DHANALAKSHMI SRINIVASAN COLLEGE OF ARTS & SCIENCE FOR WOMEN (AUTONOMOUS)

Affiliated to Bharathidasan University

(Nationally Re Accredited with A^{++} Grade by NAAC)

PERAMBALUR 621212.

M.Sc., MICROBIOLOGY SYLLABUS FOR THE ACADEMIC YEAR 2024 - 2025

DHANALAKSHMI SRINIVASAN COLLEGE OF ARTS & SCIENCE FORWOMEN

(AUTONOMOUS)

(Affiliated to Bharathidasan University, Tiruchirappalli)

(Nationally Re-Accredited with A^{++} Grade by NAAC)

PERAMBALUR-621 212

PG AND RESEARCH DEPARTMENTOF MICROBIOLOGY

M.Sc., MICROBIOLOGY SYLLABUS

2024-2025

Course Details Scheme of Exam

Sem	Course Code	Course Title	Hrs	Credit	CIA	SE	Final
I	24PMB1C1	Core Course-I General Microbiology and Microbial Diversity	6	5	25	75	100
	24PMB1C2	Core Course-II Immunology	5	5	25	75	100
	24PMB1C3	Core Course-III Microbial Genetics and Molecular Biology	5	4	25	75	100
	24PMB1C1P	CorePractical-I	6	4	40	60	100
	24PMB1E1A	Core EC-I Health and Hygine	5	3	25	75	100
	24PMB1E1B	Core EC-II Bioinstrumentation					
	24PMB1VAC	VAC-1 Herbal Technology and Cosmetic Microbiology	3	2	25	75	100
			30	23	-	-	600
II	24PMB2C4	Core Course- IV Medical Bacteriology and Mycology	5	5	25	75	100
	24PMB2C5	Core Course-V Medical Virology and Parasitology	5	5	25	75	100
	24PMB2C6	Core Course-VI Forensic Science	4	4	25	75	100
	24PMB2C7	Core Course-VII Diagnostic Microbiology	4	4	25	75	100
	24PMB2C2P	CorePractical-II	6	4	40	60	100
	24PMB2I1	Industrial Based Course-Bioremediation	3	3	25	75	100
	24PMB2N1A	NME-1	3	2	25	75	100

		Vermitechnology					
	24PMB2N1B	Microbial analysis of Air and Water					
	Self-Paced learning-Mooc	-	2*		Self-Paced learning-Mooc	-	2*
			30	27	-	-	700
III	24PMB3C8	Core Course-VIII Soil and Environmental Microbiology	6	5	25	75	100
	24PMB3C9	Core Course-IX Recombinant DNA Technology	6	5	25	75	100
	24PMB3C10	Core Course-X Fermentation Technology and Pharmaceutical Microbiology	6	5	25	75	100
	24PMB3C3P	CorePractical-III	6	4	40	60	100
	24PMB3N2A	NME-II Organic farming &Biofertilizer technology	3	2	25	75	100
	24PMB3N2B	NME-II Bioenergy					
	24P3SS	Soft Skill	3	2	25	75	100
	24P3IV	Internship/Field Study/ Industrial Visit		1			100
		Employability Skill-Mooc		2*			
			30	24	-	-	700
IV	24PMB4C11	Core Course-XI Food & Dairy Microbiology	6	5	25	75	100
	24PMB4E2A	Core EC-II Research methodology	4	3	25	75	100
	24PMB4E2B	Core EC-III-Marine Microbiology					
	24PMB4PW	Project Work	16	6	40	60	100
	24PMB4CE	Life sciences for Comprehensive Exam	4	2	25	75	100
			30	16	-	-	400
Total			120	90			2400
Extra Credit Course				90(4*)			2400

Programme Outcomes (Pos)

PO1: Problem Solving Skill

Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.

PO2: Decision Making Skill

Foster analytical and critical thinking abilities for data-based decision-making.

PO3: Ethical Value

Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities.

PO4: Communication Skill

Ability to develop communication, managerial and interpersonal skills.

PO5: Individual and Team Leadership Skill

Capability to lead themselves and the team to achieve organizational goals.

PO6: Employability Skill

Inculcate contemporary business practices to enhance employability skills in the competitive environment.

PO7: Entrepreneurial Skill

Equip with skills and competencies to become an entrepreneur.

PO8: Contribution to Society

Succeed in career endeavors and contribute significantly to society.

PO 9: Multicultural competence

Possess knowledge of the values and beliefs of multiple cultures and a global perspective.

PO 10: Moral and ethical awareness/reasoning

Ability to embrace moral/ethical values in conducting one's life.

Programme Specific Outcomes

PSO1 – Placement

To prepare the students who will demonstrate respectful engagement with others' ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.

PSO 2 - Entrepreneur

To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.

PSO3 – Research and Development

Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.

PSO4 – Contribution to Business World

To produce employable, ethical and innovative professionals to sustain in the dynamic business world.

PSO 5 – Contribution to the Society

To contribute to the development of the society by collaborating with stakeholders for mutual benefit.

CORECOURSE: I

GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY

Semester :I **MaxMarks:75**

Course Code : 24PMB1C1 **Credit : 5**

Total Period : 75 **Exam Hrs : 3**

Course Objectives

Acquire knowledge on the principles of different types of microscopes and their applications.

Compare and contrast the structure of bacteria and fungi. Illustrate nutritional requirements and growth in bacteria.

Exemplify, isolate and cultivate microalgae from diverse environmental sources.

Explain various pure culture techniques and discuss sterilization methods.

Discuss the importance and conservation of microbial diversity.

UNIT-I History and Scope of Microbiology (15Periods)

History and Recent developments in Microbiology, Spontaneous generation vs. Biogenesis.Microscopy – Principles and applications. Types of Microscopes - Bright field, Dark-field, Phase-contrast, Fluorescence microscope, Transmission electron microscope (TEM) and Scanning electron microscope (SEM). Atomic force microscope.

UNIT -II Bacterial Structure (15Periods)

Bacterial Structure, properties and biosynthesis of cellular components – Cell wall. Actinomycetes and Fungi - Distribution, morphology, classification, reproduction and economic importance. Sporulation. Growth and nutrition - Nutritional requirements, Growth curve, Kinetics of growth, Batch culture, Synchronous growth, Measurement of growth and factors affecting growth.

UNIT III Algae (15 Periods)

Algae - Distribution, morphology, classification, reproduction and economic importance. Isolation of algae from soil and water. Media and methods used for culturing algae, Strain selection and large-scale cultivation. Life cycle - *Chlamydomonas, Volvox Spirogyra* (Green algae), *Nostoc* (Cyanobacteria) *Ectocarpus, Sargassum* (Brown algae), *Polysiphonia*, *Batrachospermum* (Red algae).

UNIT IV Microbial techniques (15Periods)

Microbial techniques - Safety guidelines in Microbiology Laboratories. Sterilization, Disinfection and its validation. Staining methods – Simple, Differential and Special staining. Automated Microbial identification systems - Pure cultures techniques – Cultivation of Anaerobic organisms. Maintenance and preservation of pure cultures. Culture collection centres - National and

International.

UNIT V Microbial biodiversity (15Period)

Introduction to microbial biodiversity – Thermophiles - Classification, Thermophilic Archaebacteria and its applications. Methanogens - Classification, Habitats, applications. Alkalophiles and Acidophiles - Classification, discovery basin, its cell wall and membrane. Barophiles - Classification and its applications. Halophiles - Classification, discovery basin, cell walls and membranes – purple membrane, compatible solutes, Osmoadaptation / halotolerance - Applications of halophiles. Conservation of Biodiversity.

REFERENCES

Text Books

1. Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd.
2. Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5th Edition). Mc.Graw Hill. Inc, New York.
3. Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6th Edition). McGraw - Hill company, New York.
4. White D. Drummond J. and Fuqua C. (2011). The Physiology and Biochemistry of Prokaryotes, Oxford University Press, Oxford, New York.
5. Dubey R.C. and Maheshwari D. K. (2009). Textbook of Microbiology. S. Chand, Limited.

Book Reference

6. Tortora G. J., Funke B. R. and Case C. L. (2015). Microbiology: An Introduction (12th Edition).Pearson, London, United Kingdom
7. Webster J. and Weber R.W.S. (2007). Introduction to Fungi. (3rd Edition). Cambridge University Press, Cambridge.
8. Schaechter M. and Leaderberg J. (2004). The Desk encyclopedia of Microbiology. Elseiver Academic Press, California.
9. Ingraham, J.L. and Ingraham, C.A. (2000) Introduction to Microbiology. (2nd Edition). Books / Cole Thomson Learning, UK.
10. Madigan M. T., Bender K.S., Buckley D. H. Sattley W. M. and Stahl (2018) Brock Biology of Microorganisms. (15th Edition). Pearson.

Web Resource

http://sciencenetlinks.com/tools/microbeworld

https://www.microbes.info/

https://www.asmscience.org/VisualLibrary

https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=404

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Examine various microbes employing the microscopic techniques learnt. Measure and compare the size of microbes.	PO1, PO4, PO11
CO2	Differentiate and appreciate the anatomy of various microbes. Plan the growth of microbes for different environmental conditions.	PO1, PO4
CO3	Identify and cultivate the algae understanding their habitat. Analyze the morphology, classify and propagate depending on its economic importance.	PO7, PO8, PO9
CO4	Create aseptic conditions by following good laboratory practices.	PO3, PO4,PO7
CO5	Categorize and cultivate a variety of extremophiles following standard protocols for industrial applications.	PO5, PO7, PO8, PO9

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M			M							S			
CO2	L			S										
CO3							S	S	M					
CO4			S	S			S							
CO5					S		S	S	S					

CORECOURSE: II

IMMUNOLOGY

Semester :I **MaxMarks:75**

Course Code : 24PMB1C2 **Credit : 5**

Total Period : 75 **Exam Hrs : 3**

Course Objectives

Describe immunoglobulin and its types. Categorize Antibodies and understand its significance

Elucidate the mechanisms of different hypersensitivity reactions. List out the Vaccines and discuss their development.

Acquire knowledge about the Diagnosis methods

Explain out Immune regulation mechanisms

UNIT-I Cells and organs of Immune System (15Periods)

Cells and organs of Immune System- T and B lymphocytes – Origin, development, differentiation in humans. Innate immunity- Complement, Toll-like receptors and other components. Acquired immunity – Active and Passive immunity. Antigens - features associated with antigenicity and immunogenicity. Basis of antigen specificity. Major Histocompatibility Complex–Organization of MHC, Structure and Functions of MHC I & II molecules .

UNIT -II Antibodies (15Periods)

Antibodies- Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); Monoclonal and polyclonal antibodies. , Antigen processing and presentation, Complement System–Components of the Complement system; Activation pathways–Classical, Alternative and Lectin pathway, Biological consequences of complement Activation. Antigen recognition – TCR, Diversity of TCR, T cell surface alloantigens, lymphocyte activation, clonal proliferation and differentiation.

UNIT III Hypersensitivity (15 Periods)

Hypersensitivity – Types and mechanisms, Autoimmunity, Tumor Immunity and Transplantation immunology. Immunodeficiency-Primary immunodeficiency and Secondary immunodeficiencies. Genetics of Immunohematology – Genetic basis and significance of ABO and other minor blood groups in humans, Bombay blood group, Secretors and Non-secretors, Rh System and genetic basis of D- antigens.

UNIT IV Diagnostic Immunology (15Periods)

Diagnostic Immunology - Precipitation reaction, Immunodiffusion methods - SRID, ODD. Immunoelectrophoresis - Rocket and Counter current electrophoresis. Agglutination - Hemagglutination - Hemagglutination inhibition. Labelled Assay- Immunofluorescence assay, Radio immunoassay, FISH, ELISA. Flow cytometry, Immunoelectron microscopy

UNIT V Immune regulation (15Period)

Immune regulation mechanisms – immuno-induction, immuno- suppression, immuno-tolerance, immuno-potentiation, Immunomodulation. Role of cytokines, lymphokines and chemokines. Introduction to Vaccines and Adjuvants - Types of vaccines. Development of vaccines and antibodies in plants. Immunomics - Introduction and Applications. Antigen engineering for better immunogenicity and use for vaccine development-multiepitope vaccines. Reverse vaccinology.

REFERENCES

Text Books

1. Coico R., Sunshine G. and Benjamini E. (2003). Immunology – A Short Course. (5th Edition). Wiley-Blackwell, New York.

2. Owen J. A., Punt J., Stranford S. A. and Kuby J. (2013). Immunology, (7th Edition). W. H. Freeman and Company, New York.

3. Abbas A. K., Lichtman A. H. and Pillai S. (2021). Cellular and Molecular Immunology. (10th Edition). Elsevier.

4. David F. Keren ., Jeffrey S. Warren Diagnostic Immunology , Lippincott Williams and Wilkins Publishers,USA

5. Delves, P. J., Martin, S. J., Burton, D. R., & Roitt, I. M. (2017). Roitt's essential immunology. John Wiley & Sons.

Book Reference

6. Travers J. (1997). Immunobiology - The Immune System in Health and Disease. (3rd Edition). Current Biology Ltd. New York.

7. Delves P.J., Martin S., Burton D. R. and Roitt I. M. (2006). Roitt's Essential Immunology. (11th Edition). Wiley-Blackwell

8. Hay F. C. and Westwood O. M. R. (2002). Practical Immunology (4th Edition). Wiley-Blackwell.

9. Kenneth Murphy., Casey Weaver and Leslie Berg (2022). Janeway's Immunobiology, (10TH Edition). W W Norton & Co Inc.

10. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2007). Kuby immunology. Macmillan.

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Categorize the immune response to a variety of antigens. Identify different immune cells involved in immunity.	PO1, PO4, PO6, PO7, PO9
CO2	Justify the significance of MHC molecules in immune response and antibody production.	PO1, PO4, PO5,PO6,

		PO9
CO3	Design antibodies and evaluate immunological assays in patient samples.	PO4, PO6, PO7, PO8, PO9, PO10
CO4	Know the diagnostic methods in Immunology	PO, PO, PO, PO, PO
CO5	Explain the immune regulation mechanisms	PO, PO, PO, PO, PO

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S			M		M	S		S					
CO2	S			S	M	S			S					
CO3				S		S	S	S	S	M				
CO4				S	M	S	M		S	M				
CO5				S	M	S	M		S	S				

CORECOURSE: III

MICROBIAL GENETICS AND MOLECULAR BIOLOGY

Semester :I **MaxMarks:75**

Course Code : 24PMB1C3 **Credit : 4**

Total Period : 75 **Exam Hrs : 3**

Course Objectives

Acquire knowledge the structure DNA in prokaryotes and eukaryotes

Explain out DNA replication.

Acquire knowledge about Transcription.

Acquire knowledge about Translation.

Explain the gene transfer mechanisms.

UNIT-I Nucleic acids (15Periods)

Nucleic acid as the genetic material (Griffith's experiment, Avery, MacLeod and McCarty's experiment, Hershey-Chase experiment), Importance of Molecular Biology, Central Dogma of Molecular Biology, Model organisms for studying Molecular Biology. Structure and functions of Nucleic acids: Nucleosides & Nucleotides, purines and pyrimidines. Biologically important nucleotides, Watson and Crick model of DNA structure, A, B & Z forms of DNA, Supercoiled and relaxed DNA

UNIT -II DNA Replication (15Periods)

DNA replication: Molecular mechanisms of DNA replication: Enzymes of replication – DNA polymerases, Helicases, Binding proteins, Nucleases, Topoisomerases, and DNA Ligases, DNA replication models – conservative, semi-conservative and dispersive, Prokaryotic and Eukaryotic replication mechanisms.

UNIT III Transcription

(15 Periods)

Transcription – initiation, elongation and termination, Prokaryotic and eukaryotic RNA polymerases; Transcriptional regulation–promoters, enhancers, Transcription factors; post-transcriptional modifications – mRNA, tRNA and rRNA processing; RNA interference – siRNA, miRNA and shRNA.

UNIT IV Translation (15Periods)

Universal genetic code, codon degeneracy, wobble hypothesis; Mechanism of Translation – initiation, elongation, and termination; post-translational modifications.

UNIT V Gene Transfer Mechanisms (15Period)

Gene Transfer Mechanisms- Conjugation and its uses. Transduction, Generalized and Specialized,

Transformation– Natural Competence and Transformation. Transposition and Types of Transposition reactions. Insertion sequences, complex and compound transposons – T10, T5, and Retroposon. Mechanism – Transposons of E. coli, Bacteriophage and Yeast.

REFERENCES

Text Books

1. Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.

2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman

3. Larry, Snyder and Wendy. 1997. Molecular Genetics of Bacteria. ASM Publications.US.

Dale,J.W. 1994. Molecular Genetics of Bacteria. John Wiley and Sons.

Book Reference

4. Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press.

5. Watson, J. D. (2008). Molecular Biology of the Gene (5th Ed.) Menlo Park, CA:

6. Benjamin/Cumming

David Freifelder .S, 1987.Microbial Genetics, Jones&Bartlett, Boston.

7. Snyder, L. and Wendy, W. Molecular Genetics of Bacteria, 2/e, ASM press, Washington

8. Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition.

Web resources

https://www.molbiotools.com/usefullinks.html

https://geneticeducation.co.in/what-is-transcriptomics
https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/
https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Analyze genomic DNA of prokaryotes and eukaryotes. Understand the DNA and RNA as genetic material	PO4,PO5, PO6, PO7, PO9, PO10
CO2	Outline the Replication	
CO3	Understand the Gene Regulation- RNA and protein synthesis and processing	PO1, PO5, PO7, PO8, PO9
CO4	Understand the Gene Regulation- RNA and protein synthesis and processing	PO1, PO6, PO7, PO8, PO9
CO5	Summarize gene transfer mechanisms for experimental study.	PO4,PO5, PO6, PO7,

		PO9, PO10

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L					S	M	M	S					
CO2	M					S	M	M	S					
CO3	L				S		S	M	S					
CO4	M					S	S	M	S					
CO5	M					S	S	M	S					

COREP PRACTICAL: I

PRACTICAL I: GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY, IMMUNOLOGY, MICROBIAL GENETICS AND MOLECULAR BIOLOGY

Semester :I **MaxMarks:60**

Course Code : 24PMB1C1P **Credit : 4**

Total Period : 60 **Exam Hrs : 3**

Course Objectives

Gain knowledge on the fundamentals, handling and applications of microscopy, sterilization methods. Identify microbes by different staining methods.

Prepare media for bacterial growth. Discuss plating and growth measurement techniques.

Acquire adequate skills to perform blood grouping and serological reactions

Provide fundamental skills in preparation, separation and purification of immunoglobulin

Apply the knowledge of molecular biology skills in clinical diagnosis.

GENERAL MICROBIOLOGY AND MICROBIAL DIVERSITY (20Periods)

1. Washing and cleaning of glass wares:
2. Sterilization methods: moist heat, dry heat, and filtration.
3. Media Preparation: Preparation of liquid, Solid Semisolid media- Agar deeps, slants, plates. Preparation of basal, enriched, selective and enrichment media.
4. Staining techniques - Simple staining, Gram's staining Acid fast staining, Spore staining, Lactophenol cotton blue staining, Motility-hanging drop method.

IMMUNOLOGY (20Periods)

5. Agglutination test-ABO blood grouping, Rh Typing Agglutination test -WIDAL test, CRP and ASO
6. Double Immuno diffusion
7. Radial Immuno diffusion
8. Immuno electrophoresis
9. Total count of RBC
10. Total count of WBC
11. Demonstration of ELISA

MICROBIAL GENETICS AND MOLECULAR BIOLOGY (20Periods)

12. Isolation of Plasmid DNA from *E.coli*

13. Isolation of genomic DNA from *E. coli* and analysis by Agarose gel electrophoresis

14. Separation of proteins by polyacrylamide gel electrophoresis (SDS-PAGE)

15. Restriction digestion.

REFERENCES

1. Bamji M. S., Krishnaswamy K. and Brahmam G. N. V. (2019). Textbook of Human Nutrition. (4th Edition). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi

2. Swaminathan (1995) Food& Nutrition (Vol I) (2nd Edition). The Bangalore Printing &Publishing Co Ltd., Bangalore

3. Paniker J. C. K. and Ananthanarayan R. (2017). Textbook of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd

4. Khader V. (2000) Food, Nutrition and Health, Kalyan Publishers, New Delhi.

5. Srilakshmi, B. (2010) Food Science, (5th Edition) New Age International Ltd., New Delhi.

Web Resources

https://nap.nationalacademies.org/read/11756/chapter/13

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Identify factors affecting health and health habits.	PO1, PO5, PO10
CO2	Execute the knowledge of ventilation and lighting. Justify Health laws for food safety and hygiene.	PO5, PO10
CO3	Follow personal hygiene to avoid diseases and Prevent people from health-destroying habits and addictions.	PO5, PO10
CO4	Explore Mental hygiene and maintain emotional stability.	PO5, PO10
CO5	Participate in health education programmes	PO1, PO5, PO10

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L				S					M				
CO2					S					M				
CO3					S					L				
CO4					S					M				
CO5	L				S					M				

NON MAJOR ELECTIVE : I

HEALTH AND HYGIENE

Semester :I **MaxMarks:75**

Course Code : 24PMB1E1A **Credit : 3**

Total Period : 24 **Exam Hrs : 3**

Course Objectives

Acquire knowledge on hygiene and live healthy.

Provide insights on health laws for food safety and hygiene.

Explain health, physical exercises and their importance

Describe the various health and health education programmes by the government.

UNIT-I **(4Periods)**

Introduction to hygiene and healthful live. Factors affecting health, health habits and practices. Recognizing positive & negative practices in the community. Scientific principles related to health.

UNIT -II **(5Periods)**

Nutrition and Health – Balanced diet, Food surveillance, food Fortification, adulteration and preventive measures. Health laws for food safety. Environmental and housing hygiene. Ventilation and lighting.

UNIT III **(5 Periods)**

Physical health, physical exercises and their importance – Walking, jogging, yoga and meditation, stress relief. International control of health, WHO. Personal hygiene, Sun bathing, Colon Hygiene. Health destroying habits and addictions - Pan, supari, ganja, drinking, smoking, tea and coffee.

UNIT IV **(5Periods)**

. Mental hygiene - factors responsible, developmental tasks, basic needs, emotional stability. Mental hygiene and health in infancy, early childhood, adolescence, adulthood and old age. Mental health occupational hazards.

UNIT V **(5Period)**

Health programme and health education – Malaria control, Tuberculosis control, AIDS control programmes and Immunization Programmes. Family planning, Reproductive and Child health programmes (RCH).

REFERENCES

1. Bamji M. S., Krishnaswamy K. and Brahmam G. N. V. (2019). Textbook of Human Nutrition.

(4th Edition). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi

2. Swaminathan (1995) Food& Nutrition (Vol I) (2nd Edition). The Bangalore Printing &Publishing Co Ltd., Bangalore.

3. Paniker J. C. K. and Ananthanarayan R. (2017). Textbook of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd

4. Khader V. (2000) Food, Nutrition and Health, Kalyan Publishers, New Delhi.

5. Srilakshmi, B. (2010) Food Science, (5th Edition) New Age International Ltd., New Delhi.

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Identify factors affecting health and health habits.	PO1, PO5, PO10
CO2	Execute the knowledge of ventilation and lighting. Justify Health laws for food safety and hygiene.	PO5, PO10
CO3	Follow personal hygiene to avoid diseases and Prevent people from health-destroying habits and addictions.	PO5, PO10
CO4	Explore Mental hygiene and maintain emotional stability.	PO5, PO10
CO5	Participate in health education programmes	PO1, PO5, PO10

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L				S					M				
CO2					S					M				
CO3					S					L				
CO4					S					M				
CO5	L				S					M				

NON MAJOR ELECTIVE : II

BIOINSTRUMENTATION

Semester :I **MaxMarks:75**

Course Code : 24PMB1E1B **Credit : 3**

Total Period : 24 **Exam Hrs : 3**

Course Objectives

Explain the principles and working mechanisms of laboratory instruments

Discuss chromatography techniques and molecular biology techniques

Illustrate molecular techniques in biological applications

Acquire knowledge on spectroscopic techniques

Demonstrate the use of radio isotopes in various techniques.

UNIT-I **(4Periods)**

Basic laboratory Instruments. Aerobic and anaerobic incubator – Biosafety Cabinets - Fume Hood, pH meter, Lyophilizer, Flow cytometry. Centrifugation techniques: Basic principles of centrifugation - Standard sedimentation coefficient - measurement of sedimentation co-efficient; Principles, methodology and applications of differential, rate zonal and density gradient centrifugation - Applications in determination of molecular weight.

UNIT -II **(5Periods)**

General principles of chromatography - Chromatographic Performance parameters; Types- Thin layer chromatography, Paper Chromatography, Liquid chromatography (HPLC), Adsorption, ion exchange, Gel filtration, affinity, Gas liquid (GLC). Two dimensional chromatography.

UNIT III **(5 Periods)**

Electrophoresis: General principles– types (horizontal, vertical and two dimensional electrophoresis) - Principle and applications - paper electrophoresis, Serum electrophoresis, starch gel electrophoresis, Disc gel, Agarose gel, SDS – PAGE, Immuno electrophoresis. Blotting techniques -Southern, northern and western blotting.

UNIT IV **(5Periods)**

Spectroscopic techniques: Principle, instrumentation and application of UV- visible, FTIR spectrophotometer, spectrofluorimetry, Atomic Absorption Spectrophotometer, Flame spectrophotometer, NMR, ESR, Emission Flame Photometry and GC-MS. Detection of molecules in living cells - FISH and GISH.

UNIT V **(5Period)**

Radioisotopic techniques: Principle and applications of tracer techniques in biology. Radioactive isotopes - radioactive decay; Detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger- Muller and Scintillation counters, auto radiography and its applications. Commonly used isotopes in biology, labeling procedures and safety aspects.

REFERENCES

Text Books

1. Sharma B. K. (2014). Instrumental Method of Chemical Analysis. Krishna Prakashan Media (P) Ltd.
2. Chatwal G. R and Anand S. K. (2014.) Instrumental Methods of Chemical Analysis. Himalaya Publishing House.
3. Mitchell G. H. (2017). Gel Electrophoresis: Types, Applications and Research. Nova Science Publishers Inc.
4. Holme D. Peck H. (1998). Analytical Biochemistry. (3rd Edition). Prentice Hall.
5. Jayaraman J. (2011). Laboratory Manual in Biochemistry. (2ndEdition). Wiley Eastrn Ltd., New Delhi.

Pavia D. L. (2012) Spectroscopy (4th Edition). Cengage

6. Skoog A. and West M. (2014). Principles of Instrumental Analysis. (14th Edition). W.B.Saunders Co., Philadephia.
7. Miller J. M. (2007). Chromatography: Concepts and Contrasts (2nd Edition) Wiley-Blackwell.
8. Gurumani N. (2006). Research Methodology for Biological Sciences. (1st Edition) MJP Publishers.
9. Ponmurugan P. and Gangathara P. B. (2012). Biotechniques. (1st Edition). MJP Publishers.

Web Resources

http://www.biologydiscussion.com/biochemistry/centrifugation/centrifuge- introduction-types-uses-and-other-details-with-diagram/12489

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Make use of the laboratory instruments- laminar air flow, pH meter, centrifugation methods, biosafety cabinets following SOP.	PO4, PO6, PO7, PO8, P11
CO2	Apply chromatography techniques in the separation of biomolecules.	PO4, PO6, PO7, PO8, P11
CO3	Perform molecular techniques like mutagenesis and their detection.	PO4, PO6, PO7, PO8, P11

CO4	Estimate molecules in biological samples by adopting UV spectroscopic techniques.	PO4, PO6, PO7, PO8, P11
CO5	Cultivate organisms anaerobically.	PO4, PO6, PO7, PO8, P11

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1				S		M	M	S			S			
CO2				S		M	M	S			S			
CO3				S		S	S	S			S			
CO4				S		M	S	S			S			
CO5				S		M	S	S			L			

VALUE ADDED COURSE-I

HERBAL TECHNOLOGY AND COSMETIC MICROBIOLOGY

Semester :I **MaxMarks:75**

Course Code : 24PMB1VAC **Credit : 2**

Total Period : 24 **Exam Hrs : 3**

Course Objectives

Impart knowledge of Indian Medicinal Plants and their applications in microbiology.

Promote the technical skills involved in preparation of different types of plant extracts.

Explain methods to analyze the antimicrobial activity of medicinal plants.

Acquire knowledge on cosmetic microbiology and role of microorganisms in cosmetics.

Gain insight into pharmacopeial microbial assays and biosafety

UNIT-I **(4Periods)**

Herbs, Herbal medicine - Indian medicinal plants: Scope and Applications of Indian medicinal plants in treating bacterial, fungal and viral diseases. Basic principles involved in Ayurvedha, Sidha, Unani and Homeopathy.

UNIT -II **(5Periods)**

Collection and authentication of selected Indian medicinal plants: *Emblica officinalis, Withania somnifera, Phyllanthus amarus, Tinospora cordifolia, Andrographis paniculata, Piper longum, Ocimum sanctum, Azardirchata indica, Terminalia chebula, Allium sativum*. Preparation of extracts- Hot and cold methods. Preparation of stock solutions.

UNIT III **(5 Periods)**

Antimicrobial activity of selected Indian medicinal Plants: - In vitro determination of antibacterial and fungal activity of selected whole medicinal plants/ parts – well-diffusion methods. MIC - Macro and micro dilution techniques. Antiviral activity- cell lines- cytotoxicity, cytopathic and non-cytopathic effect.

UNIT IV **(5Periods)**

History of Cosmetic Microbiology – Need for cosmetic microbiology, Scope of cosmetic microbiology, - Role of microbes in cosmetic preparation. Preservation of cosmetics. Antimicrobial properties of natural cosmetic products – Garlic, neem, turmeric, aloe vera and tulsi. Sanitary practices in cosmetic manufacturing - HACCP protocols in cosmetic microbiology.

UNIT V **(5Period)**

Cosmetic microbiology test methods - Antimicrobial preservative efficacy, microbial content testing and biological toxicological testing. Validation methods - bioburden and Pharmacopeial

microbial assays. Preservatives of cosmetics - Global regulatory and toxicological aspect of cosmetic preservatives.

REFERENCES

Text Books

1. Ayurvedic Formulary of India. (2011). Part 1, 2 & 3. Pharmacopoeia Commission for Indian Medicine and Homeopathy. ISBN-10:8190648977.
2. Panda H. (2004). Handbook on herbal medicines. Asia Pacific Business Press Inc. ISBN:8178330911.
3. Mehra P. S. (2019). A Textbook of Pharmaceutical Microbiology. Dreamtech Press. ISBN 13:9789389307344.
4. Geis P. A. (2020). Cosmetic microbiology: A Practical Approach. (3rd Edition). CRC Press. ISBN:9780429113697
5. Brannan D. K. (1997). Cosmetic microbiology: A Practical Handbook. CRC Press.ISBN-10:0849337135.

Book Reference

1. Indian Herbal Pharmacopoeia (2002). Vol. I &II Indian Drug Manufacturers Association, Mumbai.
2. British Herbal Pharmacopoeia.(1990).Vol.I. British Herbal Medicine Association.ISBN: 0903032090.
3. Verpoorte R. and Mukherjee, P. K. (2010). GMP for Botanicals: Regulatory and Quality issues on Phytomedicines. In GMP for botanicals: regulatory and quality issues on phytomedicines. (2nd edition). Saujanya Books, Delhi.ISBN-10:81-900788-5-2/8190078852. ISBN-13:978-81-900788-5-6/9788190078856.
4. Turner R. (2013). Screening methods in Pharmacology. Elsevier. ISBN:9781483264233.
5. Cupp M. J. (2010). Toxicology and Clinical Pharmacology of Herbal Products (pp. 85-93). M. J. Cupp. Humana Press.Totowa, NJ, USA. ISBN-10:1617371904.

Web Resources

https://www.academia.edu/50236711/Modern_Extraction_Methods_for_Preparation_of_Bioactive_Plant_Extracts
https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl
https://pubmed.ncbi.nlm.nih.gov/17004305/
https://www.fda.gov/cosmetics/potential-contaminants-cosmetics/microbiological-safety-and-cosmetics
https://pubmed.ncbi.nlm.nih.gov/15156038/

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;

CO1	Identify the applications of Indian medicinal plants in treating diseases.	PO1, PO5
CO2	Identify and authenticate herbal plants.	PO6, PO7
CO3	Evaluate the antimicrobial activity of medicinal plants.	PO4, PO6, PO9
CO4	Describe the role of microorganisms and their metabolites in the preparation of cosmetics.	PO1, PO5, PO7
CO5	Validate procedures and biosafety measures in the mass production of cosmetics.	PO6, PO7

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M				S									
CO2						S	M							
CO3				S		S			M					
CO4	M				S		S							
CO5						M	S							

CORECOURSE: IV

MEDICAL BACTERIOLOGY AND MYCOLOGY

Semester :II **MaxMarks:75**

Course Code : 24PMB2C4 **Credit : 5**

Total Period : 75 **Exam Hrs : 3**

Course Objectives

Acquire Knowledge on collection, transportation and processing of various kinds of clinical specimens

Explain morphology, characteristics and pathogenesis of bacteria.

Discuss various factors leading to pathogenesis of bacteria

Acquire knowledge on antifungal agents and their importance.

Describe various diagnostic methods available for fungal disease diagnosis.

UNIT-I **(15Periods)**

Classification of medically important bacteria, Normal flora of human body, Collection, transport, storage and processing of clinical specimens, Microbiological examination of clinical specimens, antimicrobial susceptibility testing. Handling and maintenance of laboratory animals – Rabbits, guinea pigs and mice.

UNIT -II **(15Periods)**

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by species of *Staphylococci, Streptococci, Pneumococci, Neisseriae*., *Bacillus, Corynebacteria, Mycobacteria* and *Clostridium.*

UNIT III **(15 Periods)**

Morphology, classification, characteristics, pathogenesis, laboratory diagnosis and treatment of diseases caused by Enterobacteriaceae members, *Pseudomonas, Vibrio, Mycoplasma, Helicobacter, Rickettsiae, Chlamydiae, Bordetella, Spirochaetes- Leptospira*, and *Treponema* . Nosocomial, zoonotic and opportunistic infections -prevention and control.

UNIT IV **(15Periods)**

Morphology, taxonomy and classification of fungi. Detection and recovery of fungi from clinical specimens. Dermatophytes and agents of superficial mycoses. *Trichophyton, Epidermophyton & Microsporum*. Yeasts of medical importance – *Candida, Cryptococcus*. Mycotoxins. Antifungal agents, testing methods and quality control.

UNIT V **(15Period)**

Dimorphic fungi causing Systemic mycoses, *Histoplasma, Coccidioides, Sporothrix, Blastomyces.* Fungi causing Eumycotic Mycetoma, Opportunistic fungi- Fungi causing secondary infections in immunocompromised patients. Immunodiagnostic methods in mycology- Recent advancements in diagnosis. Antifungal agents.

REFERENCES

Text Books

1. Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (2017).Orient Longman, Hyderabad.
2. Greenwood, D., Slack, R. B. and Peutherer, J. F. (2012) Medical Microbiology, (18th Edition). Churchill Livingstone, London.
3. Finegold, S. M. (2000) Diagnostic Microbiology, (10th Edition). C.V. Mosby Company, St. Louis.
4. Alexopoulos C. J., Mims C. W. and Blackwell M. (2007). Introductory Mycology, (4th Edition). Wiley Publishers.
5. Chander J. (2018). Textbook of Medical Mycology. (4th Edition). Jaypee brothers Medical Publishers.
6. Salle A. J. (2007). Fundamental Principles of Bacteriology. (4th Edition). Tata McGraw-Hill Publications.
7. Collee J.C. Duguid J.P. Foraser, A.C, Marimon B.P, (1996). Mackie & McCartney Practical Medical Microbiology. 14thedn, Churchill Livingston.
8. Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22ndedn.Cambridge University Press.
9. Topley and Wilson's. (1998). Principles of Bacteriology.9th edn. Edward Arnold, London.
10. Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th edn. Elsevier, Mosby Saunders.

Web Resources

http://textbookofbacteriology.net/nd
https://microbiologysociety.org/members-outreach-resources/links.html
https://www.pathelective.com/micro-resources
http://mycology.cornell.edu/fteach.html
https://www.adelaide.edu.au/mycology/

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Collect, transport and process of various kinds of clinical specimens.	PO1,PO5,PO9
CO2	Analyze various bacteria based on morphology and pathogenesis.	PO1,PO5,PO9
CO3	Discuss various treatment methods for bacterial disease.	PO1,PO5,PO9
CO4	Employ various methods detect fungi in clinical samples and apply knowledge on antifungal agents..	PO5,PO9
CO5	Apply various immunodiagnostic method to detect fungal infections.	PO5,PO9

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	M				S				M					
CO2	M				S				M					
CO3	M				S				M					

CO4					S				M					
CO5					S				M					

CORECOURSE:V

MEDICAL VIROLOGY AND PARASITOLOGY

Semester :II **MaxMarks:75**

Course Code : 24PMB2C5 **Credit : 5**

Total Period : 75 **Exam Hrs : 3**

Course Objectives

Describe the replication strategy and cultivation methods of viruses.

Acquire knowledge about oncogenic virus and human viral infections.

Develop diagnostic skills, in the identification of virus infections.

Impart knowledge about parasitic infections.

Develop diagnostic skills, in the identification of parasitic infections.

UNIT-I **(15Periods)**

General properties of viruses - Structure and Classification - viroids, prions, satellite RNAs and virusoids. Cultivation of viruses - embryonated eggs, experimental animals and cell cultures. Purification and Assay of viruses – Physical and Chemical methods (Electron Microscopy, Protein and

Nucleic acids studies.) Infectivity Assays (Plaque and end-point).

UNIT -II **(15Periods)**

Virus Entry, Host Defenses Against Viral Infections, Epidemiology, pathogenic mechanisms, Pathogenesis, laboratory diagnosis, treatment for the following viruses: DNA Viruses- Pox , Herpes , Adeno , Papova and Hepadna , RNA Viruses- Picorna, Orthomyxo, Paramyxo, Rhabdo, HIV and other Hepatitis viruses, Arbo – Dengue virus, Ebola virus, Emerging and reemerging viral infections

UNIT III **(15 Periods)**

Bacterial viruses - ΦX 174, M13, MU, T4, lambda, Pi; Structural organization, life cycle and phage production. Lysogenic cycle-typing and application in bacterial genetics. Diagnosis of viral infections –conventional serological and molecular methods. Antiviral agents and viral vaccines.

UNIT IV **(15Periods)**

Introduction to Medical Parasitology – Classification, host-parasite relationships. Epidemiology, life cycle, pathogenic mechanisms, laboratory diagnosis, treatment for the following: Protozoa causing human infections – *Entamoeba,* Aerobic and Anaerobic amoebae, *Giardia*, *Trichomonas,*, *Cryptosporidium*, *Leishmania*, and *Trypanasoma.*

UNIT V **(15Period)**

Classification, life cycle, pathogenicity, laboratory diagnosis and treatment for parasites – Helminthes - Cestodes – *Taenia Solium, T. Saginata, T. Echinococcus*. Trematodes – *Fasciola*

Hepatica, Fasciolopsis Buski, Schistosomes. Nematodes - *Ascaris, Enterobius* and *Wuchereria*. Other parasites causing infections in immune compromised hosts and AIDS. Cultivation of parasites. Diagnosis of parasitic infections – Serological and molecular diagnosis. Anti-protozoan drugs.

REFERENCES

Text Books

1. Kanunga R. (2017). Ananthanarayanan and Panicker's Text book of Microbiology. (10th Edition). Universities Press (India) Pvt. Ltd.
2. Dubey, R.C. and Maheshwari D.K. (2010). A Text Book of Microbiology. S. Chand & Co.
3. Rajan S. (2007). Medical Microbiology. MJP publisher.
4. Paniker J. (2006). Text Book of Parasitology. Jay Pee Brothers, New Delhi.
5. Arora, D. R. and Arora B. B. (2020). Medical Parasitology. (5th Edition). CBS Publishers & Distributors Pvt. Ltd. New Delhi.

Book Reference

1. Carter J. (2001). Virology: Principles and Applications (1st Edition). Wiley Publications.
2. Willey J., Sandman K. and Wood D. Prescott's Microbiology. (11th Edition). McGraw Hill Book
3. Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A
4. Finegold S.M. (2000). Diagnostic Microbiology. (10th Edition). C.V. Mosby Company, St. Louis.
5. Levanthal R. and Cheadle R. S. (2012). Medical Parasitology. (6th Edition). S.A.

Web Resources

https://en.wikipedia.org/wiki/Virology
https://academic.oup.com/femsre/article/30/3/321/546048
https://www.sciencedirect.com/science/article/pii/S0042682215000859
https://nptel.ac.in/courses/102/103/102103039/
https://www.healthline.com/health/viral-diseases#contagiousness

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Cultivate viruses by different methods and aid in diagnosis. Perform purification and viral assay.	PO5, PO7, PO8, PO10
CO2	Investigate the symptoms of viral infections and presumptively identify the viral disease.	PO5, PO7, PO8, PO10
CO3	Diagnose various viral diseases by different methods.(serological, conventional and molecular)	PO5, PO7, PO8, PO10
CO4	Educate public about the spread, control and prevention of parasitic diseases.	PO5, PO7, PO8, PO10
CO5	Identify the protozoans and helminthes present in stool and blood specimens. Perform serological and molecular diagnosis of parasitic infections.	PO5, PO7, PO8, PO10

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1					M		L	L		M				
CO2					M		L	L		M				
CO3					M		L	L		M				
CO4					M		L	L		M				
CO5					M		L	L		M				

CORECOURSE: VI

FORENSIC SCIENCE

Semester :I **MaxMarks:75**

Course Code : 24PMB2C6 **Credit : 4**

Total Period : 60 **Exam Hrs : 3**

Course Objectives

Understand the Scope, need and learn the tools and techniques in forensic science

Comprehend organizational setup of a forensic science laboratory.

Identify and Examine body fluids for identification

Extract DNA from blood samples for investigation.

Recognize medico legal post mortem procedures and their importance.

UNIT-I **(10Periods)**

Forensic Science - Definition, history and development of forensic science. Scope and need of forensic science in present scenario. Branches of forensic science. Tools and techniques of forensic science. Duties of a forensic scientist.

UNIT -II **(15Periods)**

Forensic science laboratories - Organizational setup of a forensic science laboratory. Central and State level laboratories in India. Mobile forensic science laboratory and its functions. Forensic microbiology - Types and identification of microbial organisms of forensic significance.

UNIT III **(10 Periods)**

Forensic serology - Definition, identification and examination of body fluids - Blood, semen, saliva, sweat and urine. Forensic examination and identification of hair and fibre.

UNIT IV **(10Periods)**

DNA profiling - Introduction, history of DNA typing. Extraction of DNA from blood samples - Organic and Inorganic extraction methods. DNA fingerprinting - RFLP, PCR, STR. DNA testing in disputed paternity.

UNIT V **(15Period)**

Forensic toxicology - Introduction and concept of forensic toxicology. Medico legal post mortem and their examination. Poisons - Types of poisons and their mode of action.

REFERENCES

Text Books

1. Nanda B. B. and Tewari R. K. (2001) Forensic Science in India: A Vision for the Twenty First Century. Select Publishers, New Delhi. ISBN- 10:8190113526 / ISBN-13:9788190113526.
2. James S. H. and Nordby, J. J. (2015) Forensic Science: An Introduction to Scientific and

Investigative Techniques. (5th Edition). CRC Press. ISBN-10:9781439853832 / ISBN-13:978-1439853832.

3. Li R. (2015) Forensic Biology. (2nd Edition). CRC Press, New York. ISBN-13:978-1-4398-8972-5.
4. Sharma B.R (2020) Forensic science in criminal investigation and trials. (6th Edition)Universal Press
5. Richard Saferstein (2017). Criminalistics- An introduction to Forensic Science. (12th Edition).Pearson Press

Book Reference

1. Nordby J. J. (2000). Dead Reckoning. The Art of Forensic Detection- CRC Press, New York. ISBN:0-8493-8122-3.
2. Saferstein R. and Hall A. B. (2020). Forensic Science Hand book, Vol. I, (3rd Edition). CRC Press, New York. ISBN-10:1498720196
3. Lincoln, P.J. and Thomson, J. (1998). (2nd Edition). Forensic DNA Profiling Protocols. Vol. 98. Humana Press. ISBN: 978-0-89603-443-3.
4. Val McDermid (2014). Forensics. (2nd Edition). ISBN 9780802125156.
5. Vincent J. DiMaio., Dominick DiMaio. (2001). Forensic Pathology (2nd Edition). CRC Press.

Web Resource

http://clsjournal.ascls.org/content/25/2/114

https://www.ncbi.nlm.nih.gov/books/NBK234877/

https://www.elsevier.com/books/microbial-forensics/budowle/978-0-12-382006-8

https://www.researchgate.net/publication/289542469_Methods_in_microbial_forensics

https://cisac.fsi.stanford.edu/events/microbial forensics

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Identify the scope and need of forensic science in the present scenario.	PO1, PO6, PO7, PO8, PO9
CO2	Plan for the organizational setup and functioning of forensic science laboratories.	PO1, PO6, PO7, PO8, PO9
CO3	Analyze the biological samples found at the crime scene.	PO1, PO5, PO7, PO8, PO9
CO4	Perform extraction and identification of DNA obtained from body fluids.	PO1, PO6, PO7, PO8, PO9
CO5	Discuss the concept of forensic toxicology.	PO1, PO6, PO7, PO8, PO9

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	L					S	M	M	S					
CO2	M					S	M	M	S					
CO3	L				S		S	M	S					
CO4	M					S	S	M	S					
CO5	M					S	S	M	S					

CORECOURSE: VII

DIAGNOSTIC MICROBIOLOGY

Semester :II **MaxMarks:75**

Course Code : 24PMB2C7 **Credit : 4**

Total Period : 60 **Exam Hrs : 3**

Course Objectives

Describe appropriate safety protocol and laboratory techniques for handling specimens and biomedical waste management.
Develop working knowledge of techniques used to identify infectious agents in the clinical microbiology lab.
Elucidate various diagnostic procedures in microbiology.
Acquire knowledge on different methods employed to check antibiotic sensitivity
Gain knowledge on hospital acquired infections and their control measures.

UNIT-I **(10Periods)**

Microbiology Laboratory Safety Practices -General Safety Guidelines, Handling of Biological Hazards, Infectious health care waste disposal - Biomedical waste management, Emerging and Re-emerging infections.

UNIT -II **(15Periods)**

Diagnostic procedures - General concept of Clinical specimen collection, transport, storage and general processing in Microbiology laboratory - Specimen acceptance and rejection criteria.

UNIT III **(10 Periods)**

Diagnosis of microbial diseases - Clinical, differential, Microbiological, immunological and molecular diagnosis of microbial diseases. Modern and novel microbial diagnostic methods. Automation in Microbial diagnosis.

UNIT IV **(15Periods)**

Antibiotic sensitivity tests - Disc diffusion - Stokes and Kirby Bauer methods, E test - Dilution - Agar dilution & broth dilution - MBC/MIC - Quality control for antibiotics and standard strains.

UNIT V **(10Period)**

Nosocomial infections – common types, sources, reservoir and mode of transmission, pathogenesis and control measures. Hospital Infection Control Committee (HICC) – Functions.

REFERENCES

Text Books

1. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi. ISBN-10:0443047219 / ISBN-13-978-0443047213.
2. Tille P. M. (2021). Bailey and Scott's Diagnostic Microbiology. (15th Edition). Elsevier. ISBN:9780323681056.

3. Jawetz E., Melnick J. L. and Adelberg E. A. (2000). Review of Medical Microbiology. (19th Edition). Lange Medical Publications, U.S.A.
4. Mukherjee K.L. (2000). Medical Laboratory Technology.Vol. 1-3. (2nd Edition). Tata McGraw-Hill Education. ISBN-10:0074632604.
5. Sood R. (2009). Medical Laboratory Technology – Methods and Interpretations. (6th Edition). Jaypee Brothers Medical Publishers (P) Ltd. New Delhi. ISBN:9788184484496

Book Reference

1. Murray P. R., Baron E. J., Jorgenson J. H., Pfaller M. A. and Yolken R.H. (2003). Manual of Clinical Microbiology. (8th Edition). American Society for Microbiology, Washington, DC. ISBN:1-555810255-4.
2. Bennett J. E., Dolin R. and Blaser M. J. (2019). Principles and Practice of Infectious Diseases. (9th Edition). Elsevier. EBook ISBN:9780323550277. Hardcover ISBN:9780323482554.
3. Ridgway G. L., Stokes E. J. and Wren M. W. D. (1987). Clinical Microbiology 7th Edition. Hodder Arnold Publication. ISBN-10:0340554231 / ISBN-13:9780340554234.
4. Koneman E.W., Allen S. D., Schreckenberg P. C. and Winn W. C. (2020). Koneman's Color Atlas and Textbook of Diagnostic Microbiology. (7th Edition). Jones & Bartlett Learning. ISBN:1284322378 9781284322378
5. Cheesbrough, M. (2004). District Laboratory Practice in Tropical Countries - Part 2, (2nd Edition). Cambridge University Press. ISBN-13:978-0-521-67631-1 / ISBN-10:0-521-67631-2.

Web Resource

https://www.ncbi.nlm.nih.gov/books/NBK20370/
https://journals.asm.org/doi/10.1128/JCM.02592-20
https://www.sciencedirect.com/science/article/pii/S2221169116309509
http://www.textbookofbacteriology.net/normalflora_3.html

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Apply Laboratory safety procedures and hospital waste disposal strategies.	PO5, PO6, PO7
CO2	Collect various clinical specimens, handle, preserve and process safely.	PO6, PO7
CO3	Identify the causative agents of diseases by conventional and molecular methods following standard protocols.	PO6, PO7, PO9, PO11
CO4	Assess the antimicrobial susceptibility pattern of pathogens.	PO7, PO9
CO5	Trace the sources of nosocomial infection and recommend control measures.	PO5, PO7

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1					S	M	M							
CO2						M	S							
CO3						M	S		M		S			
CO4							S		M					
CO5					S		M							

COREP PRACTICAL: II

PRACTICAL II: MEDICAL BACTERIOLOGY AND MYCOLOGY, MEDICAL VIROLOGY AND PARASITOLOGY, DIAGNOSTIC MICROBIOLOGY

Semester :II **MaxMarks:**

Course Code : 24PMB2C2P **Credit : 4**

Total Period : 60 **Exam Hrs : 3**

Course Objectives

Develop skills in the diagnosis of bacterial infections and antimicrobial sensitivity.

Impart knowledge on fungal infections and its diagnosis.

Diagnose parasitic

To gain knowledge about industrially important microbes

Screen and utilize microorganisms for effective industrial production of metabolites.

MEDICAL BACTERIOLOGY AND MYCOLOGY , MEDICAL VIROLOGY AND PARASITOLOGY

1. Isolation and identification of bacterial pathogens from clinical specimens
2. Cultivation in basal, differential, enriched, selective and special media – Biochemical identification tests.
3. Enumeration of bacteria in urine to detect significant bacteriuria.
4. Antimicrobial sensitivity testing - Kirby Bauer method
5. Isolation and Identification of common fungi.
6. Classification of common fungi
7. Mounting and staining of VAM spores.
8. Examination of different fungi by Lactophenol cotton blue staining.
9. Cultivation of fungi and their identification - *Mucor, Rhizopus, Aspergillus, Penicillium.*
10. Microscopic observation of fungal fruiting bodies.
11. Diagnosis of Viral Infections –ELISA.
12. Examination of parasites in clinical specimens - Ova/cysts in faeces.
13. Identification of common arthropods of medical importance - spotters of *Anopheles, Glossina, Phlebotomus, Aedes,* Ticks and mites.

DIAGNOSTIC MICROBIOLOGY

14. Demonstration of Haemagglutination test, Haemagglutination inhibition test
15. Bacteriophage isolation
16. DNA isolation from Blood sample
17. DNA isolation from Hair sample
18. DNA isolation from nail

REFERENCES

Text Books

1. Cullimore D. R. (2010). Practical Atlas for Bacterial Identification, 2nd Edition. Publisher-Taylor and Francis.

2. Abbott A.C. (2010). The Principles of Bacteriology. Nabu Press.

3. Parija S. C. (2012). Textbook of Practical Microbiology. Ahuja Publishing House.

4. Cappuccimo, J. and Sherman, N. (2002) Microbiology: A Laboratory Manual, (6thEdition). Pearson Education, Publication, New Delhi.

5. Morag C. and Timbury M.C. (1994). Medical Virology. 4th edn. Blackwell Scientific Publishers.

Books Reference

6. Collee J. G., Fraser A.G. Marmion B. P. and Simmons A. (1996). Mackie & McCartney Practical Medical Microbiology. (14th Edition). Elsevier, New Delhi.

7. Chart H. (2018). Practical Laboratory Bacteriology. CRC Press.

8. Moore V. A. (2017). Laboratory Directions for Beginners in Bacteriology. Triste Publishing Ltd.

9. Cheesbrough M. (2006). District Laboratory Practice in Tropical countries.- Part 22nd Edition.Cambridge University Press.

10. Murray P.R., Rosenthal K.S. and Michael A. (2013). Medical Microbiology. Pfaller. 7th Edition. Elsevier, Mosby Saunders

Web Resources

http://textbookofbacteriology.net/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7173454/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3768729/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC149666/

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Collection of different clinical samples, transport, culture and examination.	PO7, PO8, PO9
CO2	Identify medically important bacteria, fungus and parasites from the clinical samples by staining and biochemical tests.	PO7, PO8, PO9
CO3	Promote diagnostic skills; interpret laboratory tests in the diagnosis of infectious diseases.	PO7, PO8, PO9, PO10
CO4	Perform virus and bacteriophage isolation tests.	PO7, PO8, PO9, PO10
CO5	Screening and isolation of DNA from various samples.	PO7, PO8, PO9

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1							M	M	M					
CO2							M	M	M					
CO3							M	M	L	L				
CO4							M	M	M	L				
CO5							M	M	M					

CORECOURSE:

BIOREMEDIATION

Semester :I **MaxMarks:75**

Course Code : 24PMB2I1 **Credit : 3**

Total Period : 24 **Exam Hrs : 3**

Course Objectives

Describe the nature and importance of bioremediation and use in real world applications.
Describe the typical composition of waste water and application of efficient technologies for water treatment.
Explain the fundamentals of treatment technologies and the considerations for its design and implementation in treatment plants.
Explain the potential of microbes in ore extraction and acquaint students with methods of reducing health risks caused by xenobiotics.
Familiarize the role of plants and their associated microbes in remediation and management of environmental pollution.

UNIT-I **(5Periods)**

Bioremediation - process and organisms involved. Bioaugmentation - Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation. Microbial aspects and metabolic aspects. Factors affecting the process. Recent developments and significance.

UNIT -II **(5Periods)**

Microbes involved in aerobic and anaerobic processes in nature. Water treatment - BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal. Secondary waste water treatments - use of membrane bioreactor.

UNIT III **(5 Periods)**

Composting of solid wastes, anaerobic digestion - methane production and important factors involved, Pros and cons of anaerobic process, sulphur, iron and nitrate reduction, hydrocarbon degradation, degradation of nitroaromatic compounds. Bioremediation of dyes, bioremediation in paper and pulp industries. Aerobic and anaerobic digesters – design.

UNIT IV **(4Periods)**

Microbial leaching of ores - process, microorganisms involved and metal recovery with special reference to copper and iron. Biotransformation of heavy metals and xenobiotics. Petroleum biodegradation - reductive and oxidative.

UNIT V **(5Period)**

Phytoremediation of heavy metals in soil - Basic principles of phytoremediation - Uptake and transport, Accumulation and sequestration. Phytoextraction. Phytodegradation. Phytovolatilization. Rhizodegradation. Phytostabilization – Organic and synthetic amendments in multi metal

contaminated mine sites. Role of Arbuscular mycorrhizal fungi and plant growth promoting rhizobacteria in phytoremediation.

REFERENCES

Text Books

1. Bhatia H.S. (2018). A Text book on Environmental Pollution and Control. (2nd Edition). Galgotia Publications.

2. Chatterjee A. K. (2011). Introduction to Environmental Biotechnology. (3rd Edition). Printice-Hall, India.

3. Pichtel, J. (2014). Waste Management Practices: Municipal, Hazardous, and Industrial, 2nd edition, CRC Press.

4. Liu, D.H.F and Liptak, B.G (2005). Hazardous Wastes and Solid Wastes, Lewis Publishers.

5. Rajendran, P. & Gunasekaran, P. (2006). Microbial Bioremediation. 1st edition. MJP Publishers

Book Reference

1. Sangeetha J., Thangadurai D., David M. and Abdullah M.A. (2016). Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development. (1st Edition). Apple Academic Press

2. Singh A. and Ward O. P. (2004). Biodegradation and Bioremediation. Soil Biology. Springer.

3. Singh A., Kuhad R. C., and Ward O. P. (2009). Advances in Applied Bioremediation (1st Edition). Springer-Verlag Berlin Heidelberg, Germany.

3. Atlas, R.M & Bartha, R. (2000). Microbial Ecology. Addison Wesley Longman Inc.

4. Rathoure, A.K. (Ed.). (2017). Bioremediation: Current Research and Applications. 1st edition. I.K. International Publishing House Pvt. Ltd.

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Differentiate Ex-situ bioremediation and In-situ bioremediation. Assess the roles of organisms in bioremediation.	PO1, PO2, PO4, PO5
CO2	Distinguish microbial processes necessary for the design and optimization of biological processing unit operations.	PO1, PO4, PO5, PO11
CO3	Identify, formulate and design engineered solutions to environmental problems.	PO5, PO7, PO8, PO11
CO4	Explore microbes in degradation of toxic wastes and playing role on biological mechanisms.	PO5, PO6, PO7, PO8, PO9
CO5	Establish the mechanisms of Arbuscular mycorrhizal fungi and Plant growth promoting *Rhizobacteria* in phytoremediation.	PO1, PO5, PO6, PO7, PO8

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S	M		M	S									
CO2	S			M	S						S			
CO3					S		S	S			S			
CO4					S	S	S	S	S					
CO5	M				S	M	S	S						

NON MAJOR ELECTIVE-I

VERMITECHNOLOGY

Semester :II **MaxMarks:75**

Course Code : 24PMB2N1A **Credit : 2**

Total Period : 24 **Exam Hrs : 3**

Course Objectives

Introduce the concepts of vermicomposting.

Explain the physiology, anatomy and biology of earthworms

Acquire the knowledge of the vermicomposting process.

Explain the trouble shooting, harvesting and packaging of vermin composts

Gain knowledge on applications of vermin composts and their value added products.

UNIT-I **(5 Periods)**

Introduction to Vermiculture - Definition, classification, history, economic importance- In sustainable agriculture, organic farming, earthworm activities, soil fertility & texture, soil aeration, water impercolation, decomposition & moisture, bait & food and their value in maintenance of soil structure. Choosing the right worm. Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Factors affecting distribution of earthworms in soil.

UNIT -II **(4 Periods)**

Earthworm Biology and Rearing - Key to identify the species of earthworms. Biology of *Eisenia fetida*- Taxonomy Anatomy, physiology and reproduction of Lumbricidae. Biology of *Eudrilus eugeniae* - Taxonomy Anatomy, physiology and reproduction of Eudrilidae.

UNIT III **(5 Periods)**

Vermicomposting Process - Feeds for Vermitech systems- Animal manures- Kitchen Waste and Urban waste- Paper pulp and card board solids- Compost and waste products- Industrial Wastes. Vermicomposting Basic process- Initial pre-composting phase- Mesophilic phase- Maturing and stabilization phase- Mechanism of Earthworm action. Methods of vermicomposting- a) windrows system; b) wedge system

UNIT IV **(5 Periods)**

Vermicomposting - Trouble Shooting-Temperature-Aeration- Acidity- Pests and Diseases- Ants, rodents, Birds, Centipedes, sour crop, Mite pests. Odour problems. Separation techniques- Light Separation-Sideways Separation-Vertical Separation-Gradual transfer. Harvesting Earthworms. Packing & Nutritional analysis of vermicompost.

UNIT V **(5 Periods)**

Applications of Vermiculture - Vermiculture Bio-technology, use of vermi castings in organic farming/horticulture, as feed/bait for capture/culture fisheries; forest regeneration. Application

quantity of vermicompost in Agricultural fields- crops, fruits, vegetables & flowers.

REFERENCES

Text Books

1. Ismail S. A. (2005). The Earthworm Book, Second Revised Edition. Other India Press, Goa, India

2. Rathoure A. K., Bharati P. K. and Ray J. (2020). Vermitechnology, Farm and Fertilizer. Vermitechnology, Farm and Fertilizer Discovery Publishing House Pvt Ltd.

3. Christy M. V. 2008. Vermitechnology, (1st Edition), MJP Publishers

The complete technology book on Vermiculture and Vermicompost with manufacturing Process, machinery equipment details and Plant Layout. AB Press.

4. Keshav Singh (2014). A Textbook of vermicompost: Vermiwash and Biopesticide

Book Reference

5. Roy D. (2018). Handbook of Vermitechnology. Lambert Academic Publishing.

6. Kumar A. (2005). Verms and Vermitechnology, A.P.H. Publishing Corporation, New Delhi

7. Lekshmy M. S., Santhi R. (2012). Vermitechnology, Sara Publications, New Delhi, India.

Edwards CA, Arancon NQ ShermanRL. (2011) Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management 1st edn.CRC Press.

8. Ismail, S.A. (1997). Vermicology-The Biology of Earthworm.1st edn. Orient longman

Web Resources

https://en.wikipedia.org/wiki/Vermicompost
http://stjosephs.edu.in/upload/papers/9567411a78c63d4ccfbbe85e6aa22840.pdf
https://rodaleinstitute.org/science/articles/vermicomposting-for-beginners/

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Compare and contrast the uses of vermicompost to the soil.	PO1, PO4, PO5, PO9,
CO2	Recommend different species of earthworms after acquiring knowledge on its biology.	PO1, PO4, PO6, PO9
CO3	Design the vermicomposting process.	PO1, PO4, PO6, PO7, PO8
CO4	Assess the Best Practices of Vermicomposting	PO6,PO7, PO8,PO9,

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S			M	S				S					

CO2	S			M		S			S					
CO3	S			S		S	S	S						
CO4						S	S	S	S					
CO5	S			M	S	M	S							

NON MAJOR ELECTIVE-I
MICROBIAL ANALYSIS OF AIR AND WATER

Semester :I **MaxMarks:75**

Course Code : 24PMB2N1B **Credit : 3**

Total Period : 24 **Exam Hrs : 3**

Course Objectives

To understand how microorganisms adapt to different environments and their interaction with different habitats

To understand the spread of microorganisms from the environment

To know different techniques of detection of microorganism from air and water

To acquire knowledge of treating polluted wate

To know the techniques

UNIT-I **(5Periods)**

Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens

UNIT -II **(5Periods)**

Air sample collection and analysis ,Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics.

UNIT III **(5Periods)**

Control measures- Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration.

UNIT IV **(5Periods)**

Water Microbiology-Water borne pathogens, water borne diseases. Microbiological analysis of water- Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test(MPN test), confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.

UNIT V **(4Period)**

Precipitation, chemical disinfection, filtration, high temperature, UV light.

REFERENCES

Text Books

1. Da Silva N, Taniwaki MH, Junqueira VC, Silveira N, Nascimento MS, Gomes RAR (2012) Microbiological Examination Methods of Food and Water-A Laboratory Manual, CRC Press

2. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA

Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition,

3. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition,

Academic Press Microbiology, 3rd edition, ASM press

4. Hurst CJ, Crawford RL, Garland JL, Lipson DA (2007) Manual of Environmental Microbiology, 3rd edition, ASM press

Book Reference

5. Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5th Edition). Mc.Graw Hill. Inc, New York

6. Prescott L. M., Harley J. P. and Klein D. A. (2004). Microbiology. (6th Edition). McGraw - Hill company, New York.

7. Chan E.C.S., Pelczar M. J. Jr. and Krieg N. R. (2010). Microbiology. (5th Edition). Mc.Graw Hill. Inc, New York.

8. Tortora G. J., Funke B. R. and Case C. L. (2015). Microbiology: An Introduction (12th Edition).Pearson, London, United Kingdom

Web Resources

http://sciencenetlinks.com/tools/microbeworld

Course Outcomes:

By the end of this course, the students will be able to:

Course Outcomes	On completion of this course, students will;	
CO1	Know the concepts of how microorganisms adapt to different environments.	PO1, PO4, PO5, PO9,
CO2	Acquire the knowledge of the microorganisms interaction with different habitats	PO1, PO4, PO6, PO9
CO3	Explain the different techniques of detection of microorganism from air and water.	PO1, PO4, PO6, PO7, PO8
CO4	Perform and demonstrate different method used to determine the quality of water and air	PO6,PO7, PO8,PO9,
CO5	Purify the household water	PO1, PO4, PO5,PO6, PO7

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PO 13	PO 14
CO1	S			M	S				S					
CO2	S			M		S			S					
CO3	S			S		S	S	S						
CO4						S	S	S	S					
CO5	S			M	S	M	S							

CORECOURSE: VIII

SOIL AND ENVIRONMENTAL MICROBIOLOGY

Semester : III **Max Marks :75**
Course Code : 24PMB3C8 **Credit :5**
Total Period : 75 **Exam Hrs :3**

Objectives

Explain the role of microorganisms in soil fertility.

Discuss the benefits of interactions among soil microbes and acquire awareness about microbes as biofertilizers and biocontrol agents.

Create awareness. about components of environment, environmental pollution, and detection methods.

Acquire in depth knowledge about solid and liquid waste treatments.

Develop knowledge about organic matter degradation, bioremediation, and the environment risk assessment.

UNIT-I Soil Microbiology (15Periods)

Soil Microbiology– Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity, and distribution of major group of microorganisms in soil. Quantification of soil microflora, role of microorganism in soil fertility. Mineralization of Organic & Inorganic Matter in Soil. Biological Nitrogen fixation- Chemistry and Genetics of BNF. Phytopathology and Disease cycle of Plant pathogens - Tikka and Citrus canker, Types of disease symptoms, Structural and Inducible biochemical defenses - Systemic Acquired Resistance (SAR), pathogenesis related (PR) proteins, Plantibodies, Phenolics, Phytoalexins

UNIT II Microbial Interactions (15Periods)

Microbial Interactions - Mutualism, Commensalism, Amensalism, Synergism, Competition, Rhizosphere- Rhizosphere effect, Mycorrhizae – Types, Endophytes, PGPR- Plant growth promoting bacteria– symbiotic (Bradyrhizobium, Rhizobium, Frankia), Non-Symbiotic (Azospirillum, Azotobacter, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs. Biofertilizers and Biocontrol agents – Types, benefits and application. Advantages, social and environmental aspects - Bt crops, golden rice.

UNIT III Components of Environment (15 Periods)

Components of Environment: Hydrosphere, lithosphere, atmosphere, and biosphere – definitions with examples; Energy flow in the ecosystem- Carbon, Nitrogen, Sulfur and Phosphorous cycles. Physical factors affecting distribution of microorganisms in various environments. Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Space microbiology - Microbiological research in space environment.

UNIT IV Waste management **(15Periods)**

Waste management – Solid waste - Types - management - Factors affecting solid waste generation rates. Industrial effluent treatment, primary, secondary, tertiary, and advanced treatment process. Quality assessment of decontaminated matters and other biological effluents. Biological reference standards. Utilization of Solid Waste as Food, Feed and Fuel- Composting, Vermicomposting, Bio manure and Biogas production. E waste management.

UNIT V Bioremediation **(15Period)**

Degradation of organic matter - lignin, cellulose, hemicellulose, pectin, common pesticides-herbicides (2,4-D) and pesticides (DDT), heavy metals. Biodegradation of Xenobiotics - Recalcitrant Halocarbons, Recalcitrant TNTs, PCBs and Synthetic polymers. Biodegradation of Hydrocarbons. Biodeterioration of Textiles and Leather. Pollution Control Bodies and Environmental laws in India.

REFERENCES

1. Subba Rao. N. S. (2017). Soil Microbiology. (5th Edition). MedTech Publishers.
2. Daniel. C. J. (2006). Environmental Aspects of Microbiology. (2nd Edition). Bright Sun Publications.
3. Rangaswami. G. and Mahadevan. A. (2006). Diseases of Crop Plants in India. (4th Edition). Prentice–Hall of India Pvt. Ltd.
4. Sharma P. D. (2010). Microbiology and Plant pathology. (2nd Edition). Rastogi Publications.
5. Subba Rao. N.S. (2005). Soil microorganisms and Plant Growth. (4th Edition). Oxford and IBH Publishing Pvt. Ltd.
6. Pepper I. L., Gerba C. P. and Gentry T. J. (2014). Environmental Microbiology (1st Edition). Academic Press, Elsevier.
7. Bitton, G. (2011). Wastewater Microbiology. (4th Edition). Wiley-Blackwell.
8. Bridgewater L. (2012). Standard Methods for the Examination of Water and Wastewater. American Public Health Association.
9. Shrivastava A.K. (2003). Environment Auditing. A. P. H. Publishing Corporation.
10. Tinsley, S. and Pillai, I. (2012). Environmental Management Systems – Understanding Organizational Drivers and Barriers. Earthscan.

Web Resources

https://academic.oup.com/femsec/article/93/5/fix044/3098413

http://www.fao.org/3/t0551e/t0551e05.htm
www.environmentshumail.blogspot.in/
https://www.frontiersin.org/articles/10.3389/fpls.2017.01617/full
https://serc.carleton.edu/microbelife/index.html

Course Outcomes:

By the end of this course, the students will be able to:

CO Number	COSTATEMENT	KNOWLEDGE LEVEL
CO1	Depict diversity and significance of soil microbes and predict the role of microbes in biological nitrogen fixation.	K1
CO2	Utilize the knowledge of microbial interactions, with beneficial application of biofertilizers for sustainable agriculture and benefits of biopesticides.	K2
CO3	Explain the different types of microorganisms in water. Identify the causes of water pollution and the methods for quality assessment of water and control of water borne diseases.	K3
CO4	Apply knowledge about waste treatments and microbial decomposition and bio-remediation process in environmental cleanup.	K5
CO5	Plan a clear approach on environmental issues. Control pollution and explain protection laws to public.	K4

Mapping with Programme Out comes: S-Strong, M- Medium,L-Low

Cos/Pos	PO1	PO2	PO3	PO4	PO5
CO1	**S**	**S**	**M**	**S**	**S**
CO2	**S**	**S**	**S**	**S**	**S**
CO3	**S**	**S**	**S**	**S**	**S**
CO4	**S**	**S**	**S**	**S**	**S**
CO5	**S**	**S**	**S**	**M**	**S**

CORE COURSE- IX

RECOMBINANT DNA TECHNOLOGY

Semester :III **MaxMarks:75**

Course Code : 24PMB3C9 **Credit : 5**

Total Period : 75 **Exam Hrs :3**

Objectives:

- Provide deep knowledge about Nucleic acids
- Discuss the gene regulatory mechanisms in prokaryotes and eukaryotes and importance of mutations.
- Provide in depth knowledge about artificial gene transfer mechanisms and selection of Recombinants.
- Impart knowledge on various molecular techniques and their importance in biotechnology.
- Explain the applications of genetic engineering in various fields.

UNIT I: Nucleic acids (15Period)

Structural of prokaryotic and eukaryotic genome. Introduction to prokaryotic genomic structure, Eukaryotic Genome - Structure of chromatin, chromosome, centromere, telomere, nucleosome. Modifications- methylation, acetylation, phosphorylation and its effect on structure and function of chromatin, DNA methylation and gene imprinting, organelle genome.

UNIT II: Gene regulation and expression (15Period)

Gene regulation and expression – Lac operon, arabinose and tryptophan operons. Gene regulation in eukaryotic systems - repetitive DNA, gene rearrangement, promoters, enhancer elements. Molecular basis of gene mutation - Types of mutations - base substitutions, frame shift, deletion insertion, duplication, inversion. Silent, conditional and lethal mutation. Chemical mutagenesis. Repair of DNA damage. Photoreactivation. SOS repair mechanism. Base excision repair. Nucleotide excision repair. Detection and analysis of mutations (Replica plating, Antibiotic enrichment, Ames test).

UNIT III: Tools and methods in gene cloning (15Periods)

Tools and methods in gene cloning. Restriction endonucleases – nomenclature, classification and characteristics - DNA methylases, DNA polymerases, Ligases. Adapters, linkers and homopolymer tailing. Artificial gene transfer techniques - electroporation, microinjection, protoplast fusion and microparticle bombardment. Screening for recombinants. Gene cloning

vectors for prokaryotes and eukaryotes - cloning properties and types of plasmids vectors (pBR322 , pUC vectors) - Phage Vectors(M13 and Lambda), cosmids, phasmids, phagemids and BACs - Eukaryotic vectors - Yeast vectors – Animal and plant vectors – expression vectors. Shuttle vectors

UNITIV: Techniques in genetic engineering

(15Periods)

Genomic DNA and cDNA library - Construction and Screening. Substrative hybridization for tissue specific DNA libraries. Techniques in genetic engineering Characterization of cloned DNA: Hybrid arrested translation (HAT) - Restriction mapping - restriction fragment length polymorphism (RFLP) - Polymerase chain reaction (PCR) – Principles, types and their applications. DNA sequencing - Primer walking, Sanger's method and automated sequencing methods. DNA chips and micro array

UNIT V: Plant biotechnology **(15Periods)**

Plant biotechnology - constituents and concepts of sterilization - preparation, isolation and selection of explant. Suspension cell culture, callus culture, protoplast isolation, culture & fusion. Anther and pollen culture for production. Animal biotechnology – equipment and media used for animal cell culture technology. Primary and established cell line culture and culture media. Applications of animal cell cultures. Serum protein media viability and cytotoxicity. Applications of Genetic Engineering

REFERENCES

1. Malacinski G.M. (2008). Freifelder's Essentials of Molecular Biology. (4th Edition). Narosa Publishing House, New Delhi.
2. Snusted D.P. and Simmons M. J. (2019). Principles of Genetics. (7th Edition). John Wiley and Soms, Inc.
3. Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.
4. Primrose S.B. and Twyman R. M. (2006). Principles of Gene Manipulation and Genomics. (7th Edition). Blackwell Publishing.
5. Maloy S. R. Cronan J.E. Jr. and Freifelder D. (2011). Microbial Genetics. (2nd Edition). Narosa Publishing House Pvt. Ltd.
6. Brown T. A. (2016). Gene Cloning and DNA Analysis- An Introduction. (7th Edition). John Wiley and Sons, Ltd.
7. Glick B. R. and Patten C.L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA. (5th Edition). ASM Press.
8. Russell P.J. (2010). Genetics - A Molecular Approach. (3rd Edition). Pearson New International Edition.
9. Synder L., Peters J. E., Henkin T.M. and Champness W. (2013). Molecular Genetics of

Bacteria. (4th Edition). ASM Press Washington-D.C. ASM Press.

10. Dale J. W., Schantz M.V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3rd Edition). John Wileys and Sons Ltd.

Web Resources

https://microbenotes.com/gene-cloning-requirements-principle-steps-applications/

https://geneticeducation.co.in/what-is-transcriptomics

https://www.molbiotools.com/usefullinks.html

https://geneticeducation.co.in/what-is-transcriptomics

https://courses.lumenlearning.com/boundless-biology/chapter/dna-replication/

Course Outcomes:

By the end of this course, the students will be able to:

CO Number	CO STATEMET	KNOWLEDGE LEVEL
CO1	Understand the Analyze, demonstrate and appreciate nucleic acids	K4
CO2	Investigate the types of mutation and its impact on microbes. Illustrate various strategies on gene cloning.	K3
CO3	Analyze, modify and characterize DNA modifying enzymes.	K3
CO4	Illustratively assess the molecular techniques for DNA and protein analysis.	K2
CO5	Adopt the applications of Genetic Engineering in the field	K4

Mapping with Programme Outcomes:

Cos/Pos	PO1	PO2	PO3	PO4	PO5
CO1	**S**	**M**	**M**	**S**	**M**
CO2	**S**	**S**	**S**	**S**	**S**
CO3	**S**	**S**	**S**	**S**	**S**
CO4	**S**	**S**	**S**	**S**	**S**
CO5	**S**	**S**	**S**	**M**	**S**

S-Strong,M-Medium,L-Low

CORECOURSE: X

FERMENTATION TECHNOLOGY AND PHARMACEUTICAL MICROBIOLOGY

Semester : III **Max Marks :75**

Course Code : 24PMB3C10 **Credit : 5**

Total Period : 75 **Exam Hrs : 3**

Objective:

Discuss about fermentation and its types, sensitize on methods of strain development for improved yield.

Impart knowledge on the fermenter design and types.

Acquire knowledge on the effective recovery and purification of the products.

Explain the importance of pharmaceutical microbiology.

Illustrate methods for production products using microorganisms and their quality control.

UNIT I: Bioprocesses (15 Period)

Bioprocesses - concepts and design. Industrially important microorganisms – Isolation, primary and secondary screening, preservation and improvement of industrially important strains. Upstream processing - Development of inoculums for fermentation process. Media for industrial fermentation - Formulation, optimization. Sterilization. Stages of upstream - Growth of inoculums, fermenter pre-culture and production fermentation. Types of fermentation - Batch, continuous, dual or multiple, surface, submerged, aerobic and anaerobic.

UNIT II: Fermenter (15Period)

Fermenter – Design, types and construction, Instrumentation and control. Productivity. Yield coefficients. Heat production. Aeration and agitation. Gas exchange and mass transfer. Computer Applications in fermentation technology. Fermentation Economics.

UNIT III: Downstream Processing (16Period)

Downstream Processing - Recovery and purification of intracellular and extracellular products. Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration - Physical, chemical and enzymatic methods. Extraction - Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

UNITIV:Pharmaceuticalmicrobiology (15Period)

Overview of pharmaceutical microbiology - Ecology of microorganisms - Atmosphere, water, skin, respiratory flora of workers, raw materials, packaging, building equipment and their control measures. Design and layout of sterile manufacturing unit. Contamination and Spoilage of Pharmaceutical products - sterile injectable and non-injectable, ophthalmologic preparation, implants.

UNIT V: Pharmaceutical products (14Period)

Production of pharmaceutical products and quality assurance – Vaccines, immunodiagnostics, immuno-sera, immunoglobulin. Antibiotics - Penicillin, Griseofulvin, Metronidazole. Enzymes - Streptokinase, Streptodornase. Quality assurance and quality management in pharmaceuticals.

REFERENCES

1. Patel A. H. (2016). Industrial Microbiology. (2nd Edition). Laxmi Publications, New Delhi.
2. Casida L. E. J. R. (2019). Industrial Microbiology. New Age International Publishers.
3. Sathyanarayana U. (2005). Biotechnology. (1st Edition). Books and Allied (P) Ltd.
4. Reed G. (2004). Prescott and Dunn's Industrial Microbiology. (4th Edition). CBS Publishers & Distributors.
5. Waites M. J., Morgan N. L., Rockey J. S. and Higton G. (2013). Industrial Microbiology: An Introduction. Wiley Blackwell Publishers.
6. Stanbury P. T. and Whitaker. (2016). Principles of Fermentation Technology. (3rd Edition). Pergamon Press. NY.
7. Handa S. S. and Kapoor V. K. (2022). Pharamcognosy, (4th Edition). Vallabh Prakashan Publishers, New Delhi.
8. Kokate C. K., Durohit A. P. and Gokhale S. R. Pharmacognosy. (2002). (12^{th} Edition). Nirali Prakasham Publishers, Pune.
9. Hugo W. B. and Russell A. D. (2004). Pharmaceutical Microbiology. (7th Edition). Blackwell Scientific Publication, Oxford.
10. Wallis, T.E. (2005). Text book of Pharmacognosy. (5th Edition). CBS publishers and distributors, New Delhi.

Web Resources

https://ib.bioninja.com.au/options/untitled/b1-microbiology organisms/fermenters.html

https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/penicilli n.html

https://www.sciencedirect.com/topics/biochemistry-genetics-andmolecular-biology/ethanol-fermentation

https://www.usp.org/sites/default/files/usp/document/harmonization/genmethod/q05b_pf_ira_34_6_2008.pdf

http://www.simbhq.org/

Course Out comes:

By the end of this course, the students will be able to:

CO Number	COSTATEMENT	KNOWLEDGELEVEL
CO1	Develop microbial strains, carry out fermentation and recover the products of the process.	K3
CO2	Design fermenters according to needs for various products.	K2
CO3	Recover the end products of the fermentation process economically.	K3
CO4	Utilize the knowledge on pharmaceutical microbiology for industrial production of products.	K5
CO5	Produce therapeutic products from microbes employing technology and analyze the quality the products.	K6

Mapping with Programme Outcomes:s

Cos/Pos	PO1	PO2	PO3	PO4	PO5
CO1	**S**	**S**	**M**	**S**	**S**
CO2	**M**	**S**	**S**	**S**	**S**
CO3	**S**	**S**	**S**	**S**	**S**
CO4	**S**	**S**	**S**	**S**	**S**
CO5	**S**	**S**	**S**	**M**	**S**

S-Strong,M-Medium,L-Low

CORE PRACTICAL: III

Practical III: Soil and Environmental Microbiology, Recombinant DNA Technology and

Fermentation Technology and Pharmaceutical Microbiology

Semester : III **Max Marks :60**
Course Code : 24PMB3C3P **Credit : 4**

Total Period : 60 **Exam Hrs : 6**

SOIL AND ENVIRONMENTAL MICROBIOLOGY

Objective: To isolate soil microorganisms and vermicompost preparation

- Isolation of cellulose degrading bacteria
- Preparation of a Vermicompost
- Isolation of *Rhizobium* from soil /leguminous plant
- Isolation of VAM from soil
- Cultivation of *Azolla*
- Microbiological analysis of water –MPN technique
- Enumeration of bacteria and fungi from air – Air sampler
- Factors influencing and affecting the growth of microorganisms.
- Isolation of plant pathogen

RECOMBINANT DNA TECHNOLOGY

Objective: To learn the principle of Transduction, Transformation, etc.

- Transduction
- Detection of Antibiotic resistant mutants
- Amplification of DNA by PCR
- Transformation of bacteria by Calcium chloride method
- Blue-White screening method
- Western blotting - Demonstration
- Southern blotting – Demonstration

FERMENTATION TECHNOLOGY AND PHARMACEUTICAL MICROBIOLOGY

Objective: To know the process of fermentation and pharmaceutical Microbiology

- Protease enzyme production
- Amylase enzyme production
- Vinegar production
- Ethanol Production
- Microbiological assay of antibiotics by cup plate method

REFERENCES

1. Russell P. J. (2019). Genetics – A Molecular Approach (3rd Edition). Pearson Education, Inc.
2. Glick B. R. and Patten C. L. (2018). Molecular Biotechnology – Principles and Applications of Recombinant DNA (5th Edition). ASM Press.
3. Gunasekaran P. (2007). Laboratory Manual in Microbiology. New Age International.
4. James G Cappucino. and Natalie Sherman. (2016). Microbiology – A laboratory manual. (5th Edition). The Benjamin publishing company. New York.
5. Hurst, C.J., Crawford R.L., Garland J.L., Lipson D.A., Mills A.L. and Stetzenbach L.D. (2007). Manual of Environmental Microbiology. (3rd Edition). American Society for Microbiology.
6. Sambrook J. and Russell D.W. (2001). Molecular Cloning: A Laboratory Manual. (7^{th} Edition). Cold Spring Harbor, N.Y: Cold Spring Harbor Laboratory Press.
7. Brown T.A. (2016). Gene Cloning and DNA Analysis. (7^{th} Edition). John Wiley and Jones, Ltd.
8. Dale J. W., Schantz M. V. and Plant N. (2012). From Gene to Genomes – Concepts and Applications of DNA Technology. (3^{rd} Edition). John Wileys and Sons Ltd.
9. Pepper I., Gerba C. and Brendecke J. (2004). Environmental Microbiology - A Laboratory Manual. (2^{nd} Edition). Academic Press, Elsevier.
10. Yates M.V., Nakatsu C.H., Miller R.V. and Pillai, S.D. (2016). Manual of Environmental Microbiology. (4^{th} Edition). Wiley.

Web Resources

https://www.molbiotools.com/usefullinks.html

https://geneticgenie.org3.

https://currentprotocols.onlinelibrary.wiley.com/doi/pdf/10.1002/cpet.5

https://vlab.amrita.edu/index.php?sub=3&brch=272

https://nptel.ac.in/courses/102105087

Course Outcomes:

By the end of this course, the students will be able to:

CO Number	COSTATEMENT	KNOWLEDGELEVEL
CO1	Utilize various molecular techniques for gene manipulation and detection of mutants.	K3
CO2	Undertake novel research with techniques like PCR and blotting analysis.	K4
CO3	Assess the microbial quality of water and air and relate the results to standards.	K5
CO4	Synthesize biofertilizers and vermicompost. Cultivate mushrooms using solid waste.	K4
CO5	Identify various plant pathogens	K5

NON MAJOR ELECTIVE : II

ORGANIC FARMING AND BIOFERTILIZER TECHNOLOGY

Semester :III **Max Marks :75**

Course Code :24PMB3N2A **Credit : 2**

Total Period : 24 **Exam Hrs :3**

Objective

- Impart knowledge on the importance, types and advantages of organic farming thereby creating awareness on conserving environment and natural resources, encouraging sustainable agriculture.
- Familiarize with the basic concepts of farm development and relate the development of organic farming in their countries to meet global trends.
- Explain the various types of biofertilizer and the scope in its production.

- Discuss about biofertilizer production and its field application, promoting economy.
- Develop the skill to analyze the quality of packaging, storage, assess the shelf life and bioefficacy of biofertilizers

Unit I : Organic farming (4Period)

Organic farming – Definition, relevance. Biological nutrient management - Organic manures, vermicompost, green manure, organic residue, biofertilizer soil amendments. Integrated pest and weed management - Use of biocontrol agents, bio pesticides etc. Organic and Conventional farming. Organic and Chemical farming – Comparison.

Unit II: Certification and Schemes (5 Period)

Certification and Schemes - Certification and Schemes. Organic certification in brief. Integrated farming system- definition, goal, components. Factors affecting ecological balance. Land degradation. Soil health management. Models of IFS for rainfed and irrigated conditions and different categories of farmers. Government schemes - NPOF, NPOF, NHM, HMNEH, NPMSH&F and RKVY.

UnitIII:Biofertilizer (5Period)

Biofertilizers - Introduction, types, advantages and future perspective. Introduction, status and scope. Structure and characteristic features of bacterial biofertilizers- *Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium* and *Frankia*.

Unit IV: Cyanobacteria,fungal Biofertilizers &Nitrogen fixation (5 Period)

Cyanobacterial biofertilizers- Anabaena, Nostoc, *Hapalosiphon*and fungal biofertilizers- AM mycorrhiza and ectomycorhiza. Nitrogen fixation -Free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilization and phosphate mobilization, potassium solubilization.

Unit V : Production technology (5Period)

Production technology - Strain selection, sterilization, growth and fermentation, mass production of carrier based and liquid bio-fertilizers. FCO specifications and quality control of biofertilizers. Application technology for seeds, seedlings, tubers. Biofertilizers - Storage, shelf life, quality control and marketing. Factors influencing the efficacy of biofertilizers.

REFERENCES

1. Sharma A. K. (2001). Hand book of Organic Farming. Agrobios.
2. Gaur A. C. (2006). Hand book of Organic Farming and Biofertilizers. Ambika Book Agency.

3. Subba Rao N.S. (2017). Bio-fertilizers in Agriculture and Forestry. (4th Edition). Med Tech publisher.

4. Subba Rao N. S. (2002). Soil Microbiology. Soil Microorganisms and Plant Growth. (4th Edition). Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

5. Sathe T.V. (2004). Vermiculture and Organic Farming. Daya Publishers.

6. Rakshit A. and Singh H. B. (2015). ABC of Organic Farming. (1st Edition). Jain Brothers.

7. Dubey R. C. (2008). A Textbook of Biotechnology. S. Chand & Co., New Delhi.

8. Bansal M. (2019). Basics of Organic Farming. CBS Publisher.

9. Bhoopander G., Ram Prasad., (2019) Biofertilizer for sustainable agriculture and Environment, Springer

10. Niir Board., (2012) (1st Edition) Biofertiliser and organic farming

Course Outcomes:

By the end of this course, the students will be able to:

CO Number	**COSTATEMENT**	**KNOWLEDGE LEVEL**
CO1	Produce biofertilizers and distinguish between organic and conventional farming.	K3
CO2	Plan a Complete Farm Business including marketing, operation and financial outline.	K4
CO3	Practice the application of microbial bio-fertilizers in large scales, thereby increasing soil fertility.	K3
CO4	Develop integrated farming for sustainable agriculture.	K4
CO5	Promote the quality of packaging, storage, increase shelf life, accelerate the bio efficacy of bio fertilizers as per BIS standards	K5

MappingwithProgrammeOutcomes:

Cos/Pos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**S**	**S**	**S**	**S**	**S**
CO2	**M**	**S**	**S**	**S**	**M**

CO3	**S**	**S**	**S**	**M**	**S**
CO4	**S**	**S**	**S**	**S**	**S**
CO5	**S**	**S**	**S**	**M**	**S**

S-Strong,M-Medium,L-Low

NON-MAJOR ELECTIVE: II

BIOENERGY

Semester : III **Max Marks : 75**

Course Code : 24PMB3N2B **Credit : 2**

Total Period : 24 **Exam Hrs : 3**

Objectives:

- Acquire knowledge on bioenergy utilizing organic wastes for energy recovery.
- Discuss methods and strategies of exploiting microbes for the production technology of biodiesel.
- Describe resources and techniques for the production and estimation of eco-friendly biofuels and the extent of their use potentially.
- Gain knowledge for executing biogas plant in communities.

- Explain possibility of using microbes for the production of bio-hydrogen as a source of future fuel.

UNITI-Introduction (4Periods)

Bioenergy – Biomass Energy Resources. Biomass conversion methods. Microbes as bioresources for bioenergy products (Bacteria, fungi, yeast and microalgae) - Bioprospecting of microbial strains for biofuel production.

UNIT II- Biodiesel (5Periods)

Biodiesel − Microbes and Biodiesel. Production and feed stock. Techniques of lipid extraction and conversion to biodiesel. Biodiesel quality and its assessment. Strategies of genetic engineering of organisms for biodiesel production. Biodiesel production from single cell organisms (*Cryptococcus, Cunninghamella, Mortierella*).

UNITIII-Fuels from Microorganisms (5Periods)

Alcoholic Fuels from microorganisms: Biochemical conversion to ethanol: Biomass pre-treatment, Starch to sucrose conversion and Sucrose to ethanol fermentation. Role of enzymes and their applications in ethanol production. Distillation and Quantification of ethanol. Production and Estimation of biobutanol, biomethanol, biopropanol and bioglycerol.

UNIT IV-Biogas (5Periods)

Biogas - Microbes and Biogas production, Biogas plants – types – design – construction– Biogas Bottling

Technology and Development in India, Biogas appliances – burner, luminaries and power generation – effect on

engine performance. Application of Biogas slurry in agriculture**.**

UNITV- Biohydrogen (5Periods)

Biohydrogen– Production from bacteria and algae. Commercialized microalgae (*Spirulina, Dunaliella, Hematococcus and Chlorella*) and their production. Economics of microalgae production. Cultivation of seaweeds. Microbial fuel cells.

REFERENCES

1.Dahiya A. (2014). Bioenergy- Biomass to Biofuel. (1st Edition). Academic Press Editor.

2. Brown R. C. (2003). Biorenewable Resources: Engineering New Products from Agriculture. (1st Edition). Wiley Blackwell Publishing.

3. Jawaid M., Hakeem K. R. and Rashid U. (2014). Biomass and Bioenergy: Processing and

Properties. (1st Edition). Springer Cham

4. Caye M. Drapcho, Tery H. Walker (Biofuels EngineeringProcess Technology. McGraw Hill.

5. Teri. Bio energy Powering the Future. Pearson Longman Publications.

6. Konur O. (2018). Bioenergy and Biofuels. (1st Edition). CRC Press.

7. *Lee* J. W.(2012). Advanced Biofuels and Bioproducts. (13th Edition), Springer.
8. Khanal S. (2008). Anaerobic Biotechnology for Bioenergy Production: Principles and Applications. (8th Edition). Wiley-Blackwell Publishing.
9. Pradeep Chaturvedi.(1995). Bioenergy Resources. Concept Publishing Company.
10. Lee S. (2018).Biofuel and Bioenergy. Taylor and Francis

Web Resources

https://www.elsevier.com Biofuels and Bioenergy

https://www.sciencedirect.com › book › bioenergy

https://www.un.org/en/climatechange/what-is-renewable energy?gclid=EAIaIQobChMIqriN2Nao-wIV2HwrCh2pfA5mEAAYASAAEgI-p_D_BwE

https://www.energy.gov/eere/bioenergy/bioenergy-basics

https://www.iea.org/fuels-and-technologies/bioenergy

Course Outcomes:

By the end of this course, the students will be able to:

CO Number	**COSTATEMENT**	**OWLEDGELEVEL**
CO1	Evaluate the various aspects of biomass production and their implementation.	K3
CO2	Design and construct a biodiesel plant.	K4
CO3	Carry out the process of fermentation for bio – alcohol fuels.	K3
CO4	Identify the nature of biogas as a biofuel and their technologies and applications.	K6
CO5	Design, execute and extract biohydrogen from algae.	K6

Mapping with Programme Outcomes:

Cos/Pos	PO1	PO2	PO3	PO4	PO5
CO1	S	S	M	S	S
CO2	M	S	S	S	S
CO3	S	S	S	M	S
CO4	S	S	S	S	S
CO5	S	S	S	S	S

S-Strong, M-Medium, L-Low

CORE COURSE XI

FOOD AND DAIRY MICROBIOLOGY

Semester : IV **Max Marks :75**

Course Code : 24PMB4C11 **Credit : 5**

Total Period : 75 **Exam Hrs : 3**

Objectives:

- Discuss microorganisms involved in food spoilage.
- Illustrate bacterial and nonbacterial food borne infections important in public health.
- Familiarize various national and international aspects of food safety and quality assurance.
- Elaborate on microbiology of milk, preservation techniques and production of dairy products.

- Explain Dairy plant hygiene, quality control and waste disposal.

UNIT I Microorganisms of food (15Periods)

Microorganisms of food- Scope of food Microbiology. Contamination and spoilage of food – vegetables, fruits, poultry, fish, eggs, meat, meat products and canned foods. Food Preservation - Temperature (low and high), drying, radiation and chemicals.

UNIT II Food infections (15Periods)

Food microbiology and public health. Food hazards. Food infections - Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli, Salmonella, Shigella, Yersinia enterocolitica, Listeria monocytogenes and Campylobacter jejuni. Nonbacterial food borne illness - Helminthes, nematodes, protozoa, toxigenic fungi and food borne virus.

UNIT III Quality assurance of food (15Periods)

Quality assurance of food - International aspects of Quality and safety assessment of foods. Microbiological quality standards for food. Government regulatory practices and policies - FDA, HACCP, BIS (IS), FSSAI-2014. Food adulteration and common food additives.

UNIT IV Dairy microbiology-I (15Periods)

Introduction to Dairy microbiology – Milk production and hygiene. Microorganisms associated with milk. Microbial metabolites and their role in spoilages- souring, curdling, gassiness, ropiness, proteolysis, lipolysis, abnormal flavour and colour. Antimicrobial systems in raw milk. Microbiological grading of raw milk. Milk borne diseases and their control. Bacteriological aspects of milk processing – Thermization, pasteurization, boiling, sterilization, UHT, bactofugation, and membrane filtration.

UNIT V Dairy microbiology-II (15Periods)

Composition and chemistry of cream, butter, ghee, ice-cream, cheese, kefir, koumiss, rennin, condensed and dried milks, infant food. Spoilage of ghee and use of antioxidants. Chemistry of milk fermentation. Chemistry of rennin coagulation of milk and changes occurring during ripening of cheese, physico-chemical changes in the manufacture and storage of milk powder, lactose, crystallization and its significance. Dairy plant hygiene and sanitation. Disposal of dairy waste. Microbiological standards for Milk and Milk products- PFA BIS, Codex/ ISO standards.es. Patent licensing and agreement. Patent infringement-meaning, scope, litigation, case studies.

REFERENCES

1. Adams M. R. and Moss M. O. (1996). Food Microbiology, New Age International (P) Limited Publishers, New Delhi.
2. Frazier W.C., Westhoff. D. C. and Vanitha K.N. (2013). Food Microbiology. (6th Edition). McGraw Hill Education.
3. Jay J. M., Loessner M. J. and Golden D.A. (2006). Modern Food Microbiology.(7th Edition). Springer.
4. Doyle M. P., Buchanan R. L. (2012). Food Microbiology: Fundamentals and Frontiers. (4th Edition). American Society for Microbiology Press.
5. Ray B. and Bhunia A. (2013). Fundamentals of Food Microbiology. (5th Edition). CRC Press.
6. Robinson R. K. (2000). Dairy Microbiology3rdedn, Elsevier Applied Science, London.
7. Adams M.R, and Moss M.D, (2005). Food Microbiology 4thedn, New Age International Pvt. Ltd., Publishers.First edition.
8. Banwarst. G.J. (2003). Basic Food Microbiology 2nd edn, CBS Publishers and distributors.
9. Hobbs, B.C. and Roberts, D, (1968), Food Poisoning and Food Hygiene 7thedn. Edward Arnold: London.
10. Vijaya R K, (2004). Food Microbiology 1st edn. MJP Publishers, Chennai.

Web Resources

https://www.fssai.gov.in

https://www.who.int/news-room/fact-sheets/detail/food-safety

https://www.fda.gov/food/hazard-analysis-critical-control-point-haccp/haccp-principles-application-guidelines

Course Outcomes:

By the end of this course, the students will be able to:

CO Number	**COSTATEMENT**	**NOWLEDGELEVEL**

CO1	Utilize the knowledge on process of food contamination and spoilage to preserve food.	K1
CO2	Use the knowledge on food borne disease to protect public health.	K2
CO3	Familiarize various national and international aspects of food safety and quality assurance.	K3
CO4	Prepare dairy products and perform quality checks.	K4
CO5	Apply microbiological standards to milk and milk products.	K4

Mapping with Programme Out comes:

Cos/P	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	**S**	**S**	**M**	**S**	**S**
CO2	**S**	**S**	**S**	**S**	**S**
CO3	**S**	**S**	**S**	**M**	**S**
CO4	**S**	**S**	**M**	**S**	**S**
CO5	**S**	**S**	**S**	**S**	**S**

S-Strong, M-Medium, L-Low

SEMESTER –IV

RESEARCH METHODOLOGY

Semester : II **Max Marks : 60**

Course Code :24PMB4E2A **Credit : 3**

Total Period : 24 **Exam Hrs : 3**

Objectives

- To impart scientific, statistical and analytical knowledge for carrying out research work effectively.
- To understand science frameworks for scientific inquiry
- To understand the various methods for conducting empirical research

- To examine trends and patterns in the use of various research methods
- To screen and select the correct journals to publish their research findings

UNIT I: Biosafety regulations (4Periods)

Biosafety regulations - Good laboratory practices - Good manufacturing practices in industry. Storage and disposal of hazardous wastes: radioactive materials – pathogenic strains. GMO's and their release in environment.

UNIT II: Research (5Periods)

Research: research in Biological sciences- Objective – thrust areas and research priorities in Micobiology to meet global competency- Origin of the research problem - Collection of literature: Internet –library – index card preparation - Experimental approach.

UNIT III: Scientific communication (5Periods)

Classification – structure and replication, epidemiology, pathogenesis, prophylaxis of DNA viruses –Pox virus, Herpes virus, Adeno virus and Hepatitis virus. Classification – structure and replication, epidemiology, pathogenesis, prophylaxis of RNA viruses –Picorna virus, Polio, Rabies, HIV Toga and Rota virus.

UNIT IV : Standards of journals (5Periods)

Standards of journals: national and international – online and printed – paid and unpaid – peer reviewed journal – SCI journals – impact factor- h-index,i10 index.Research engines: Elsiever, Springer, Pubmed, Google scholar, Academic journals, online digital library- Social network for research community: Research gate, Research Pages, Frontiers Research Network, Elsevier Lab.

UNIT V: Research Proposal Writing (5Periods)

Writing research proposal for getting financial support – Sponsoring agencies – (DST, DBT, UGC, CSIR, ICMR, MoEF, MoEs, DRDO, DRDE, TNSCTE, TNSCST and NABARD). Research ethics – Intellectual property Rights – Overcome the difficulties in biological research.

REFERENCES

1. Sharma K. R. (2002) Research methodology. National Publishing House, New Delhi.
2. Gurumani N. (2009) Research methodology for biological science, MIP publisher.
3. Geofferey R, Marczyk, David De Mattea, David Festinga. (2005) Essentials of Research Design & Methodology, John Wiley & Sons Publisher.
4. Shanti Bhushan Mishra, Shashi Alok. (2017) Handbook of research methodology.

5. Dawn P. Wooley, Karen B. (2017). Byers Biological Safety: Principles and Practices, 5th Edition.

6. Ann M Korner. (1996) Guide to publish a scienctifc paper, Bioscript Press.

7. Beins B. C. and McCarthy M.A. (2011). Research Methods and Statistics. Pearson Education Inc. New Jersey.

8. Rober A. Day. (1996).How to write and Publish a scientific paper, Cambridge Univeristy Press.

9. Anderson J.B. and Poole M. (2011). Assignment and Thesis Writing. 4th edn. Wiley India Private Limited.

10. Kothari C.R. and Garg G (2004) Research Methodology: Methods and Techniques. 2nd Edition. New Age International Publishers

Web Resources

https://www.studocu.com/en-ca/document/mount-royal-university/quantitative-research methods- and-data-analysis/lecture-notes-all-lectures/344093

https://archive.nptel.ac.in/courses/102/104/102104061/

https://onlinecourses.nptel.ac.in/noc20_hs06/preview

https://youtu.be/E2gGF1rburw

https://www.youtube.com/watch?v=BECG9ban4rs

Course Outcomes:

By the end of this course, the students will be able to:

CO Number	COSTATEMENT	KNOWLEDGELEVEL
CO1	Get knowledge on research proposal preparation and apply to the sponsoring agencies.	K2
CO2	Benefits through socio-research networks.	K2
CO3	Understanding of the history and methodologies of scientific research, applying these to recent published papers	K3
CO4	Understanding and practicing scientific reading, writing, presentations	K5
CO5	Appreciating scientific ethics through case studies.	K6

Mapping with Programme Outcomes:

Cos/Pos	PO1	PO2	PO3	PO4	PO5
CO1	S	S	S	S	S
CO2	M	S	S	S	S
CO3	S	S	S	S	S
CO4	S	S	M	S	M
CO5	S	S	S	S	S

S-Strong, M-Medium, L-Low

CORE ELECTIVE COURSE:III

MARINE MICROBIOLOGY

Semester : II **Max Marks :60**

Course Code :24PMB4E2B **Credit : 5**

Total Period : 75 **Exam Hrs :3**

Objectives

- Gain fundamental knowledge of marine environment and the microbial communities inhabiting the oceans.
- Discuss the metabolic diversity of marine microorganisms and their interrelationships.
- Explain the survival of microorganisms in extreme environments.

- Illustrate pathogens and contaminants in sea foods.
- Describe the applications of marine biotechnological products and their future role in a rapidly changing planet.

UNIT I: Marine Environment : (15Periods)

Marine microbial environment - Benthic & littoral zone, salt pan, mangroves and estuarine microbes, microbial loop. Marine microbial communities – Bacteria, fungi, protozoa. Microbial interactions – Endosymbionts and Ectosymbionts.

UNIT II: Dynamics of Marine Microbes (15Periods)

Dynamics of Marine Microbes - Carbon cycle: Phototrophic microbes, the oceanic carbonate system and global warming – Nitrogen cycle: Nitrogen fixers – Iron limitation – ocean fertilization – phosphorus cycle. Decomposition of organic matter. Bioleaching and biodeterioration of natural and synthetic materials.

UNIT III: Marine extremophiles (15Periods)

Marine extremophiles: Mechanism of survival at extreme environments – Adaptive mechanisms in thermophilic, alkalophilic, osmophilic, barophilic, psychrophilic hyperthermophilic and halophilic microorganisms – Importance in biotechnology.

UNIT IV: **Marine Microbial Diseases (15Periods)**

Marine Microbial Diseases: Aqua culture pathogens & Water borne pathogens -Aeromonas, Vibrio, Salmonella, Pseudomonas, Leptospira, Corynebacteria and viral diseases. Rapid diagnosis of contamination in sea foods and aquaculture products.

UNIT V: Marine Microbial Biotechnology (15Periods)

Applications of Marine Microbial Biotechnology: Production and applications of marine microbial products – Enzymes, Antibiotics, Organic acids, Toxins, Biosurfactants and Pigments. Sea food preservation methods. Probiotic bacteria and their importance in aquaculture.

REFERENCES

1. Munn C. B. (2019). Marine Microbiology: Ecology and Applications. (3rd Edition). CRC Press. ISBN:9780367183561.
2. Bhakuni, D.S. and Rawat D. S. (2005). Bioactive Marine Natural Products. Anamaya Publishers, New Delhi. ISBN:1-4020-3472-5.
3. Brock T. D. (2011). Thermophilic Microorganisms and Life at High Temperatures. Springer. ISBN-13:978-1461262862 / ISBN-10:1461262860.
4. Nybakken, J.W. (2001). Marine Biology. (5th Edition). Benjamin Cummings. ISBN:0321030761 9780321030764.

5. Veena. (Understanding marine biology. Discovery Publishing.
6. Maier R. M., Pepper I. L. and Gerba C. P. (2006). Environmental Microbiology. (2nd Edition). Academic Press. ISBN:978-0-12-370519-8.
7. Belkin S. and Colwell R. R. (2005). Oceans and Health: Pathogens in the Marine Environment. Springer. ISBN:978-0-387-23708-4.
8. Scheper T. (2009). Advances in Biochemical Engineering/Biotechnology-Marine Biotechnology. Springer. ISBN:978-3-540-69356-7. E-ISBN:978-3-540-69357-4.
9. Gasol J. M. and Kirchman D. L. (Eds.). (2018). Microbial Ecology of the Oceans. (3rd Edition). Wiley-Blackwell. ISBN:978-1-119-10718-7.

CO Number	COSTATEMENT	OWLEDGE LEVEL
CO1	Apply the knowledge on marine microbial communities and their interactions.	K3
CO2	Illustrate the role of marine microorganisms in biogeochemical cycles.	K2
CO3	Categorize the extreme environments in the oceans and the survival mechanisms adapted by the microorganisms living in these environments.	K4
CO4	Identify the diseases affecting marine organisms and its diagnosis.	K4
CO5	Evaluate the marine microorganisms as a resource for novel microbial products.	K5

10. Kim S. K. (2019). Essentials of Marine Biotechnology. Springer.

Web Resources

https://link.springer.com/content/pdf/bfm%3A978-0-387-23709-1%2F1
https://www.researchgate.net/publication/285931262_Bioactive_Marine_Natural_Products
http://link.springer.com/content/pdf/bfm%3A978-3-642-03470-1%2F1.pdf
https://link.springer.com/book/10.1007/b102184
https://www.wiley.com/en-bs/Microbial+Ecology+of+the+Oceans%2C+3rd+Edition-p-9781119107187

Course Out comes:

By the end of this course, the students will be able to:

Mapping with Programme Outcomes:

Cos/Pos	PO1	PO2	PO3	PO4	PO5

CO1	**S**	**S**	**M**	**S**	**S**
CO2	**S**	**S**	**S**	**S**	**S**
CO3	**S**	**S**	**S**	**M**	**S**
CO4	**S**	**S**	**S**	**S**	**S**
CO5	**S**	**S**	**S**	**S**	**S**

S-Strong, M-Medium, L-Low

PROJECT WORK WITH VIVA VOCE

Semester : IV **Max Marks : 60**

Course Code : 24PMB4PW **Credit : 6**

Total Period /Week : 16 **Exam Hrs : 3**

OBJECTIVES OF THE COURSE

To impart advanced practical knowledge to conduct a research project.

To plan and design statistically, retrieve relevant literature, organize and conduct, process the data, photograph relevant observations, evaluate by statistical programmes.

Present the project in any regional/national conference/seminar

The work has to be conducted in department under the guidance of the project supervisor.

The method of valuation of the project and Industrial visit report submitted by the candidate is outlined as follows:

Internal (2 out of 3 presentations)	-	25 Marks
Viva	-	15 Marks
Project Report	-	60 Marks

LIFE SCIENCES FOR COMPETITIVE EXAMINATIONS

Semester : IV **Max Marks :75**

Course Code : 24PMB4CE **Credit : 2**

Total Period:- 24 **Exam Hrs :3**

Objectives:

- Impart knowledge on structure, metabolism and function of biomolecules.
- Understand the importance of inheritance biology.
- Discuss in-depth about the different types of ecosystems and their importance.
- Outline the major drivers in biodiversity and various conservation approaches.

- Introduce basic concepts of evolution and biological clock

UNIT I **(5Periods)**

Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA). Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins. Structure of atoms, molecules and chemical bonds. Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Bioenergetics.

UNIT II **(4Periods)**

Cellular Organisation, Cell division and cell cycle, Membrane structure and function, Organization of genes and chromosomes, Structural organization and function of intracellular organelles, DNA replication, repair and recombination, Protein synthesis and processing.

UNIT III **(5Periods)**

Inheritance Biology, Mendelian principles- Dominance, segregation, independent assortment, Linkage and Gene mapping, Karyotyping, Extrachromosomal inheritance - Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Human genetics-Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

UNITIV **(5Periods)**

Ecology- Habitat and Niche, biotic and abiotic interactions, Biome- biogeographical zones of India. Ecological Succession, Population Ecology- Characteristics of a population; population growth curves, Environmental pollution-global environmental change, Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Biodiversity Management approaches. Indian case studies on Conservation/Management strategy (Project Tiger, Biosphere Reserves).

UNIT V **(5Periods)**

Evolution and Behaviour- Evolution - Theories- Darwin's, Lamarck's, Oparin Haldane. Paleontological, Embryological and Molecular evidences. Hardy Weinberg's Law. Speciation; Allopatricity and Sympatricity. Adaptive radiation and Convergent evolution; Sexual selection; Co-evolution. Altruism, Biological clocks, Migration and Parental care. Molecular Evolution- Concepts of neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny.

REFERENCES

1. Nelson D. L. and Cox M. M. (2008). Lehningers Principles of Biochemistry. (5th Edition). W.H. Freeman and Company.

2. Chapman J. L. (1998).Ecology: Principles and Applications. (2nd Edition). Cambridge University Press.

3. Krishnamurthy V. K. (2003). Textbook of Biodiversity. Science Publishers.

4. Rogers A. L. (2011). Evidence of Evolution. University of Chicago Press. Chicago.

5. Stites D.P.,Abba I.Terr, Parslow T.G.(1997). Medical Immunology. 9thEdn, Prentice-Hall Inc.

6. Pontarotti P. (2018). Origin and Evolution of biodiversity. (1st Edition). Springer.

7. Verma P. S. and Agarwal V. K. (2004). Cell biology, Genetics, Molecular Biology, Evolution and Ecology. (2nd Edition). S Chand publication.

8. Lewin R. and Foley R. (2004). Principles of Human Evolution. (2nd Edition). Black well Publishing Company.

9. Boyer R.F. (2002) Modern Experimental Biochemistry 3rd Edition. Pearson Education.

10. Wilson K., Walker J., Clokie S and Hofmann A. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edition. Cambridge University Press.

Web Resources

https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_

https://www.livescience.com/474-controversy-evolution-works.html.

https://www.examrace.com/Study-Material/Life-Sciences/

https://www.kopykitab.com/Methods-In-Biology-Life-Science-Study-Material-For-CSIR-NET-Exam-by-Panel-Of-Experts

https://www.erforum.net/2017/01/life-science-biology-handwritten-notes-for-competitive-exams.html

Course Outcomes:

By the end of this course, the students will be able to:

CO Number	COSTATEMENT	KNOWLEDGE LEVEL
CO1	Define, classify and assess the structure, biological functions and interactions of Biomolecules.	K4
CO2	Validate the knowledge of collective and progressive notions of cellular organization.	K5
CO3	Assess and describe the importance of inheritance biology.	K4
CO4	Establish acquaintance and understanding of ecology &	K5

	Biodiversity in a broader sense.	
CO5	Understand the processes of evolution, relate with natural selection, adaptation and speciation.	K6

Mapping with Programme Out comes:

Cos/Pos	PO1	PO2	PO3	PO4	PO5
CO1	**S**	**S**	**S**	**S**	**S**
CO2	**M**	**S**	**S**	**S**	**M**
CO3	**S**	**S**	**S**	**S**	**S**
CO4	**S**	**S**	**M**	**S**	**S**
CO5	**S**	**S**	**S**	**S**	**S**

S-Strong, M-Medium, L-Low