X-ray crystallography, NMR/MRI.

Unit 5 **12 Hrs**

Biomolecular Structures: Understanding structures of proteins at different levels-primary, secondary, tertiary and quaternary – conformational analysis and forces. Understanding structures of nucleic acids at different levels, Details of lipid structures.

References

1. Charles, R., Cantor, I. and Schimmel, P.R. (2004) Biophysical Chemistry, Part II, W.H.Freeman & Co., New York.
2. Daniel, M. 2007. Basic Biophysics for Biologist, Agrobios, India.
3. Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968), 884-890.
4. Lehninger, A. L. (2012). *Principles of Biochemistry* (6th ed.). New York, NY: Worth.
5. Nolting, B. (2006) Methods in Modern Biophysics, 2nd Edition, Springer Publications, New Jersey.
6. RMJ Cotterill, Biophysics An Introduction, John Wiely and Sons New York
7. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). *Methods in Molecular Biophysics: Structure, Dynamics, Function*. Cambridge: Cambridge University Press.
8. Serdyuk, I.N., Zaccai, N.R. and Zaccai, J. (2007) Methods in Molecular Biophysics – Structure, Dynamics and Function, Cambridge University Press, India
9. Voet, D., & Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons.

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Date: _____	Date: _____

Text Book, if any.

1. RN Roy A text book of Biophysics New Central book Agency Kolkotta
2. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.

PROGRAM	M. Sc., Biotechnology				
Course Code **PABTC104**	Course Name: **Developmental Biology and Immunology**	**L** 4	**T** 0	**P** 0	**C** 4
Year and Semester	I Year (I Semester)	Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**	
			✓		
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**	

Course Objectives

- To provide fundamentals and advances of developmental biology.
- To impart basic knowledge in Immunology encompassing, history, development and its impact on human system.
- To help the students familiarize with the organs and cells of the immune systems, the immune response and molecular interactions involved in immune response.

Course Outcomes

	At the end of the course the student will be able to:	BTL
1	Understand the basic concepts of development in plants and animals	K2
2	Describe model organisms and landmark discoveries in research related to developmental biology	K2
3	Able to explain the antigen-antibody interaction and their specificity and sensitivity	K2
4	Learn the key concepts of immunological mechanisms	K1
5	Understand the types of cells involved in the nervous system	K3
6	Explain various immune techniques in disease detection	K2

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Basic concepts of Developmental Biology: Life Cycles and Developmental Patterns, Gametogenesis, fertilization and early development in plants and animals: Morphogenesis and organogenesis in plants and animals. General stages in Cell Development Potency, induction, competence, determination and differentiation; stem cells; chromosomal inheritance and extra-chromosomal inheritance. Cell differentiation, embryonic development, Growth, Metamorphosis and Regeneration.

Unit 2 **12 Hrs**

Advances in Developmental Biology: Developmental Biology of Model Organisms; Zebrafish, frog; Sea urchin, Drosophila melanogaster; *Arabidopsis thaliana; Dictyostelium discoideum; Saccharomyces cerevisiae* and *Bacillus subtilis*; Programmed cell death, aging and senescence

Unit 3 **12 Hrs**

Components of the immune system: History of Immunology, innate immune response (PRRs, Neutrophils, Dendritic cells), complement system, humoral and cellular immunity and its components (T and B cell signaling).

Unit 4 **12 Hrs**

Cells and organs of the immune system: Overview of lymphoid system, cells of the immune system, primary and secondary lymphoid organs, tertiary lymphoid tissues.

Unit 5 **12 Hrs**

Antigen and antibodies: Antigen concept, criteria of antigens, immunogen, antibodies (structure, specificity, diversity), antigen-antibody interactions. Immunological tolerance, immunosuppression, history and status of tumour immunology, autoimmune disorders and immunology of infectious disease.

References

1. Basir Seemi Farhat (2012). Textbook of Immunology, 2nd edition, PHI Learning.
2. Bruce Alberts et al., Molecular Biology of the Cell, 6th Edition 2014.
3. Judy Owen, Jenni Punt and Sharon Stanford, (2012), Kuby Immunology, 7th edition, W.H.Freeman and Company, New York, USA.
4. Kuby, J. Goldsby,R.A., Kindt,T.J. and Osborne, B.A. (2007). Immunology, 6th edition, W.H.Freeman and Company, NewYork, USA.
5. Peter J. Delves, Ivan Maurice Roitt, Seamus J.Martin and Deninis Burton (2016). Essential Immunology, 13th edition, Wiley Blackwell Scientific Publications, London.
6. Scott F. Gilbert, Developmental Biology, 10th Edition 2013.

Text Book, if any.

1. Rao, C.V. (2006). An Introduction to Immunology, 2nd edition, Narosa Publishing House, Delhi, Chennai, Mumbai, Kolkata.
2. Madhavee Latha P. (2012). Textbook of Immunology, 1st edition, S. Chand Publishers.

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTP101**	Course Name: **Molecular Biology and Biochemistry Lab**		**L** 0	**T** 0	**P** 4	**C** 2
Year and Semester	I Year (I Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
			✓			
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	
Course Objectives	• Develop comprehensive understanding in the salient features involved in the isolation of Nucleic acids • Provide technical skills about electrophoresis and PCR • To facilitate the skills of the students in Qualitative and Quantitative Analysis of biomolecules					
Course Outcomes	At the end of the course the student will be able to:					BTL
	1	Define the basic concepts involved in the nucleic acid isolation from plant, animal and microorganism sources				K2
	2	Explain the principles of quantification of nucleic acids and molecular weight analysis				K2
	3	Knowledge in the amplification of DNA using PCR				K2
	4	Estimate carbohydrates, protein etc.				K1
	5	Learn separation techniques for various phytochemicals				K3
	6	Estimate the biochemical composition and enzymes kinetics				K4

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Molecular Biology

1. Isolation of genomic DNA from plant and animal tissue
2. Isolation of genomic and plasmid DNA from microorganism (*E. coli*)
3. Isolation of RNA by Orcinol method
4. Quantitative and qualitative analysis of isolated genomic DNA using spectrophotometer
5. Agarose gel electrophoresis of DNA and analysis of their molecular weights by gel documentation
6. Amplification of DNA using Polymerase Chain Reaction

Biochemistry

1. Estimation of total carbohydrate by Anthrone method
2. Estimation of reducing sugars by Di Nitro Salicylic acid method
3. Estimation of cholesterol by Zak's method
4. Estimation of protein by Lowry's/ Bradford's method
5. TLC separation of phytochemicals

References

1. Michael R. Green, Joseph Sambrook, Molecular Cloning a Laboratory Manual, 4th ed., Chsl Press, New York.2018.
2. Sawhney S. K., Randhir Singh, Introductory practical Biochemistry. Narosa publishers, 2006

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:	**L**	**T**	**P**	**C**
PABTP102	**Microbiology and Immunology Lab**	0	0	4	2
Year and Semester	I Year (I Semester)	Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				

Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**
			✓	
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**

Course Objectives

- To make the student understand the basic principles involved in the isolation of different kinds of microorganisms
- To Identify the microorganisms using various staining techniques and tests
- To impart the knowledge on the application of immunology in diagnostic and therapeutics

Course Outcomes

	At the end of the course the student will be able to:	BTL
1	Develop media for cultivation of microorganisms	K2
2	Demonstrate microbial isolation and staining techniques for identification of microorganism	K2
3	Demonstrate the skill in collecting blood and separating serum.	K2
4	Evaluate the generation of antibodies through different experimental methods.	K1
5	Analyze the effect of adverse immune reactions.	K3
6	Demonstration off blood groups detection	K4

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POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Microbiology

1. Media preparation- Nutrient broth, Nutrient agar, slants, soft agar
2. culturing of microorganisms– in broth and in plates (pour plates, streak plates)
3. Staining Techniques (Simple, Gram staining and negative staining)
4. Exposing the Sabouraud's agar plate in different location -Fungal identification by LPCD mount
5. Antibiotic sensitivity assay – Disc and Well diffusion method

Immunology

1. Blood Grouping
2. Drawing Blood and separation of Serum.
3. Study of Tonicity using RBC model
4. Maintenance of Fish & Dissection of Lymphoid organs
5. Preparation and Administration of Antigen.
6. Estimation of specific Antibodies using Haemagglutination.
7. Graft Rejection
8. Delayed type hypersensitivity in Fish

References

1. James G. Cappuccino, Microbiology: A Laboratory Manual, 5th Edition, Benjamin Science Publishing, 2009.
2. Senbagam Duraisamy, Practical Immunology A Laboratory Manual: LAP LAMBERT Academic Publishing; 1st edition, 2017.

Semester - II

PROGRAM	M. Sc., Biotechnology				
Course Code **PABTC201**	Course Name: **Genetic Engineering and Bioinformatics**	**L** 4	**T** 0	**P** 0	**C** 4
Year and Semester	I Year (II Semester)	Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**	
			✓		
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**	

Course Objectives

- Acquaint students with the concepts in Genetic engineering.
- Develop technical skills about different types of restriction enzymes, types of vectors used for cloning.
- To learn and understand specific databases and perform effective database searches.

Course Outcomes

	At the end of the course the student will be able to:	BTL
1	Understand the use of restriction endonucleases in gene cloning.	K2
2	Able to describe the different vectors (prokaryotic) that can be used in gene cloning experiments.	K2
3	Demonstrate the various strategies of cloning, screening and selection methods.	K2
4	Apply the knowledge of Bioinformatics skill to solve the biological problems in Genomics and Proteomics.	K1
5	Analyse different types of Biological databases and resources.	K3
6	Apply various software tools in bioinformatics	K3

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Gene Cloning: Principles of Gene Cloning: Restriction enzymes - Classification - nomenclature; Endonucleases, Exonucleases, Ligases - Modifying enzymes; Linkers, Adapters and Homopolymer tailing. Properties of ideal vectors, Plasmids as vectors - PBR322 - pUC vectors - M13-Lambda phage vectors, Cosmid vectors, Phagemids, Shuttle vectors, Expression vectors, YAC, BAC, Mammalian cells-SV40.

Unit 2 **12 Hrs**

PCR: Polymerase chain reaction – Method-Limitations and applications- Types of Primers – Universal, Nested, Poison primers- Types – Q-PCR, RT-PCR- Probe Preparation and methods of Labelling, Southern Hybridization - Northern hybridization; Western blotting, Autoradiography; DNA finger printing.

Unit 3 **12 Hrs**

Recombinant DNA: Construction of recombinant DNA: Preparation of competent cell-Transformation (Physical, chemical and biological methods of Transformation), transfection- Recombinant selection and screening of Recombinant DNA- Gene Sequencing, Libraries and rDNA Applications-Transgenesis and Bioethics.

Unit 4 **12 Hrs**

Bioinformatics: Introduction to Bioinformatics: Scope and applications of bioinformatics, global bioinformatics scenario, definition of terms - orthology, paralogy, xenology and analogy; Similarity and identity- Introduction to databases- types of

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databases, information retrieval system (Entrez and SRS) and database collaboration, file formats, sequence, structure and pathway databases of nucleotides and proteins.

Unit 5 **12 Hrs**

Application of bioinformatics: Multiple Sequence Alignment, progressive method, iterative method; data searching tools for homologous sequences analysis - BLAST & FASTA; Sequence editors - BioEdit, BoxShade etc. Prediction tools- profile, motifs, domains, and feature identification - Phylogenetic prediction: Phylogenetic tree construction - distance based method and character-based methods; Gene prediction, protein structure & functions prediction, Phylogenetic analysis package – MEGA.

References

1. Attwood, T. and Parry, D. (2002) Introduction to Bioinformatics – Pearson Publication, Asia
2. Claverie, J-M. and Notredame, C. (2003) Bioinformatics – A Beginner's guide, 1st Edition –Wiley Publishing Inc, New York.
3. Dubitzky, W. (2007) Fundamentals of Data mining in Genomics and Proteomics, Springer Publication, New Jersey.
4. Gibas, C. and Jambeck, P. (2001) Developing Bioinformatics Computer Skills, Schroff. Publishers & Distributors Pvt. Ltd.
5. Gromiha, M.M. (2010) Protein Bioinformatics: From Sequence to Function, Academic Press, New Delhi.
6. Krane, D.L. (2006) Fundamental Concept of Bioinformatics, Pearson Publication, Asia.
7. Lacroix, Z. and Critchlow, T. (2009) Bioinformatics: Managing Scientific Data – Mayan Kaufmann Publishers, San Francisco.
8. Mount, D. (2006) Bioinformatics, Sequence and Genome Analysis, CBS.
9. Ramsden, J.J. (2009) Bioinformatics: An introduction, Kluwer Academic Publishers
10. Sambrook, J and Russes D. Molecular Cloning. 3 volumes. Cold Spring Harbor Laboratory Press.
11. Simpson, R.J. (2003) Protein and Proteomics, Cold Spray Harbour Laboratory, New York.
12. Varma V.S Cell Biology Genetics: Molecular Biology, Evolution and Ecology
13. Winchester. A. M. Genetics (Third Edition). 1996.

Text Book, if any.

1. Alberts Bruce. "Molecular biology of the cell''. 4th edition, Garland Science publishers. 2002.
2. Roy, D. (2009) Bioinformatics, Narosa publishing house, India.

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTC202**	Course Name: **Genomics and Proteomics**		**L** 4	**T** 0	**P** 0	**C** 4
Year and Semester	I Year (II Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
			✓			
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	

Course Objectives

- Provide advanced theoretical knowledge on the organization and function of genomes.
- Understand the principles of functional genomic analyses.
- Have knowledge on the advanced methods and approaches in proteomics.

Course Outcomes

	At the end of the course the student will be able to:	BTL
1	Define and describe structural, functional, and comparative genomics	K2
2	Learn detailed structure and organization of genes and other DNA elements in a genome	K2
3	Describe advanced techniques and methods used for genome analysis, such as DNA microarrays and NGS based platforms.	K2
4	Able to understand the importance and application of proteomics in medical field.	K1
5	Well acquainted with proteome databases.	K3
6	Summarize the basics of Genomics and proteomics and its recent advancement	K2

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POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Basics of Genomics and Proteomics: Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria, and chloroplast.

Unit 2 **12 Hrs**

Genome Mapping: Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping.

Unit 3 **12 Hrs**

Comparative Genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand the evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence. Genome Sequencing Projects: Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

Unit 4 **12 Hrs**

Proteomics: Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.

Unit 5 **12 Hrs**

Functional Genomics and Proteomics: Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in the genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.

References

1. Arthur M. Lesk. Database Annotation in Molecular Biology: Principles and Practice.
2. Brown T.A., "Genomes", BIOS Scientific Publishers Ltd, Oxford, 4th Edition, 2018.
3. Daniel C. Liebler, "Introduction to Proteomics: Tools for the New Biology", Humana Press, Totowa, New Jersey, 2002
4. Dubitzky, W. (2007) Fundamentals of Data mining in Genomics and Proteomics, Springer Publication, New Jersey.
5. James D. Watson and Mark Zoller, Recombinant DNA, 2nd Edition
6. Malcolm Campbell A. and Laurie J. Heyer, "Discovering genomics, proteomics and Bioinformatics", Pearson/Benjamin Cummings, New Delhi, 2006.
7. Mount, D. W. Bioinformatics: Sequence and genomic analysis Cold Spring Harbour Laboratory Press. New York, 2004
8. Smith and Albala (Eds), Protein array, Biochips and Proteomics Marcel Dekkar, New York.

Text Book, if any

1. Simpson, R.J. (2003) Protein and Proteomics, Cold Spray Harbour Laboratory, New York.
2. Sandor Suhai, "Genomics and Proteomics- Functional and computational Aspects", Springer, New York, 2000.

PROGRAM	M. Sc., Biotechnology				
Course Code **PABTC203**	Course Name: **Artificial Intelligence and Machine Learning**	**L** 4	**T** 0	**P** 0	**C** 4
Year and Semester	I Year (II Semester)	Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				

Course category				
Humanities and Social Sciences	**Management courses**	**Professional Core**	**Professional Elective**
		✓	
Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**

Course Objectives	• To familiarize the fundamental Theoretical and Practical concepts in AI/ML • To understand the data entry and data calculations using various statistical tools. • To learn various computer software skills required for Drug Discovery and to build strong theoretical foundation.

Course Outcomes	At the end of the course the student will be able to:	BTL
1	Acquire knowledge of modern machine learning and deep learning methods.	K2
2	Understand important problems in drug discovery that AI can address.	K2
3	Formulate AI based solutions for industrial and healthcare applications.	K2
4	Get hands on experience on using various tools, libraries for various machine learning and deep learning methods.	K1
5	Acquire the ability to approach novel problems in Science with AI/ML.	K3
6	Apply the knowledge on AI and ML in Molecular diagnosis	K3

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

AI foundation: Introduction to Artificial Intelligence, AI fundamentals, Use-cases and applications of AI, Issues concerning AI in business, ethics and bias, jobs and scope. Brief history of AI and ML in Healthcare and Pharmacy, Machine Learning workflow and terminologies, computational models of intelligence; conceptual frameworks from cognitive and educational psychology, neuroscience, information theory, and linguistics; philosophical foundations of AI.

Unit 2 **12 Hrs**

Introduction to Data Manipulation and Data Visualization. Introduction to Data Science, Flow of Data Science, Numpy, Pandas: Data Frames, operations, Pandas built-in data visualization, Matplotlib, Matplotlib visualization. Data pre-processing: Importing libraries, importing dataset, taking care of missing data, encoding categorical data, split data into train and test set, features scaling.

Unit 3 **12 Hrs**

Introduction to Machine Learning: Introduction, Types of Machine Learning: Supervised, Unsupervised, Reinforcement learning and Transfer Learning, Applications, Classification vs Prediction Problems, Regression models (Prediction Problem), Mean Square Error, R2 Score, Rule-based machine learning (Association Learning). Machine Learning and Medical bio-sensors: ML in micro biosensors and devices for electronic data capture (ECG, Actigraphy, Oximetry), data disambiguation techniques, Bayesian ML, SVM-optimal mix, Shallow learning, Ensemble Learning, anomaly detection. Probabilistic and Statistical analysis

Unit 4 **12 Hrs**

CART (Classification and Regression Tree): Linear Regression, Multiple linear regression, polynomial regression, Decision

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trees, Kernel-Ridge Regression, Random-Forest, evaluating regression models performance, Logistic Regression, SVM, KNN (Confusion matrix, accuracy score), Decision trees classification, Random-Forest classification, classification model selection in python, evaluating classification models performance. Introduction to R in Healthcare: Basic analysis in R, R programming: understanding common data distribution and types of variables, formulate scientific hypothesis, correlation and dependence. Statistical analysis, Survival analysis, Logical and Logistic regression. Ways to choose predictors in regression model, Run and interpret Kaplan-Meier curves in R

Unit 5 **12 Hrs**

Deep Learning: Introduction, Types of Deep Learning, ANN, Neural Networks, DNN, RNN, CNN architectures for medical data manipulations. Challenges in Pharmaceutical industries which AI can solve: Notations, Approaches of AI to be used in solving healthcare data and its applications. Case studies: Disease identification and diagnosis-Google DeepMind Health, Personalized Treatment/Behavioral Modification (Study any one case), COVID – 19 Coronavirus Prediction Outcomes, Forecasting, Analysis & Visualization.

References

1 Arlindo, L. Oliveir Biotechnology, Big Data and Artificial Intelligence, Biotechnol. J. 2019, 14, 1800613. DOI: 10.1002/biot.201800613
2 Dean, T., Allen, J., & Aloimonos, Y. (1995). Artificial intelligence: theory and practice. Benjamin-Cummings Publishing Co., Inc.
3 Erik Pettersson, Joakim Lundeberg, Afshin Ahmadian. Review Generations of sequencing technologies, Genomics 93 (2009) 105–111
4 Graves, A.; Wayne, G.; Reynolds, M.; Harley, T.; Danihelka, I.; Grabska-Barwinska, A.; Gomez Colmenarejo, S.; et al. Hybrid Computing Using a Neural Network with Dynamic External Memory. Nature 2016, 538, 471.
5 Harel, S.; Radinsky, K. Prototype-Based Compound Discovery using Deep Generative Models. Mol. Pharmaceutics 2018
6 Hopgood, A.A. (2021). Intelligent systems for engineers and scientists: A practical guide to artificial intelligence. CRC press.
7 Johnson, D. (2002). The Indispensable Teachers' Guide to Computer Skills. Linworth Publishing, Inc., 480 E. Wilson Bridge Rd., Suite L, Worthington, OH 43085.
8 Kimball, R. & M. Ross, The Data Warehouse Toolkit: The Complete Guide to Dimensional Modeling, John Wiley & Sons, Indianapolis, IN 2011
9 Nathan Brown (Editor). Artificial Intelligence in Drug Discovery: Volume 75. Publisher : Royal Society of Chemistry (11 November 2020) 424 pages
10 Putin, E., Asadulaev, A., Ivanenkov, Y., Aladinskiy, V., Sanchez, Lengeling, B., Aspuru-Guzik, A., Zhavoronkov, A. Reinforced Adversarial Neural Computer for de Novo Molecular Design. J. Chem. Inf. Model. 2018, 58 (6), 1194 −1204
11 Brett Lantz, Machine Learning with R: Expert techniques for predictive modelling, 3rd Edition
12 Daphne Koller and Friedman. Probabilistic Graphical Models - Principles and Techniques, The MIT Press, 2009
13 Garrett Grolemund, Hands-on programming with R: Write your own functions and simulations, 2014
14 Hastie, Tibshirani, Friedman. The elements of statistical learning, Second edition, Springer, 2009

Text Book, if any.

1 Russell, Norvig, Artificial Intelligence: A Modern Approach, Third edition, Prentice Hall, 2010
2 Tsang. Foundations of constraint satisfaction, Academic press, 1993.
3 Anil Philip, Aliasgar Shahiwala, Mamoon Rashid, Md Faiyazuddin. (Editors) A Handbook of Artificial Intelligence in Drug Delivery, 1st Edition - March 27, 2023, Elsevier,

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTC101**	Course Name: **Genetic Engineering and Bioinformatics Lab**		**L** 0	**T** 0	**P** 4	**C** 2
Year and Semester	I Year (II Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
			✓			
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	
Course Objectives	• To impart knowledge on the basic laboratory techniques employed in a genetic engineering Lab • To learn and understand specific databases and perform effective database searches.					

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	• To solve the biological problems in Genomics and Proteomics		
Course Outcomes	At the end of the course the student will be able to:		BTL
	1	Gain experience in the development of molecular tools for viral vector-based gene delivery	K2
	2	Demonstrate various tools involved in genetic engineering	K2
	3	Express, purify and analyze recombinant protein	K2
	4	Understand the significance of biological databases and their utilization.	K1
	5	Construct phylogenetic tree	K3
	6	Apply various software tools in bioinformatics	K3

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Genetic Engineering

1. RE digestion of the PCR product & cloning the digested PCR product into *E.coli* Expression vector by ligation*
2. Preparation of competent *E.coli* and transformation of the cloned plasmid and selection of recombinant clones.*
3. Analysis of expressed protein using SDS-PAGE.
4. Western blotting analysis

*Demo in Lab visits

Bioinformatics

1. NCBI Database
2. ExPASy Database
3. EMBOSS pairwise Sequence Alignment
4. Freiburg RNA Tools Smith-Waterman
5. Swiss-Prot Database
6. Gene Prediction
7. EMBL-EBI database
8. Tree Reconstruction based on Molecular Phylogeny Data

References

1. Michael R. Green, Joseph Sambrook, Molecular Cloning: A Laboratory Manual (Fourth Edition), 2012
2. Andreas D. Baxevanis, B. F. Francis Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd Edition, Wiley and Sons, 2012

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:		**L**	**T**	**P**	**C**
PABTP202	**Genomics, Proteomics, AI and ML Lab**		0	0	4	2
Year and Semester	I Year (II Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
			✓			

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	Basic Science	Engineering Science	Open Elective	Mandatory

Course Objectives

- Able to know database searching, alignments and pattern matching
- To explore how ever-growing gene and protein data-sets can provide key insights into human disease
- To identify innovative research directions in Artificial Intelligence and Machine Learning

Course Outcomes

At the end of the course the student will be able to:		BTL
1	Perform computational analysis and wet-lab investigations	K2
2	Familiar with conditions for designing primers for PCR	K2
3	Demonstrate Proteomic analysis	K2
4	Understand Pharma data analysis based on computer science	K1
5	Learn the importance and application of Artificial Intelligence and Data Science	K3
6	Apply the knowledge on AI and ML in Molecular diagnosis	K3

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Genomics, Proteomics

1. ORF finding using bioinformatics tools
2. Searching similar sequences using BLASTp, BLASTt and BLASTn
3. Multiple sequence alignment and finding conserved sequences.
4. Designing primers for PCR
5. Protein Structure: Data, Visualization, Alignment, Pocket detection, Homology Modeling
6. Molecular Docking: Protein-Protein and Protein Small molecule/drug

AI and ML

1. Data Manipulation using Numpy and Pandas,
2. Data Visualization in different Graphs and basic python based on arrays, list, data management, functions.
3. Clustering: K-means clustering, Hierarchical clustering
4. R programming for Pharma data analysis, Data classification using Python
5. IRIS Flower Classification using KNN

References

1. Tripathi, Manoj & Gautam, Ajay & Tiwari, Sushma & Ahuja, Ashok & Tiwari, Reshu & Sharma, A & Singh, A. (2020). Introduction to Bioinformatics (Practical Manual: MBB 555).

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Semester – III

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTC301**	Course Name: **Drug Design and Discovery**		**L** 4	**T** 0	**P** 0	**C** 4
Year and Semester	II Year (III Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
			✓			
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	
Course Objectives	• To explore the process of drug development, from target identification to final drug registration. • To provide the knowledge in drug development as a process involving target selection, lead discovery using computer-based methods and combinatorial chemistry/high-throughput screening. • To develop skills in specialized areas related to bioavailability, clinical trials, and the essentials of patent law					

Course Outcomes		At the end of the course the student will be able to:	BTL
	1	Describe and justify the importance of rational drug design methods over irrational approaches.	K2
	2	Classify the computational methods used in drug discovery	K2
	3	Be able to discuss the challenges of using various computer-assisted drug design methods	K2
	4	Gained a basic knowledge of applying computational methods in drug design and discovery.	K1
	5	Demonstrate their ability to work in teams and communicate scientific information effectively	K3
	6	Construct, review and evaluate preclinical and clinical pharmaceutical studies.	K4

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Introduction to drug design and discovery: Stages of Drug discovery and development, Drug Discovery approaches – Drug discovery by Rational Drug design, Random Screening, Serendipity, Clinical observations, etc. with examples. Fundamentals of Computational drug design: Introduction to molecular mechanics and quantum mechanics, Energy Minimization methods and Conformational Analysis. Applications of Computational methods in drug discovery.

Unit 2 **12 Hrs**

Target Identification and Validation: Target identification methods, Criteria of target validation, Study of targets using RCSB protein data bank, Concept of Homology modeling for construction of a model for target protein. Lead generation and databases: 1D, 2D, and 3D chemical structures and software to draw it – Chemdraw, MarvinSketch, ACD/ ChemSketch etc., Converting 2D to 3D chemical structures – Open Babel, Small molecule structure databases – ZINC, Drug bank, Coconut, ChEMBL, Pubchem etc. Structure-based drug design (SBDD): Concept of SBDD, Methods of SBDD – Docking, Fragment-based drug design, De-novo drug design, etc., Ligand receptor interaction, Binding energy scores (Dock score)

Unit 3 **12 Hrs**

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Molecular Docking: Concept and application of molecular docking, Steps in molecular docking – Protein preparation, Ligand preparation, Active site identification, Grid generation, Selection of parameters for docking, interpretation of docking results. Software used for molecular docking studies. Molecular Dynamic Simulation: Introduction to molecular dynamics. Importance of molecular modeling in drug design. Software used for molecular dynamics studies.

Unit 4 **12 Hrs**

Quantitative Structure Activity Relationship (QSAR): SAR versus QSAR, History, and development of QSAR, Types of physicochemical parameters, experimental and theoretical approaches for the determination of physicochemical parameters such as Partition coefficient, lipophilic effects, logP, and logD, the effect of ionization on logP, calculation of logP and logD, Steric effects- the Taft equation Hammet's substituent constant and Tafts steric constant. Hansch analysis, Free Wilson analysis, 3D-QSAR approaches like COMFA and COMSIA. Software used for 3D QSAR Studies. Pharmacophore Mapping: Pharmacophore concept, Introduction to Pharmacophore mapping, Steps in Pharmacophore mapping studies, Applications of Pharmacophore modeling studies. Software used for Pharmacophore mapping.

Unit 5 **12 Hrs**

Virtual screening (VS): Concept of virtual screening. Virtual screening Vs High throughput screening. Different methods of virtual screening e.g., Docking-based VS, 3D QSAR, Pharmacophore-based VS. Drug like Properties (DLP): Concept of Drug like Properties, Importance of DLP in drug discovery projects, Prediction of Absorption, Distribution, Metabolism, Elimination and Toxicity (ADMET) of the molecule, Lead Optimization, Software for prediction of DLP. Cheminformatics, Bioinformatics, and Artificial Intelligence: Introduction to Cheminformatics, Bioinformatics, and Artificial Intelligence and their applications in drug discovery and development.

References

1. Stroud R.M. and Moore J.F., 2008, Computational and structural approaches to drug discovery, Vol. 8, RSC Press.
2. Martin Y.C., 2010, Quantitative Drug Design: A Critical Introduction, 2nd Ed., CRC Press.
3. Smith J.H. and Williams H., 2006, Principles of Drug Design and Action, 4th Ed., CRC Press.
4. Abraham D.J., 2003, Burger's Medicinal Chemistry and Drug Discovery, 6th Ed., Vol. 1, John Wiley & Sons: New York.
5. Burger's Medicinal Chemistry, Drug Discovery and Development, 8th Ed., Vol. 1, 2021, John Wiley & Sons: New York.
6. Patrick G.L., 2013, An Introduction to Medicinal Chemistry, 5th Ed., Oxford University Press.
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8. Kerns, E.H.; Di, L., 2008, Drug-Like Properties: Concepts, Structure Design, and Methods: from ADME to Toxicity Optimization, 1st Ed., Academic Press, Oxford.
9. Leach A. R., 2001, Molecular Modelling – Principles and Applications, 2nd Ed., Prentice- Hall.
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11. Kubinyi H., 1994, 3D QSAR in Drug Design: Theory, Methods, and Applications, Vol. 1, Springer.
12. Schlick T., 2010, Molecular Modeling and Simulation -An Interdisciplinary Guide, 2nd Ed., Springer.
13. Artificial Intelligence in Drug Discovery. United Kingdom: Royal Society of Chemistry, 2020.

Text Book, if any

1. Strømgaard K., Krogsgaard-Larsen P. & Madsen U, 2016, Textbook of Drug Design and Discovery, 5th Ed., CRC Press.

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTC302**	Course Name: **Biosafety, Bioethics, and IPR**		**L** 4	**T** 0	**P** 0	**C** 4
Year and Semester	II Year (III Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
			✓			
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	
Course Objectives	• To understand Biosafety regulations and IPR • To introduce the biosafety regulations and ethical concepts in biotechnology • To emphasize on IPR issues and need for knowledge in patents in biotechnology					
Course Outcomes	At the end of the course the student will be able to:					BTL

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	1	Interpret the basics of biosafety and bioethics and its impact on all the biological sciences and the quality of human life	K2
	2	Recognize the importance of biosafety practices and guidelines in research	K2
	3	Comprehend the benefits of GM technology and related issues	K2
	4	Recognize the importance of protection of new knowledge and innovations and its role in business	K1
	5	Learn the patent processes in India	K3
	6	Summarize awareness on the Biosafety, Bioethics, Intellectual property rights.	K2

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Introduction: Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, Biosafety guidelines - Government of India, WTO and other international agreements related to biosafety, Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture- Bt Cotton, Bt Brinjal etc; Environmental release of GMOs; Cross border movement of germplasm; Risk management issues - containment.

Unit 2 **12 Hrs**

Bioethics: Definition; General considerations of bioethics, bioethics and medical research, ethical issues in Biotechnology, GMOs, human genetics research, gene therapy; human cloning, eugenics, artificial intelligence, organ transplantation, religion and bioethics

Unit 3 **12 Hrs**

Introduction to Intellectual Property: General Introduction to intellectual property rights and its different forms, Farmers Rights, Animal and Plant breeders' rights; Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs

Unit 4 **12 Hrs**

IPR in the era of Globalization: protection of IP, IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO, and TRIPS; Recent Development in Patent System and Patentability of Biotechnology invention, Budapest treaty.

Unit 5 **12 Hrs**

IPR and India: Patent Process in India: Basic requirements, patentable subject matter, novelty and the Public Domain; Patent infringements and revocation; Patent Litigation. Implications of intellectual property rights on the commercialization of biotechnology products.

References

1. Anupam Singh, Ashwani Kumar Singh. Intellectual Property Rights and Bio-technology: Biosafety and Bioethics. Narendra Publishing House. 2012
2. Brigitte Anderson, Intellectual Property Rights, Edward Elgar Publishing
3. Deepa Goel and Shomini Parashar. IPR, Biosafety and Bioethics. Pearson Publishers. 2013.
4. Fleming, D.A., Hunt, D.L. Biological safety Principles and practices (3rd Ed). ASM Press, Washington, 2000.
5. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
6. Graham Dutfield, Intellectual Property Rights and the Life Sciences Industries, Ashgate Publishing
7. Rehm H.J. and G. Reed, Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions, 2008
8. Tamali Sen Gupta. Intellectual Property Law in India. Kluwer Law International. 2011.
9. Thomas, J.A., Fuch, R.L. Biotechnology and Safety Assessment (3rd Ed). Academic Press, 2002
10. Watal J. Intellectual Property rights in the WTO and Developing countries. Oxford University Press. 2001.

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Date: _____	Date: _____

11. WIPO Intellectual Property Handbook

Text Book, if any.

1. Sree Krishna. V., Bioethics and Biosafety in Biotechnology. New Age International (P) Limited. 2007.

PROGRAM	M. Sc., Biotechnology				
Course Code **PABTC303**	Course Name: **Ecotoxicology and Nanobiotechnology**	**L**	**T**	**P**	**C**
		4	0	0	4
Year and Semester	II Year (III Semester)	Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				

Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**
			✓	
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**

Course Objectives

- To understand toxicology and effects of contaminants in ecosystems
- To introduce the concepts and fundamentals of nanotechnology
- To understand the synthesis and characterization of nanomaterials and their application in biomedical fields

Course Outcomes

	At the end of the course the student will be able to:	BTL
1	Describe sources and fates of chemicals in the environment	K2
2	Able to present and explain mechanisms for adverse effects of chemicals	K2
3	Understand the basic principles of nanotechnology	K2
4	Understand and apply the knowledge of nanomaterials and nanobiomaterials to enable health sector advancements.	K1
5	Analyse the impact of nanotechnology in various sectors	K3
6	Apply nanotoxicology in bioremediation and biomedical sciences	K3

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **12 Hrs**

Introduction to ecotoxicology: Definition and Scope of eco–toxicology – Branches in Ecotoxicology - Environmental Fate and Sources of Pollutants – Measurement of LD50 and LC50 values. Practical problems in assessing toxicity - Route of entry and its influence in toxicity-Factors that influence toxicity- Chemical, biological, nutritional and physical factors. Ecotoxicology, Biomarkers and Biomonitoring

Unit 2 **12 Hrs**

Eco-Toxicological Testing & Applications: Principles of Biological Tests for Toxicity –Types of Toxicity Testing: Acute, Chronic, Prolonged toxicity, Teratogenicity, Carcinogenicity, Mutagenicity - Concept of bioassay, threshold limit value, margin of safety, therapeutic index - Dose-Response Relationship Toxicity Testing, and ADME I (Absorption, Distribution, Metabolism and Excretion) - ADME II (Toxicokinetics and Metabolism), and Classes of Environmental Chemicals - Biochemical Effects and Mechanism of Toxicity of Pollutants.

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Unit 3	**12 Hrs**
Applications of ecotoxicology: Regulatory frame for ecotoxicology; role of ecotoxicology in environmental protection- national and international standards in ecotoxicology; safety limits - predictive ecotoxicology; QSAR and mathematical models - risk assessment; human vs. ecological risks.	
Unit 4	**12 Hrs**
Introduction to Nanobiotechnology: Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials - Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging.	
Unit 5	**12 Hrs**
Medical applications: Nanomaterials in Diagnostics, therapeutics, drug delivery, Nano Surgery and Tissue Engineering. Drug Delivery Applications, Bioavailability, Sustained and targeted release. Benefits of Nano drug delivery system. Use of Microneedles and nanoparticles for targeted and highly controlled drug delivery. Nano robots in drug delivery and cleaning system. Design of nanoparticles for oral delivery of peptide drugs. Nanotoxicity assessment: *In-vitro* laboratory tests on the interaction of nanoparticles with cells - Health and environmental impacts of nanotechnology.	

References

1. Gary M. Rand, Editor. *Fundamentals of aquatic toxicology: effects, environmental fate, and risk assessment*. 2nd ed. Boca Raton: CRC Press, 1995.
2. Glenn W. Suter. Ed. *Ecological risk assessment*. 2nd ed. Boca Raton: CRC Press/Taylor & Francis, 2007. 643 p
3. Grassian, V.H, "Nanoscience and Nanotechnology – Environmental and health impacts", John Wiley & Sons, 2008
4. HOFFMAN, D.J. and B.A. RATTNER. *Handbook of Ecotoxicology*. Boca Raton, FL, USA: CRC Press, 1994.
5. Hunt, G and Mehta, M. 2007. Nanotechnology: Risk, Ethics and Law, Earthscan, London
6. John H Duffs.; Howard G J Worth. (Editors). 2015. Fundamental Toxicology. 2nd Edition Publisher: Royal Society of Chemistry; UK, 516 pages
7. Laura Robinson & Ian Thorn, 2005. Toxicology and Ecotoxicology in chemical safety Assessment. Black well Publishing Ltd. CRC Press.
8. Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press
9. Newman, Michael C. and Michael A. Unger. *Fundamentals of ecotoxicology*. 2nd ed. Boca Raton, Fla.: Lewis Publishers, 2003.
10. Nolting, B. (2006) Methods in Modern Biophysics, 2nd Edition, Springer Publications, New Jersey.
11. Nordberg. G. Effects and Dose-response Relationships of Toxic metals, Elsevier Scientific Publishing Co., New York
12. Ram. M, Andreescu. S.E, and Hanming. D, Nanotechnology for Environmental Decontamination, 2011, McGraw Hill.
13. Sellers. K, Mackay. C, Bergeson. L.L, Clough S.R, Nanotechnology and Environment, CRC Press, 2009
14. Simeonova P.P, Opopol N, and Luster M.I, Nanotechnology: Toxicological Issues and Environmental Safety", Springer 2006.
15. Yuliang Zhao and Harising Nalwa (2007). Nanotoxicology, American Scientific Publishers
16. Vencatesan R.; Randolph V. L.; (2006). "Bionanotechnology: Proteins to Nanodevices, Springer

Text Book, if any.

1. Parthasarathy, B.K. 2007. Challenges and Opportunities in Nanotechnology, Isha Books, New Delhi
2. Peter Calow. Handbook of ecotoxicology. Oxford: Blackwell scientific publications, 1994.

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:		**L**	**T**	**P**	**C**
PABTP301	**Drug Design and Discovery Lab**		0	0	4	2
Year and Semester	I Year (I Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
			✓			
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	

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Course Objectives	• To understand phases in drug development and discovery process • To explore Computer-aided drug designing • To get knowledge on molecular structure prediction for drug development		
Course Outcomes	At the end of the course the student will be able to:		BTL
	1	Familiarize with drug development pathway	K2
	2	Able to understand secondary structure prediction and validation	K2
	3	Demonstrate biologically active compounds in a drug candidate	K2
	4	Organize the computational methods used in drug discovery	K1
	5	Understand various gene finding programs	K3
	6	Construct, review and evaluate preclinical and clinical pharmaceutical studies.	K4

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM),			**3.** SUBSTANTIAL (HIGH)		

Drug Design and Discovery lab

1. Gene finding programs – GeneMark, GeneScan
2. Biology Workbench – retrieval of sequences, alignment of sequences, phylogenetic tree building – rooted and unrooted trees – alignment presentation method – secondary structure prediction of proteins.
3. Computer-aided drug design and analysis – demonstration of the modules of Schrödinger Drug Design Suite.
4. Secondary structure prediction and validation
5. Molecular mechanics
6. Structure Based Drug Design
7. Ligand Based Drug Design
8. Molecular Dynamics
9. Binding Site Identification

References

1. Spriet, Alain et al. Methodology of clinical drug trials. Basel: Karger, (2004)

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:		**L**	**T**	**P**	**C**
PABTP302	**Ecotoxicology and Nanobiotechnology Lab**		0	0	4	2
Year and Semester	I Year (I Semester)		Contact hours per week (4Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
			✓			
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	

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Course Objectives	• To know about the impacts of contaminants including pesticides on individuals and ecosystems • To understand the changes in the state or dynamics of an organism due to toxicity • To summarize the importance and synthesis of Nanoparticles		
Course Outcomes	At the end of the course the student will be able to:		BTL
	1	Understand the exposure and effects of environmental contamination	K2
	2	Determine metals / organics / pesticides etc. using various techniques	K2
	3	Understand fundamental concepts of nanotechnology and nanomaterials	K2
	4	Have knowledge on the fabrication and characterization of nanomaterials	K1
	5	Familiarize with the principle of TEM/SEM	K3
	6	Apply nanotoxicology in bioremediation and biomedical sciences	K3

Ecotoxicology:

1. Conduct Acute Toxicity testing using Plankton, and bivalve / fish and calculate the endpoints such as LC50/EC50, NOAEC, Safe Limit under toxicant exposure.
2. Conduct Chronic Toxicity testing using Plankton, and calculate the endpoints such as NOEC/LOEC. Safe Limit under toxicant exposure.
3. Determination of Cytotoxicity of fish under acute exposure.
4. Quantification of metals / organics in water, sediments and biological samples using AAS/GCMS
5. Determination of metals / organics / pesticides etc., using GCMS/ ICP-AES/AAS – working principles and protocols

Nanotechnology:

1. Biological Synthesis of Nanoparticles (Seaweeds / Microbes)
2. Chemical Synthesis of Nanoparticle
3. Testing anti-bacterial property of Synthesized Nanoparticles.
4. Determination of shape and size of Nanoparticles using TEM/SEM – working principles and protocols.

References

1. Glenn W. Suter. Ed. *Ecological risk assessment*. 2nd ed. Boca Raton: CRC Press/Taylor & Francis, 2007. 643 p
2. Grassian, V.H, "Nanoscience and Nanotechnology – Environmental and health impacts", John Wiley & Sons, 2008
3. Hunt, G and Mehta, M. 2007. Nanotechnology: Risk, Ethics and Law, Earthscan, London
4. John H Duffs.; Howard G J Worth. (Editors). 2015. Fundamental Toxicology. 2nd Edition Publisher: Royal Society of Chemistry; UK, 516 pages
5. Laura Robinson & Ian Thorn, 2005. Toxicology and Ecotoxicology in chemical safety Assessment. Black well Publishing Ltd. CRC Press.
6. Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press
7. Newman, Michael C. and Michael A. Unger. *Fundamentals of ecotoxicology*. 2nd ed. Boca Raton, Fla.: Lewis Publishers, 2003.
8. Nolting, B. (2006) Methods in Modern Biophysics, 2nd Edition, Springer Publications, New Jersey.
9. Nordberg. G. Effects and Dose-response Relationships of Toxic metals, Elsevier Scientific Publishing Co., New York
10. Parthasarathy, B.K. 2007. Challenges and Opportunities in Nanotechnology, Isha Books, New Delhi
11. Ram. M, Andreescu. S.E, and Hanming. D, Nanotechnology for Environmental Decontamination, 2011, McGraw Hill.
12. Sellers. K, Mackay. C, Bergeson. L.L, Clough S.R, Nanotechnology and Environment, CRC Press, 2009
13. Simeonova P.P, Opopol N, and Luster M.I, Nanotechnology: Toxicological Issues and Environmental Safety", Springer 2006.
14. Yuliang Zhao and Harising Nalwa (2007). Nanotoxicology, American Scientific Publishers
15. Vencatesan R.; Randolph V. L.; (2006). "Bionanotechnology: Proteins to Nanodevices, Springer

Text Book, if any.

1. Gary M. Rand, Editor. *Fundamentals of aquatic toxicology: effects, environmental fate, and risk assessment*. 2nd ed. Boca Raton: CRC Press, 1995
2. HOFFMAN, D.J. and B.A. RATTNER. *Handbook of Ecotoxicology*. Boca Raton, FL, USA: CRC Press, 1994.
3. Peter Calow. *Handbook of ecotoxicology*. Oxford: Blackwell scientific publications, 1994.

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Professional Elective Courses (PEC)

PROGRAM	M. Sc., Biotechnology				
Course Code **PABTE101**	Course Name: **Marine Resources and Bioprospecting**	**L** 3	**T** 0	**P** 0	**C** 3
Year and Semester	I Year (I Semester)	Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				

Course Category				
Humanities and Social Sciences	**Management courses**	**Professional Core**	**Professional Elective**	
			✓	
Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**	

Course Objectives

- To acquire knowledge about various marine bio-resources; importance of sustainable utilization and management of the marine bio-resources.
- To understand the marine natural products in disease treatments, drug development; environmental and industrial applications; agriculture, aquaculture and fisheries sectors, animal husbandry;
- To know the IPR concept for marine-biotechnological licensing.

Course Outcomes	At the end of the course the student will be able to:	BTL
1	Understand the uniqueness of various marine bio-resources from microalgae, to invertebrates and vertebrates.	K2
2	Acquire knowledge about threats, protection, conservation and management of marine resources for various applications.	K2
3	Acquire knowledge isolation, extraction, purification, structure elucidation techniques of marine bioactive compounds from microbes to vertebrates for various applications.	K2
4	Relate the traditional knowledge on Marine Bioprospecting and recognize the current development.	K1
5	Understand the regulatory affairs in marine pharmacology for industrial applications	K3
6	Apply the knowledge for marine pharmacological research and marketing strategy	K2

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Coastal and Marine Resources: Distribution and diversity of Microbes, Seaweeds, Seagrasses, Mangroves, Invertebrates and Vertebrates and their Ecological Significance

Unit 2 **9 Hrs**

Management and Sustainable Use of Marine Bioresources: Institutional responsibilities – Ecosystem - Based Management Approaches - marine resource management measures – village -based marine resource management measures.

Unit 3 **9 Hrs**

Traditional and Current Applications of Marine Resources: Traditional use of marine bio and other resources: medicines, food, neutraceuticals etc; Marine Bioprospecting-choice of organisms, ecosystem selection, screening criteria; Marine Organisms –Bioprospecting for beneficial products: Industrial, Medical, Environmental, Pharmaceutical, cosmetic, diagnostic, agriculture and fisheries, and agricultural applications – Future prospects.

Unit 4 **9 Hrs**

Extraction and Characterization of Bio-Products: Separation, purification and structural characterization of bioactive compounds. Molecular Docking Analysis. Biological, Toxicological and Clinical Evaluation: Types of Screening, Screening Models and Activity, Anticancer Screening, Testing Methods: Toxicity Evaluation, Use of Animals in Experiments, Clinical

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Trials

Unit 5 **9 Hrs**

Challenges and Opportunities in Marine Pharmacology: Biopharmaceutics classification system. Regulatory affairs in clinical trials IND, NDA, ANDA- Parts and contents, Safety monitory boards, FDA in various countries including India. Synthetic equivalents of marine natural products, approval and marketing of marine natural products, improvement of academic and industry collaborations, sustainable resources for marine pharmaceuticals, environmental challenges of resources for marine pharmaceuticals, newer opportunities in Marine Pharmacology.

Reference Books

1. Vanessa Sunkel, 2010. Marine Bioprospecting and Natural Product Research
2. Se-Kwon Kim, 2013. Bioprospecting of Marine Microbial Symbionts: Exploitation of Underexplored Marine Microorganisms
3. Anne Osbourn, Rebecca J. Goss and Guy T. Carter, 2014. Marine Bioprospecting
4. Shyam, S Salim and Sathiadhas, R and Sathianandan, T V and Geetha, R and Aswathy, N and Vipinkumar, V P (2010) *Marine fisheries resources: exploitation, management and regulations in India.* Seafood Export Journal, 40(2).25-34.
5. UNESCAP. 2003. Community-based decision-making on coastal fisheries. Kitakyushu, Japan: UNESCAP.
6. Manuel Barange and Roger Harris (Eds). Marine Ecosystems and Global Change. International Geosphere Biosphere Programme 2003, IGBP Science No. 5
7. Heinz Lüllmann, Klaus Mohr, Lutz Hein and Detlef Bieger. Jürgen Wirth, Darmstadt. Color Atlas of Pharmacology 3rd edition. Thieme Stuttgart, New York 2005.
8. Cannell, R.J.P. 1998. Methods in Biotechnology: Natural Products Isolation. Humana Press, Totowa.
9. Charles B. Spainhour, 2005. NATURAL PRODUCTS**,** *Drug Discovery Handbook*, by Shayne Cox Gad, John Wiley & Sons, Inc. pp: 72

Text Book, if any

1. Thompson, J.E., Sarojini, R and Nagabhushanam, R. 1991. Bioactive compounds form marine organisms. Oxford & IBH Publishing Co. Pvt., Ltd. New Delhi.
2. Attaway, D.H. and Zaborsky, O.R. 1993. Marine Biotechnology: Pharmaceutical and bioactive natural products. Plenum Press, New York.
3. Bhakuni, D.S., and Rawat, D.S. 2005. Bioactive Marine Natural Products, Co-published by Springer, New York 10013, USA with Anamaya Publishers, New Delhi, India.

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTE102**	Course Name: **Fish Biotechnology**		**L** 3	**T** 0	**P** 0	**C** 3
Year and Semester	I Year (I Semester)		Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course Category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
					✓	
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	
Course Objectives	• To obtain knowledge on breeding of fish. • To study the genetic markers for fish disease resistance and DNA vaccines. • To understand the concepts of genetic engineering and molecular modeling in marine fishes.					
Course Outcomes	At the end of the course the student will be able to:					BTL
	1	Explain about fish breeding, Hybridization of fishes and conservation of germplasm.				K2
	2	Explain the application on molecular and immunogenetics.				K2
	3	Apply techniques in fish feed production industries.				K2
	4	Understand Genetic Engineering Techniques in aquaculture industry				K1
	5	Infer the Molecular Modelling Techniques & Trans genesis in fishes				K3
	6	Apply the molecular tools for advanced research in fish biotechnology				K2

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POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Fish Breeding: Fish Breeding: Synthetic hormones for induced breeding- GnRHH analogue structure and function. Hybridization of fishes - selective breeding, cross breeding, development of disease resistance and high quality of new strains, transgenic fish production. Chromosome manipulation, its role in aquaculture, androgenesis, gynogenesis, sex reversal and tripoidy, cryopreservation and conservation of germplasm.

Unit 2 **9 Hrs**

Molecular and Immunogenetics: Biochemical Markers: Allozyme polymorphism and its application in estimating population genetic parameters. Cell hybridization: Somatic cell fusion, hybridoma technology, Production and Application of monoclonal Antibodies.

Unit 3 **9 Hrs**

Fish Feed Development and Feeding Techniques: Feed Technology: Micro encapsulated feeds, micro coated feeds, micro-particulate feeds and bio-encapsulated feeds, mycotoxins, and their effects on feeds.

Unit 4 **9 Hrs**

Genetic Engineering in Marine Fishes: Mammalian cell expression system special features, selectable markers; Transfection: principle, types, selection: transduction by viral vectors, construct design (strong and constitutive promoters, inclusion of introns). Fish cell expression systems: Tissue specific promoters and applications.

Unit 5 **9 Hrs**

Molecular Modeling Techniques: Transgenesis: Methods of gene transfer in fishes, single gene traits, screening for transgenic, site of integration, applications, regulations of GMOs, IPR, Evaluation of GFP transgenic.

Reference Books

1. Alberts Bruce *et a*l, 2002. "Molecular biology of the cell''. 4th edition, Grland Science publishers: 1249 p. ISBN:0-8153-3218-1.
2. John R. W.Mesters Ed. Animal cell culture –Practical approach, Oxford.
3. Lanfroshney, R. Culture of animal cells (3rd edition), Wiley-Liss.
4. Pasteur et al., Practical Isozyme Genetics. Ellis Horewood Ltd, England: 215p 1988.

Text Books if any

1. Reddy. P.V.G.K; Ayappan *et al*., "Text book of fish Genetics and Biotechnology''. 218p ICAR publications. ISBN: 81-7164-029-x. 2005.

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:		**L**	**T**	**P**	**C**
PABTE201	**Bioprocess & Fermentation technology**		3	0	0	3
Year and Semester	I Year (II Semester)		Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course Category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
					✓	
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	

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Course Objectives	• To study the design and construction of fermentor and parameters to be monitored and controlled in fermentation process. • To study the cell growth and product formation and evaluate the kinetics and mechanism of microbial growth. • To impact knowledge about biological and biochemical technology, with a focus on biological products, the design and operation of industrial practices.		
Course Outcomes	At the end of the course the student will be able to:		BTL
	1	Evaluate factors that contribute in enhancement of cell and product formation during fermentation process.	K2
	2	Analyse kinetics of cell and product formation in batch, continuous and fed-batch cultures	K2
	3	Examine the application of biological and engineering principles to problems involving microbial, mammalian, and biological/biochemical systems.	K2
	4	Understand and explain the development of bioprocess engineering in educational world and industry to support a bio-based economy.	K1
	5	Analyse kinetics of cell and product formation in batch, continuous and fed-batch cultures	K3
	6	Examine the application of biological and engineering principles to problems involving microbial, mammalian, and biological/biochemical systems.	K2

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Basic principles of Bioprocess Technology: Introduction to concepts of bioprocess engineering, Overview of bioprocesses with their various components, Isolation, screening and maintenance of industrially important microbes; Strain improvement for increased yield and other desirable characteristics, Microbial growth and death kinetics with respect to fermenters, optimization of bioprocesses, yield coefficient, doubling time, specific growth rate, metabolic and biomass productivities, effect of temperature, pH and salt concentration on product formation.

Unit 2 **9 Hrs**

Concepts of basic mode of fermentation processes: Bioreactor designs; Types of fermenters; Concepts of basic modes of fermentation - Batch, fed batch and continuous; Solid substrate, surface and submerged fermentation; Fermentation media; Design and types of culture/production vessels- Batch, Fed batch, CSTBR, airlift, packed bed and bubble column fermenter; Impeller, Baffles, Sparger.

Unit 3 **9 Hrs**

Upstream and downstream processing: Media formulation; Inoculum development and Sterilization; Aeration and agitation in bioprocess; Measurement and control of bioprocess parameters; Scale up and scale down process. Bioseparation techniques; Cell disruption methods; Liquid-liquid extraction; Purification by chromatographic techniques; Reverse osmosis and ultrafiltration, drying, crystallization, storage and packaging; Treatment of effluent and its disposal.

Unit 4 **9 Hrs**

Applications of enzymes in food processing: Mechanism of enzyme function and reactions in process techniques; Enzymatic bioconversions e.g., starch and sugar conversion processes and their downstream processing; baking by amylases, deoxygenation and desugaring by glucose oxidase, beer mashing and chill proofing; cheese making by proteases.

Unit 5 **9 Hrs**

Applications of Microbes in food process operations and production: Fermented foods and beverages; cheese and bread production, 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 colours and flavours, alcoholic beverages and other products; Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products, probiotics, prebiotics and symbiotics.

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Text & Reference Books

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition, Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991.

PROGRAM	M. Sc., Biotechnology				
Course Code **PABTE202**	Course Name: **Research Methods, Statistics & Scientific Communication Skills**	**L**	**T**	**P**	**C**
		3	0	0	3
Year and Semester	I Year (II Semester)	Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				
Course Category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**	
				✓	
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**	
Course Objective	• To introduce the students to the field of research • To understand the statistical methods for biological applications • To make familiarise with research articles and research writing				

Course Outcome	At the end of the course the student will be able to:	BTL
	1 Understand the basic principles of Biostatistics	K2
	2 Learn about the importance and role of a researcher	K2
	3 Evaluate, present and publish scientific articles	K2
	4 Know to apply statistics in research	K1
	5 Write research proposals and scientific writing using the proper ways	K3
	6 Apply for sample analysis, data processing and preparing a research article	K3

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Introduction and scope: Science, Scientific Field and Biological research. Role of a researcher in different stages of a project, Routes to research funding (academic and commercial). Research, Definition, Importance of research, Characteristics of research, Types and steps in research, Identification, Selection and formulation of research problem, Research questions, Research design – Formulation of Hypothesis, Review of Literature.

Unit 2 **9 Hrs**

Types of research articles: Type of Articles (review, letters etc). Scientific paper format (Abstract, Introduction, Materials and Methods, Results, Discussion). Writing (ethical Vs unethical), evaluating, presenting and publishing the results of scientific research in the academic press (journals, conferences etc). Choosing the appropriate journal (Sources, Information, Instructions to authors, peer review system, journal evaluation), Case studies of areas of current research. Formulating a research plan and its presentation.

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Unit 3	**9 Hrs**
Sampling methods: Sampling theory, types of sampling, Steps in sampling, Advantages and limitations of sampling. Collection of Data: Primary Data, Meaning, Data Collection methods, Secondary data, Meaning - Relevance's, Limitations and cautions. Statistics in Research.	
Unit 4	**9 Hrs**
Sampling methods: Probability Sampling and Non-Probability Sampling methods, Measure of central tendency and measure of dispersion, Random variables and Probability Distribution, Simple problems involving Binomial, Poisson and Normal variables. Formulation of Hypothesis (One-tailed & Two-tailed), Type I and Type II errors, power of a test, Significance of a test, P-value testing, Hypothesis Testing (students T-test, Z-test, Chi-square test), Regression and correlation analysis, Analysis of variance (ANOVA).	
Unit 5	**9 Hrs**
Scientific Communication skills: Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.	

Reference Books

1. Angellka Hofmann (2014). Scientific Writing and Communication. Oxford University Press
2. Daniel. W.W., Biostatistics: A foundation for analysis in the Health Sciences, Publisher: John
3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.
4. Kothari, C.R. 2019. Research Methodology Methods and Techniques New Age International Publishers
5. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
6. Washington, D.C.: On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). National Academies Press.
7. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.

Text Books, if any

1. Ronald Forthofer, Eun Lee, Mike Hernandez, 2006. Biostatistics: A Guide to Design, Analysis and Discovery, 2nd Edition, Publisher: Elsevier.
2. Zar., J.H., Biostatistical Analysis, 5th Edition, Prentice Hall
3. Santosh Gupta, 2022. Research Methodology Methods and Statistical Techniques, Deep & Deep Publications

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:		**L**	**T**	**P**	**C**
PABTE203	**Marine Environmental Biotechnology**		3	0	0	3
Year and Semester	I Year (II Semester)		Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course Category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
					✓	
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	

Course Objectives	• To understand the different aspects of the marine environment (physical, chemical and biological). • To understand their interaction with the marine organisms.	
Course Outcomes	At the end of the course the student will be able to:	BTL
	1 Outline the major and minor pollutants involved in for marine environment and its bioremediation. Acquire knowledge about threats, protection, conservation and management of marine resources for various applications.	K2
	2 List out the reason for marine disaster and to operate the disaster management.	K2
	3 Understand the impact of global warming and current status of global warming.	K2
	4 Extend the information about biological process affecting to the marine environment.	K1
	5 Explain the conservation of marine resources and management.	K3

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	6	Summarize about the pollution and impact of global warming and conserve the marine ecosystems.	K2

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Ecosystem introduction and Marine Pollution: Sea as a biological environment – ecological factors – light, temperature, salinity, pressure. Adaptations to pelagic, benthic, oceanic and coastal zones. Ecosystem structure and functions, abiotic and biotic component, Energy flow, food chain, food web, Ecological Pyramids-types, biogeochemical cycles, ecological succession, Ecads and ecotypes, Introduction to Marine pollution, Marine pollutants; Major and Minor, Sources of Marine Pollutants, Anthropogenic inputs for marine pollution, Assessment techniques for marine pollution, Bioremediation of marine pollution; Marine toxicology

Unit 2 **9 Hrs**

Coastal systems and Marine Disasters Management: Mangroves, sea weeds, sea grass, salt marshes, sand dunes, coral reefs - intertidal and interstitial zones. Deep sea adaptations - Fauna of hydrothermal vents, cold seeps, whale falls and other reducing habitats. Natural and manmade Marine disasters: Tsunami, volcano eruption, landslides, earthquakes, shipwrecks, oil spills, cyclones, etc; Disaster Management- principles, systems and operation; Role of Media in Disaster Management, Forecasting of marine disasters, environmental impact and risk assessment

Unit 3 **9 Hrs**

Impact of Global warming and climate change on Marine environment: Global processes impacting the Marine environment; Detecting Changes in the Oceans: Molecular biology and genetics techniques, New video technologies, New hydroacoustic tools; Sea level rise and sea surface temperature, Current status and research on Global warming-Carbon trading, Kyoto protocol, Ocean acidification

Unit 4 **9 Hrs**

Biological Processes affecting Marine environment: Marine fouling-Microfoulers and Macrofoulers, Biofilm formations, basic principles of antifouling, Marine corrosion, Eutrophication, Marine borers, – Biology, strategy, interactions, prevention and control; Marine Toxicology

Unit 5 **9 Hrs**

Marine Resources Management: Conservation and management of marine resources: in situ and ex situ. Marine biosphere reserves - Marine parks - heritage sites. Role of National and International agencies, Integrated Coastal zone Management

Text & Reference Books

1. Adam D. Nemeth, The Marine Environment: Ecology, Management and Conservation,
2. Peter Saenger, Managing marine environments by RA Kenchington: Book review, Southern Cross University
3. Sree Krishna.V., Bioethics and Biosafety in Biotechnology. New Age International (P) Limited Publishers 2007.

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:		**L**	**T**	**P**	**C**
PABTE204	**Algae Biotechnology**		3	0	0	3
Year and Semester	I Year (II Semester)		Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course Category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
					✓	
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	

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Course Objectives	• Impart the knowledge of different techniques employed in alage technology • Improve the understanding of applications and products derived from microalgae • Illustrate the characterization of algae using biochemical and molecular tools		
Course Outcomes	At the end of the course the student will be able to:		BTL
	1	Understand the importance of algae and their culture techniques	K2
	2	Summarize the value-added products of algae	K2
	3	Outline the application of algae in Industry and environment	K2
	4	Elaborate the cell characteristics of microalgae and Infer algal characterization using molecular tools	K1
	5	Investigate different products from algal sources through technological interventions	K3
	6	Apply the knowledge on genetic tools to explore the marine bioactive compounds	K2

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Introduction to Algal Biotechnology: Micro and Macro-algae Resources in India – Utilities of Algae. Biodiversity and Conservation of Algae - Potential and Challenges in Algal Biotechnology.

Unit 2 **9 Hrs**

Blue Technology: Taxonomy – systematics - physiology of micro and macro-algae. Micro and macroalgae - Cultivation Techniques: Laboratory, Mass and Field Cultivation- Photo bioreactor based production; Downstream processing - heterotrophic production.

Unit 3 **9 Hrs**

Genetics and Genetic Engineering: Developing Algae for Commercial Production - Genetic Engineering: Cyanobacteria, Green Algae, Diatoms - Engineering of Algae- Chloroplast. Metabolic Engineering: Cyanobacteria and Algae.

Unit 4 **9 Hrs**

Commercial Production of Algae: Overview of Algae Products – Algal Scale Up and Processing – Biomolecules from Micro and Macro Algae: Omega-3 Polyunsaturated Fatty Acids – Nutraceuticals – Pharmaceuticals – Biofertilizers. Bio-fuel - CO2 sequestration and pollution control. Industrial Applications – Value Added Products.

Unit 5 **9 Hrs**

Genomics and Metabolomics in Algal Biotechnology: Resources: Genomic – Transcriptomic – Proteomic – Metabolomics and Metabolic models. Mutant Resources for Microalgae – Microalgae: High Throughput Screening - Regulatory Approval for New Algae Food Products.

Reference Books

1. Barsanti L. & P. Gualtieri. Algae-Anatomy, Biochemistry and biotechnology, Taylor & Francis, 2006.
2. BECKER, E.W. 1994 Microalgae-Biotechnology and microbiology. Cambridge University Press.
3. Bryant D.A., Molecular Biology of Cyanobacteria, Kluwer Academic Publisher, 1995.
4. Chácon-Lee, T.L. & González-Mariño, G.E. 2010. Microalgae for "healthy" foods–possibilities and challenges. Comprehensive reviews in food science & food safety, 9.
5. Chandramohan, D. 2007. Prospects of Biodiesel from marine microorganisms. Proceedings of the National Workshop on BIODIESEL, Organised by School of Energy, Environment & Natural Resources, Madurai Kamaraj University, Madurai and Ahimsa Agri division, Chennai, 17th and 18th October, 2007. TRIVEDI, P.C. 2001 Algal Biotechnology. Pointer publishers, Jaipur, India.
6. Gouveia, L. 2011. Microalgae as a feedstock for biofuels. Springer Briefs in Microbiology, London.
7. Stevenson, R.J., ML Bothwell, R.L. Lowe (Eds), Algal Ecology- Fresh Water Benthic Ecosystems. Academic Press, 1996.
8. Varfolomeev, S. D. & Wasserman, L. A. 2011. Microalgae as a source of biofuel, food, fodder, and medicines. Applied Biochemistry and Microbiology, 49, 789-807.

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Date: _____	Date: _____

9. Venkata Raman G.S. 1972. Algal Biofertilizers and Rice cultivation. Today and Tomorrow printers and publishers, New Delhi;
10. Whittan, B.A. & M Potts, Ecology of Cyanobateria-Their diversity in time and space. Kluwer Academic Publishers.

Text Books if any

1. Barsanti, Laura and Paolo Gualtieri, 2005 Algae-Anatomy, Biochemistry and Biotechnology. Taylor & Francis, London, New York.
2. Fogg G.E. Stewart, W.D.P., Fay P., and Wals by A.E. 1973. The blue green algae. Academic Press. London
3. Richmond A. (Ed). Hand Book of Microalgal culture, Blackwell Publishing House, 2003

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTE301**	Course Name: **Molecular Technique and Diagnostics**		**L**	**T**	**P**	**C**
			3	0	0	3
Year and Semester	II Year (III Semester)		Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course Category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
					✓	
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	

Course Objectives	• To know the purification and quantification of different nucleic acids and proteins • To provide knowledge on various molecular techniques used in the field of diagnostics • To understand the theoretical aspects of various sequencing techniques	
Course Outcomes	At the end of the course the student will be able to:	BTL
	1 Perform molecular techniques including nucleic acid extraction, conventional and real-time polymerase chain reaction	K2
	2 Understand the concept of nucleic acid sequencing	K2
	3 Recognize and troubleshoot problems in routine molecular diagnostic techniques	K2
	4 Able to perform separation of biomolecules	K1
	5 Relate wet-lab and dry-lab works	K3
	6 Perform molecular techniques and advance the research activities in biomolecules	K2

POS/ COS	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

DNA Techniques: Isolation of genomic and plasmid DNA, purification and quantification of DNA, Agarose gel electrophoresis, Restriction digestion, Ligation, Modification, Methylation analysis, Mutagenesis, Labeling, Southern blotting and Oligonucleotides.

Unit 2 **9 Hrs**

RNA Techniques: Isolation, purification, quantification, different RNAs, cDNA synthsis, Northern blotting, Reverse blotting, Dot and Slot Blot, *In Vitro* Transcription, mRNA Stability Assay, RACE, Reverse Transcription (RT), RNA Electrophoresis, Small RNAs, microRNA, small nuclear RNA, RNA Interference (RNAi), RNA Splicing, RNase Protection Assay.

Unit 3 **9 Hrs**

Protein Techniques and Biomolecules separation: Basic concepts in Proteins, Basic concepts in Recombinant protein

expression studies, Expression vectors, Expression host strains, Different induction methods, Purification of recombinant proteins, Protein sequencing, Peptide sequencing, Western blotting, enzyme assays. Principles of biomolecules separation, Distillation, crystallization, solvent extraction, chromatography techniques, electrophoresis, filtration techniques, reverse osmosis.

Unit 4 **9 Hrs**

Molecular medicine Techniques: DNA/RNA/protein-based diagnostics, fluorescence in situ hybridisation (FISH). DNA techniques within diagnostics and forensic medicine are dealt with together with techniques for functional genome analysis, array technology for gene expression, comparative genomics, tissue expression and current methods for analysis of epigenetic regulatory mechanisms such as chromatin immunoprecipitation (ChIP).

Unit 5 **9 Hrs**

Molecular Phylogeny and its applications: Principles of molecular taxonomy, Principles and methods of DNA sequencing, sequence alignment techniques, construction and analysis of phylogenetic tree, PCR techniques, genetic fingerprinting, Pyrosequencing, DNA barcodings. IT enabled tools in molecular phylogeny. Integration of wet-lab and dry-lab works.

Reference Books

1. Barsanti, Laura and Paolo Gualtieri, 2005 Algae-Anatomy, Biochemistry and Biotechnology. Taylor & Francis, London, New York.
2. Biji T. Kurien (Editor), Western Blotting: Methods and Protocols: 1312 (Methods in Molecular Biology) by R. Hal Scofield (Editor)
3. Campbell, A.M. & Heyer, L.J. 2002 Discovering Genomics, Proteomics and Bioinformatics. Benjamin/Cummings.
4. Joseph Sambrook and David W. Russell. Molecular Cloning-A Laboratory Manual Vol1. 2001.
5. McPherson. M. J. & Moller S. G., PCR - The Basics (Garland Science, 2nd Edition). (2006). Taylor & Francis
6. Primrose. S.B., Twyman R.M. (2014) Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell Science Limited.
7. Sean R.Gallagher, SDS-Polyacrylamide Gel Electrophoresis (SDS-PAGE); Current protocols essential laboratory techniques.
8. Stuart M. Brown. Next-Generation DNA Sequencing Informatics, 2nd Edition. New York University School of Medicine.
9. Barsanti, Laura and Paolo Gualtieri, 2005 Algae-Anatomy, Biochemistry and Biotechnology. Taylor & Francis, London, New York.
10. Xinkun Wang. Next Generation Sequencing Data Analysis, CRC Press.
11. M. Green and J. Sambrook Molecular Biology: A laboratory Manual, 4th edition, 2012
12. Micheal Wink editor. An introduction to Molecular Biotechnology–Molecular fundamentals, methods and applications in Modern Biotechnology (2006)

Text Books, if any

1. Barsanti, Laura and Paolo Gualtieri, 2005 Algae-Anatomy, Biochemistry and Biotechnology. Taylor & Francis, London, New York.
2. Fogg G.E. Stewart, W.D.P., Fay P., and Wals by A.E. 1973. The blue green algae. Academic Press. London
3. Richmond A. (Ed). Hand Book of Microalgal culture, Blackwell Publishing House, 2003

PROGRAM	M. Sc., Biotechnology					
Course Code **PABTE302**	Course Name: **Stem Cell and Cancer Biology**		**L** 3	**T** 0	**P** 0	**C** 3
Year and Semester	II Year (III Semester)		Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course Category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**		**Professional Elective**	
					✓	
	Basic Science	**Engineering Science**	**Open Elective**		**Mandatory**	
Course Objectives	• To understand the unique properties of stem cells • To provide fundamental concepts of Cancer Biology • To get knowledge on different forms of cancer therapy					

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Course Outcomes	At the end of the course the student will be able to:		BTL
	1	Familiarize with basics of stem cells	K2
	2	Identify the cell culture protocols	K2
	3	Understand the therapeutic applications of stem cells.	K2
	4	Explains about the carcinogenesis and various cancer therapies.	K1
	5	Summarize the basics of stem cell & cancer biology & its recent advancement	K3
	6	Familiarize with the application of stems and cancer studies	K2

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Introduction to Stem cells: Introduction to stem cells and basis of stemness; Embryonic stem cells, embryonal carcinoma cells, embryonic germ cells, adult stem cells, hematopoietic stem cells, mesenchymal stem cells, cancer stem cells, induced pluripotent stem cells.

Unit 2 **9 Hrs**

Stem Cell isolation and Culture: Cell culture basics and protocols; Stem Cell Niches; Hematopoietic Stem Cells, Mesenchymal Stem Cells, Fetal Stem Cells, Isolation, characterization and maintenance of embryonic stem cell isolated from: Mouse and Human. Serum and feeder free culture of human embryonic stem cells, evolution of xeno-free culture systems.

Unit 3 **9 Hrs**

Therapeutic application of Stem cells: Gene therapy – genetically engineered stem cells – stem cells and Animal cloning – transgenic animals and stem cells – Biomarkers in Cancer – Therapeutic applications – Parkinson disease - Neurological disorder – limb amputation – heart disease - spinal cord injuries – diabetes – burns, Regenerative Therapy – Introduction; Applications of Regenerative Medicine.

Unit 4 **9 Hrs**

Fundamentals of cancer biology: Regulation of cell cycle, mutations that cause changes in signal molecules, effects on receptor, signal switches, tumour suppressor genes, modulation of cell cycle in cancer, different forms of cancers, diet and cancer. Cancer screening and early detection, Detection using biochemical assays, Tumor markers, molecular tools for early diagnosis of cancer. Cancer Epidemiology.

Unit 5 **9 Hrs**

Carcinogenesis and Cancer Therapy: Theory of carcinogenesis, Chemical carcinogenesis, metabolism of carcinogenesis, principles of physical carcinogenesis, x-ray radiation-mechanisms of radiation carcinogenesis. Different forms of therapy, chemotherapy, radiation therapy, detection of cancers, prediction of aggressiveness of cancer, advances in cancer detection. Use of signal targets towards therapy of cancer; Gene therapy.

Reference Books

1. Kristen Renwick Monroe; Ronald B. Miller; Jerome S. Tobis, Fundamentals of The Stem Cell Debate: The Scientific, Religious, Ethical, And Political Issues, 2008.
2. Lanza R. and I. Klimanskaya, Essential of Stem Cells Methods. Academic Press. 2009
3. Lanza, R., J. Gearhart et al (Eds), Essential of Stem Cell Biology. Elsevier Academic press. 2008.
4. Taner Demirer, Progress in Stem Cell Transplantation, Science, Technology and Medicine open access publisher. 2015.
5. Weinberg, Robert A. The Biology of Cancer. New York: Garland Science, 2007.

Text Books, if any

1. Anthony Atala, James A. Thomsson. 2007. Principles of Regenerative Medicine. Academic Press; 1 edition
2. Margaret Knowles and Peter Selby. Introduction to the Cellular and Molecular Biology of Cancer. Oxford University Publishers. 2005.

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PROGRAM	M. Sc., Biotechnology				
Course Code **PABTE303**	Course Name: **Enzyme Technology and Applications**	**L** 3	**T** 0	**P** 0	**C** 3
Year and Semester	II Year (III Semester)	Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background				

Course Category	Humanities and Social Sciences	Management courses	Professional Core	Professional Elective
				✓
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**

Course Objectives

- To understand the mechanism of biocatalyst
- To learn the kinetics of enzymatic reaction
- To learn about applications of enzymes

Course Outcomes

	At the end of the course the student will be able to:	BTL
1	Understand the properties of enzymes	K2
2	Understand molecular aspects of enzymes	K2
3	Apply enzymes in stereospecific reactions	K2
4	Evaluate application of enzymes	K1
5	Analyze commercial production of enzyme	K3
6	Analyses the applications of enzymes with reference to marine organisms	K2

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Introduction: Enzyme classification and nomenclature, General properties of enzymes like effect of pH, temp, ions etc.

Unit 2 **9 Hrs**

Extraction, assay and purification of enzymes. Steady state kinetics. Michaelis-Menden, Line weaver-Burke, Eadie-hofstee and Hanes-Woolf equations and Km value.

Unit 3 **9 Hrs**

Enzyme inhibitors, Pre-steady state kinetics. Fast kinetics to elucidate the intermediates and rate limiting steps (Flow and Relaxation methods). Enzyme specificity. Evidences for enzyme substrate complex. Nucleophilic and electrophilic attack. Role of metal ions in enzyme catalysis.

Unit 4 **9 Hrs**

Mechanism of enzyme action e.g., Lysozyme, chymotrypsin, DNA polymerases, RNase, Zymogens and enzyme activation. Allosteric interactions and product inhibition; complex kinetics and analyses, Membrane bound enzymes – Extraction, assay lipid protein interaction and effect of fluidity on enzyme activity.

Unit 5 **9 Hrs**

Coenzyme; Clinical and Industrial applications of enzymes. Immobilization of enzymes and their application. Ribozymes and their applications. Enzyme engineering.

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Reference Books

1. Chaplin M.F. and C. Bucke, Enzyme Technology, Cambridge University Press.
2. Copeland, R.A. Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis, John Wiley and Sons Inc.
3. James. E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill
4. Mathews, C.K., VanHolde, K.E. and Ahem, K.G. (2000) Biochemistry, 3rd Edition, Benjamin Cummings Publishing Co., Inc., U.K.
5. Segel, I.H. Enzyme Kinetics: Behaviour and Analysis of Rapid Equilibrium and Steady State Enzyme Systems, Wiley-Inter-science
6. Trevor Palmer, Enzymes Biochemistry, Biotechnology, Clinical Chemistry
7. Uhlig, H. Industrial Enzymes & their applications John Wiley and Sons Inc
8. Voet, D. and Voet, J.G. (2010) Biochemistry, 4th Edition, John Wiley and Sons, New York.
9. Wiseman, Enzyme Biotechnology, Ellis Horwood Pub.

Text Books if any

1. Palmer T. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, First East – West Press Edition, 2004
2. Berg, J., Tymoezko, J.L. and Stryer, L. (2008) Biochemistry, 6th Edition, W.H. Freeman Publishing Company, New York.
3. Nelson, D.L and Cox, M.M. (2008) Lehninger's Principles of Biochemistry, 5th Edition W.H. Freeman Publishers, New York.

PROGRAM	M. Sc., Biotechnology					
Course Code	Course Name:		**L**	**T**	**P**	**C**
PABTE304	**Biodegradation and Bioremediation Technology**		3	0	0	3
Year and Semester	II Year (III Semester)		Contact hours per week (3Hrs)			
Prerequisite course	Any Under Graduate Degree with Life Science background					
Course Category	**Humanities and Social Sciences**	**Management courses**	**Professional Core**	**Professional Elective**		
				✓		
	Basic Science	**Engineering Science**	**Open Elective**	**Mandatory**		
Course Objectives	• To acquire the knowledge of environmental problems and develop technologies • To develop skills in bioreactors and biotreatment methods of industrial wastewater and to find solution to create green and clean environment • To enable the degradation possibilities using biological methods.					
Course Outcomes	At the end of the course the student will be able to:					BTL
	1	Infer the biotechnological solutions to address environmental issues including pollution, mineral, renewable energy and water recycling				K2
	2	Appraise the opportunities for incorporating environmental quality into products, processes and projects.				K2
	3	Develop technologies for bioremediation and biodegradation and demonstrate the professional responsibility towards protecting the environment				K2
	4	Apply scientific solutions for the development of environmental sustainable products				K1
	5	Infer the bioremediation of heavy metal pollution and oil degrading microbes				K3
	6	Appraise the opportunities for incorporating environmental quality into products, processes and projects.				K2

POS/ COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	3	1	1	1	2	1	1
CO2	3	2	2	2	2	1	1	2	2	2	1
CO3	3	1	2	1	3	1	2	1	2	1	1
CO4	2	1	1	2	2	1	2	1	3	2	1
CO5	2	1	2	1	3	1	3	1	3	2	1
CO6	3	2	3	2	3	2	2	2	3	1	2
Average	2.67	1.50	2	1.67	2.67	1.17	1.83	1	2.50	2	1.25
CORRELATION LEVELS			1. SLIGHT (LOW)			**2.** MODERATE (MEDIUM)			**3.** SUBSTANTIAL (HIGH)		

Unit 1 **9 Hrs**

Introduction to Bioremediation: Clean up technologies to treat contaminated soil and water systems – Solid Waste disposal and Treatment Methods – Advantages and disadvantages of biological and non-biological bioremediations - Types of bioremediations; intrinsic and accelerated bioremediation; case studies - future prospects for bioremediation

Unit 2 **9 Hrs**

Bioremediation and Degradation: Microbes and Plants in Biodegradation and Biotransformation. Microbial metabolism and factors influencing microbial activity. In situ and Ex situ bioremediation - Mineralization vs. Partial Degradation – Factors influencing biodegradation process; Methods in biodegradability determination - Bioremediation of VOCs, diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and polyaromatic hydrocarbons. Xenobiotics; Persistence and biomagnification of xenobiotic molecules; Microbial interactions with xenobiotics; Bioremediation of plastic waste.

Unit 3 **9 Hrs**

Aerobic Bioremediation: Bioremediation of Surface Soils: Fate and transport of contaminants in the Vadose zone – Biodegradation in soil ecosystems – Types of soil treatment systems – Bioreactors. Subsurface Aerobic Bioremediation: In situ Bioremediation, Bioventing, treatment of Harbour Sediments and Lagoon treatment. Bioremediation in fresh water and marine systems. Anoxic/Anaerobic Bioremediation – Anoxic/Anaerobic Processes – Fermentation

Unit 4 **9 Hrs**

Bioremediation of Heavy metals and Oil Spill: Sources of heavy metals - Microbial Interactions of microbes with inorganic pollutants - Microbial metal resistance; Microbial transformation - Accumulation and concentration of metals; Biosorption – Oil Spills - Oil field microbiology - Improved oil recovery - Bioremediation in marine and estuarine systems: factors affecting bioremediation; need for introducing microbial cultures.

Unit 5 **9 Hrs**

Development of Bio products and Technologies: Bioleaching - Bio pesticide - Bio fertilizer - Biodegradable plastics - integrated bio-digester for biogas and electricity generation - biosensor for environmental monitoring - quorum sensing.

Reference Books

1. Andrea, L.; (2001). "Natural Attenuation of Environmental Contaminants". Battelle Press, University of Michigan,
2. Prasad, Ram, Aranda, Elisabet, 2018 (Eds.), Approaches in Bioremediation – (2018), Springer
3. Bernd B., 2001. Biodegradation and Persistence. Springer, University of Virginia.
4. Chakravarthy, A.M., 1928. Biodegradation and detoxification of Environmental pollutants, CRC Press
5. David S., 2010. Bioremediation Protocols. Humana Press.
6. Eve, Riser-Roberts.; (2010). "Remediation of Petroleum Contaminated Soils: Biological, Physical, and Chemical Processes". CRC Press, Lewis Publishers
7. Ghulam, R. C.; (2010). "Biological Degradation and Bioremediation of Toxic Chemicals, Timber Press
8. Jogdand S.N. Environmental Biotechnology 1995. 1st edition. Himalaya Publishing House. Bombay.
9. John. T. C.; (1995). "Bioremediation Engineering: Design and Application". McGraw-Hill
10. Lily, Y. Y.; (1995). "Microbial Transformation and Degradation of Toxic Organic Chemicals". Wiley-Liss, University of Michigan
11. Metcalf and Eddy, Wastewater Engineering – Treatment, Disposal and Reuse. Tata McGraw Hill, New Delhi
12. Raffi, F.; Yehuda F.; Shaul R.; (1999). "Novel Approaches for Bioremediation of Organic Pollution". Kluwer Acad., Plenum Publ.
13. Ronald, M. A.; (2005). "Bioremediation: Applied Microbial Solutions for Real-World Environmental Cleanup". ASM press, University of Michigan, ISBN: 1555812392, 9781555812393.
14. Shahnawaz, M.; Sangale, M. K.; Ade, A. B., 2019. "Bioremediation Technology for Plastic Waste"
15. Trivedi, P.C.; (2010). "Bioremediation of Wastes and Environmental Laws"

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16. Varjani, S. J. Agarwal, A. K., Gnansounou, E., Gurunathan, B. (Eds). 2018. “Bioremediation: Applications for Environmental Protection and Management”
17. Victor, M.; Glenn J.; Say, K. O.; Andrea, L.; 2001. “Bioremediation of Energetics, Phenolics, and Polycyclic Aromatic Hydrocarbons”. Battelle Press
18. William Chang (Editor), 2017. Biodegradation and Bioremediation. Syrawood Publishing House,

Text Books if any

1. Alan Scragg, Environmental Biotechnology. 2005. 2nd edition. Pearson Education Limited, England.
2. Edurado, D 2008. Microbial Biodegradation: Genomics and Molecular Biology, Spain
3. Katherine, H. B.; Diane, S. H., (1994). “Bioremediation”. McGraw-Hill,
4. Martin A.; (1999). “Biodegradation and Bioremediation”. 2nd Edition, Acad. Press,

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Model Question:

END SEMESTER EXAMINATIONS – Month xxxx

Programme & Batch: M. Sc. Biotechnology | Semester: III
Course Name: Biosafety, Bioethics and IPR | Course Code: PABTC302
Duration: 3 hours | Maximum Marks: 100 marks

Instructions:

1. Before attempting any question paper, be sure that you got the correct question paper.
2. The missing data, if any, may be assumed suitably.
3. Use the sketches wherever necessary.

Question No	Question	Mark	BTL	CO
	Part A (10×2 = 20 Marks) Answer all Questions			
1	What is the role of GEAC?	2	K1	CO1
2	What is LMO and GMO?	2	K1	CO1
3	List out the risk groups involved in biohazards	2	K1	CO2
4	What are the ethics in biotechnology?	2	K1	CO2
5	What is a copyright?	2	K1	CO3
6	What is a plant patent?	2	K1	CO3
7	What is GATT principle?	2	K1	CO4
8	What is GATT GATS and TRIPS?	2	K1	CO4
9	Name two basic criteria that determines the patentability of invention in India	2	K1	CO5
10	What is InPaSS?	2	K1	CO5
	Part B (1×10 = 10 Marks) Compulsory Question			
11	Explain about non patentable inventions in India	10	K3	CO6
	Part C (5×14 = 70 Marks) Answer All Questions			

12 (a)	Explain in detail about the biosafety guidelines followed in India	14	K2	CO1
	(OR)			
12 (b)	Categorize the assessing the biosafety risks based on pathogens and safety precautions	14	K4	CO1
13 (a)	Summarize about artificial intelligence (AI) also explain the types and benefits and risks of AI	14	K2	CO2
	(OR)			
13 (b)	Explain the ethical guidelines should be followed for GMO studies in detail	14	K2	CO2
14 (a)	Explain the role of NCBI & GenBank citations for researchers credibility	14	K2	CO3
	(OR)			
14 (b)	Explain the intellectual property rights with its various forms	14	K2	CO3
15 (a)	Summarize the recent development in patent system and patentability of biotechnology?	14	K2	CO4
	(OR)			
15 (b)	Explain the link between TRIPS WTO and WIPO in detail?	14	K2	CO4
16 (a)	Simplify the process of patent search and patent databases	14	K2	CO5
	(OR)			
16 (b)	Illustrate about the patent process in India	14	K2	CO5

Knowledge Level as per Bloom Taxonomy
K1- Remember; K2- Understand; K3- Apply; K4- Analyse; K5- Evaluate; K6- Create