National College (Autonomous)

Tiruchirappalli-620 001.

(For the students admitted from the Academic Year 2022-2023 onwards)

Syllabus for M.Sc., MICROBIOLOGY

PG & Research Department of Biotechnology & Microbiology

National College (Autonomous)

Tiruchirappalli – 620 001.

NATIONAL COLLEGE (AUTONOMOUS)

TIRUCHIRAPPALLI – 620 001.
(College with Potential for Excellence)
(Nationally Reaccredited at 'A+' Level by NAAC)

PG AND RESEARCH DEPARTMENT OF BIOTECHNOLOGY AND MICROBIOLOGY

Vision:

To create potential and competent professionals through career oriented training aided with advanced technical skills and equipping them with professional ethics, environmental and societal apprehension.

Mission:

- Dissemination of global demand based knowledge through teaching with technical professionalism.
- Creation of individuals with social and environmental concern.
- Training the students to create economically and environmentally viable solutions.

Programme Educational Objectives (PEOs):

PEO 1: Cognitive Objective:

PEO 1a: Developing the potential for vertical career growth in microbiology-oriented industries, service sectors and related avenues.

PEO 1b: Inculcating technical and managerial skills crucial for real time scenarios through the enhancement of problem solving skills and advanced technical documentation ability.

PEO 2: Affectionate Objective:

Grooming the students with technical proficiency to equip them for the emergence of sustainable technology and solutions for prevailing environmental, societal and cultural concerns.

PEO 3: Behavioral Objective:

Instilling knowledge and awareness on professional ethics, bioethical and health issues, intellectual property rights and life-long learning through career oriented courses such as IPR, biosafety and bioethics.

Programme Outcomes (POs):

No.	Description
PSO1	Proficient knowledge in the lead domains of Microbiology and its applications
PSO2	Enriched written and verbal communication for the dissemination of knowledge, skills and ideas
PSO3	Efficiency to solve complex problems, critically relate, analyze existing situations and proficiency for the selection of appropriate technologies
PSO4	Knowledge that imparts leadership and teamwork qualities for application in various fields of Microbiology and integrated branches
PSO5	Moral, ethical, societal and environmental awareness associated with sustainability issues.
PSO6	Global standards with multi-cultural competency, self-introspected attitudes and thirst for scientific updation.

National College (Autonomous)

(Nationally Re-Accredited at 'A+' Level by NAAC)

Tiruchirappalli – 620 001.

M.Sc., Microbiology Program Structure under CBCS

(For candidates admitted from the Academic year 2022 – 23 onwards)

SEM	Subject Code	Course	Title of the Paper	Hrs / Week	Credit	Exam Hours	Marks		Total
							Int.	Ext.	Max. Mark
I	P22MB1	Core Course I	General Microbiology	6	6	3	25	75	100
	P22MB2	Core Course II	Microbial Physiology	6	5	3	25	75	100
	P22MB3	Core Course III	Molecular Biology & Microbial Genetics	6	5	3	25	75	100
	P22MB4P	Core Course IV	Lab I: Lab in Microbial physiology, molecular biology, microbial genetics & immunology	6	4	6	25	75	100
	P22MBE5	Elective Course I	Immunology & Immunotechnology	6	4	3	25	75	100
TOTAL				**30**	**24**	**-**	**125**	**375**	**500**
II	P22MB6	Core Course V	Bacteriology	6	5	3	25	75	100
	P22MB7	Core Course VI	Virology	6	5	3	25	75	100
	P22MB8	Core Course VII	Mycology & Parasitology	6	5	3	25	75	100
	P22MB9	Core Course VIII	rDNA Technology	6	5	3	25	75	100
	P22MB10P	Core Course IX	Lab II: Bacteriology, Virology, Mycology and rDNA Technology	6	4	6	25	75	100
TOTAL				**30**	**24**	**-**	**125**	**375**	**500**
III	P22MB11	Core Course X	Microbial Technology	6	5	3	25	75	100
	P22MB12	Core Course XI	Soil & Agricultural Microbiology	6	5	3	25	75	100
	P22MB13	Core Course XII	Food & Dairy Microbiology	6	5	3	25	75	100
	P22MB14E	Elective Course II	Bioinformatics	6	4	3	25	75	100
	P22MB15P	Core Course XIII	Lab III: Microbial Tech, Soil & Agri. Microbio, Food & Dairy Microbio and Bioinformatics	6	4	6	25	75	100
TOTAL				**30**	**23**	**-**	**125**	**375**	**500**
IV	P22MB16	Core Course XIV	Research Methodology, IPR, Biosafety & Bioethics	5	4	3	25	75	100
	P22MBE17	Elective Course XV	Environmental Microbiology	5	5	3	25	75	100
	P22MB P18	Core Course XVI	Project Work	20	10	-	25	75	100
Total				**30**	**19**	**-**	**75**	**225**	**300**
Grand Total				**120**	**90**	**-**	**450**	**1350**	**1800**

SEMESTER – I		CODE - P22MB1
Core Course I: GENERAL MICROBIOLOGY		
CREDITS - 6		HOURS – 6

Objectives:

- To understand the historical background in the field of microbiology
- To study the basic classification and structure of microbes.
- To understand the characteristics of all microbes.
- To explain the control and isolation of microorganisms.
- To describe microbial identification.

Course Outcomes:

On successful completion of the course, learner will be able to:

Cognitive Level	Course Outcomes	Knowledge Level
CO1	Relate scope, concepts and landmark achievements in Microbiology	K1
CO2	Outline the basic understanding of classification of prokaryotic and eukaryotic microbes	K2
CO3	Apply the working principles of microscopy	K3
CO4	Examine cellular and sub cellular components of bacterial cell.	K4
CO5	Evaluate sterilization, disinfection and antimicrobial agents	K5
CO6	Adapt methods and tools for identification and cultivation of bacteria.	K6

C1–Remember C2-Understand C3 –Apply

UNIT-I: Taxonomy:

Definition and scope of Microbiology. Landmark achievements in 20th century. Evolutionary concepts - classification of microorganisms and general principles of nomenclature – Kingdom concepts – Bergeys' classification of Systemic Bacteriology – basic understanding of classification of archaea - viruses, alage, fungi and protozoa.Molecular taxonomy – recent trends.

UNIT-II : Biodiversity:

General characteristics and nature of Archaebacteria – Eubacteria – Cyanobacteria – Mycoplasmas – Rickettsiae – Chlamydias – Spirochaetes – Actinomycetes – Protozoa – Alage – Fungi and Viruses.

UNIT-III : Ultra structure and Cell cycle:
Microbial cell – difference between prokaryotic and eukaryotic microbial cells.Ultrastructure of bacteria – subcellular structures - cell surface – cytoplasmic membrane and other membranous structures – capsule – organs of locomotion – pili and fimbriae.

UNIT -IV : Visualization and methods of identification:
Microscopy - Principles and application of simple - compound, field - phase contrast – fluorescent and electron microscopes. Preparation and staining of specimens of light and electron microscopes. Methods of bacterial identification based morphological, physiological – biochemical – serological properties - Molecular Identification.

UNIT -V : Culture Media and Culture Techniques:
Types of nutrient media.Culture techniques – methods of maintenance and preservation of microorganisms.Concepts of Sterilization and Disinfection – Physical – chemical – Biological control of Microorganisms.Antimicrobial agents and its evaluation.

Text Books:

1.Pelczar T.R. M J Chan ECS and Kreig N R (2006). Microbiology. 5thedition, Tata McGraw-Hill INC. New York.
2.Willey, J., Sandman, K. & Wood, D. Prescott's Microbiology. (2020). 11thedition. McGraw-Hill Education.
3.Hans G. Schlegel. (1993).General microbiology. 7thedition. Cambridge university press.
4.Dubey R.C and Maheswari D.K (2022). A Text of Microbiology. Revised edition, S. Chand and Company Ltd., New Delhi.
5.GeetaSumbali and Mehrotra R.S (2009). Principles of Microbiology. 1stedition, Tata McGraw Hill P. Ltd., New Delhi.
6.Rajan S and Selvi Christy R. (2018). Essentials of Microbiology, CBS Publishers, New Delhi, 2018.
7.Schlegel HG. (2008) General Microbiology, Cambridge University Press, UK.
8.Baveja, C.P. and Baveja, V. (2017). APC Text Book of Microbiology.4thEdition, Arya Publications, New Delhi.
9.Arora D.R. (2020). Textbook of Microbiology, 6thedition. CBS publishers.
10.Salle A.J. (1996). Fundamental principles of Bacteriology, 7th edition. Tata McGraw-Hill publishing company limited, New Delhi.
11.Reba Kanungo. (2020). Ananthanarayan and Paniker's Text Book of Microbiology, 11th edition, Universities Press (India) Private Limited.

Reference Books:

1. Black, J.G. and Black, L.J. (2017). Microbiology: Principles and Explorations. 10th Edition.John Wiley & Sons, Inc.
2. Chess, B. (2021). Talaro's Foundations in Microbiology.11th Edition. McGraw Hill Publishing Company.
3. Tortora, G.J, Funke, B.R. and Case, C.L. (2018). Microbiology: An Introduction. 13th Edition Addison-Wesley.
4. Atlas, R.M. (2015). Principles of Microbiology 2nd edition.WCB McGraw Hill Publications, New Delhi.
5. Madigan, T.M. Martinko, M.J. Bender, S.K. Buckley, H.D. Stahl, A.D. and Brock, T. (2017).Brock Biology of Microorganisms.14thEdition, Licensing agency, UK.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	9	9	9	3	9	9
CO6	9	3	9	9	9	9
Weightage	48	36	36	42	48	54

SEMESTER – I		CODE - P22MB2
Core Course II: MICROBIAL PHYSIOLOGY		
CREDITS - 5		HOURS – 6

Objectives:

- To understand the growth characteristics of microbial cell.
- To learn the carbohydrate and lipid metabolism of microbial cell .
- It provides different aspects of stress physiology .
- To describe different phases of microbial growth and its association.
- To learn energy yielding and efficient metabolism.
- To analyze different phases of microbial growth and its association.

Course Outcomes:

On successful completion of the course, learner will be able to:

Cognitive level	Course Outcomes	Knowledge level
CO1	Define carbohydrate metabolism and energy production	K1
CO2	Illustrate general account on characteristics and metabolism of autotrophs.	K2
CO3	Categorize types and composition of lipids and sterols in microbes	K3
CO4	Explicate microbial stress response and sporulation.	K4
CO5	Interpret growth characteristics of microbes and its regulation	K5
CO6	Predict nutritional requirements, uptake and transport of nutrients in microbes	K6

C1–Remember C2-Understand C3 –Apply

UNIT 1:

Introduction to the Physiology of Microbial cell – Metabolic flow from glucose. Carbohydrate metabolism and Energy production: Glycolytic pathways: EMP pathway – hexose monophosphate – phosphoketolase - oxidative pentose phosphate cycle – ED pathway. Gluconeogenesis – TCA Cycle – Glyoxylate cycle. Energy production – substrate level phosphorylation–oxidative phosphorylation.Energetics of Chemolithotrophs.pH Homeostasis.

UNIT-II:

Pathways for utilization of sugars other than glucose – pectin and aldohexurmate. Cellulose degradation. Utilization of Starch, Glycogen and Related compounds. Metabolism of Aromatic compounds. Fermentation pathways - Anaerobic respiration - Fermentation balances – lactic

acid – Butyric acid – Mixed fermentations - Propionic acid – Acetic acid. General account of the characteristics and Metabolism of Autotrophs.

UNIT-III:

Lipids and Sterols – types and composition in microorganism.Biosynthesis of fatty acids and Phospholipids.Degradation of lipids.Biosynthesis of mevalonate, squalene and sterols.Amino acid biosynthesis – Glutamate family - Aspartate and Pyruvate families, Serine-Glycine families, Aromatic amino acids pathways. Synthesis of Purines and Pyrimidines – Interconversion – Salvage pathways.

UNIT-IV:

Microbial growth and its regulation: Growth of cocci and bacilli - phases of growth curve – growth rate – generation time – synchronous growth – measurements. Nutritional requirements and types of microorganisms.Uptake and transport of nutrients.

UNIT-V:

Factors influencing microbial growth.Microbial associations – biofilm, microbiome – quorum sensing. Stress Physiology – Osmotic stress – pH tolerance, heat shock, starvation stress. Cell differentiation - Bacterial spores – Exo and Endo spores.Cytological, physiological, and genetic aspects of sporulation.Germination and outgrowth of endospores.

Text Books:

1.Moat. A.G. and Foster.J.W. (2017).Microbial Physiology, John Wily sons. White J.D. Motteshead. D.W. Harrison S.J. Enivronmental system.

2.Caldwell, D.R. (1995) Microbial Physiology and metabolism, Wm. C. Brown Publishers, USA.

3.Srivastava, M.L. (2008). Microbial Biochemistry, Narosa Publishing House, New Delhi.

4. Satyanarayana, Uand Chakrapani, U. (2013). Biochemistry, 4thEdition.Book and Allied Pvt. Ltd.

5.Ram ReddyandRedd, S.M. (2022). Microbial Physiology.2ndedition.Scientific publisher.

6.Sokatch, J. R. (2014).Bacterial Physiology and Metabolism.Academic Press.

7. Meenakumari, S. (2006). Microbial Physiology.MJP publisher.

8. Singh,B.D and Singh, R.P.(2009). Microbial Physiology and Microbial Genetics.Kalyani Publisher.

Reference Books:

1.Michael M. Madigan, Kelly S. Bender, Daniel H. Buckley, W Matthew Sattley, David A. Stahl, (2017). Brock Biology of Microorganisms, 15th edition,.Pearson Publisher.

2. David White, James Drummond and Clay Fuqua. (2011).The Physiology and Biochemistry of Prokaryotes. 4thEdition, Oxford University Press.

3. TusharRanjan, Prasad D. B and Sahni S. (2018).A Text Book for Microbial Physiology and Enzymology.Kalyani Publisher.

4.Robert Poole K. (2007). Advances in Microbial Physiology, Volume 53, Elsevier Science and Technology.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	9	9	3	9	9	9
CO6	9	3	9	9	9	9
Weightage	48	36	30	48	48	54

SEMESTER - I		CODE - P22MB3
Core Course III: MOLECULAR BIOLOGY & MICROBIAL GENETICS		
CREDITS - 5		HOURS – 6

Objectives

- To study the characteristics of genetic material and its experimental evidences.
- To learn the structure of nucleic acids.
- To understand the process involved in gene expression, protein synthesis and repair mechanisms.
- To discuss gene transfer mechanisms.
- To understand the gene regulation mechanisms.

Course Outcomes:

On successful completion of the course, learner will be able to:

Cognitive level	Course Outcomes	Knowledge level
CO1	Recall the properties of genetic material and it is replication	K1
CO2	Explain the structure of nucleic acids	K2
CO3	Categorize the repair mechanisms in microorganisms	K3
CO4	Distinguish the types of plasmids and gene transfer mechanisms.	K4
CO5	Determine the gene expression and regulation mechanisms	K5
CO6	Elaborate the process of transcription , translation and their post process modifications.	K6

C1–Remember C2-Understand C3 –Apply

UNIT 1:

Nucleic Acids - DNA and RNA.DNA as genetic material – History, discovery of DNA Structure – Griffith, Avery, Hershey and Chase Experiments.RNA as Genetic Material.Structural features of DNA and RNA.Replication of DNA and RNA – general principles – modes of replication.Replication of circular and linear forms of DNA.

UNIT -II:

Transcription – general principles and steps involved – transcriptional factors. Post transcriptional modifications in prokaryotes – export of RNAs. Translation – events – regulatory elements - post translational modifications.

UNIT-III:

Transfer of genetic information in prokaryotes: Plasmids – types – replication. Conjugation – discovery - F^+ x F^- - Hfr – F' conjugation - Interrupted mating experiments. Transformation –

discovery – competency - Transfection. Transduction – discovery – process and types. Bacteriophage genetics – Lysogenic conversion - transduction mapping.

UNIT-IV:

Recombination – models and genetics of recombination. Transposable elements – IS elements – Transposons – Conjugative transposition - Bacteriophage Mu – Evolutionary considerations. Mutagenesis – nature of events – molecular basis of mutation – evolutionary aspects. DNA repair mechanisms.

UNIT-V:

Regulation of gene expression - Constitutive - inducible and repressible gene expressions. Operon concepts – Lactose – Galactose – Arabinose – Tryptophan – Arginine. Membrane mediated regulation – Put system. Flagellar phase variation.Translational repression.

Text Books:

1. Atherly A. G, Girton J. R and McDonald J. F. (1999). The Science of Genetics, Harcourt College Publishers.
2. David Freifelder. (2004). Molecular Biology, 4thReprint.,Narosa Publishing House, NewDelhi, India.
3. Jeyanthi, G.P. (2009). Molecular Biology, MJP Publishers.
4. Chaudhari,K. (2013). Microbial genetics. Energy and Research Institute.
5. Streips,U.N and Ronald E. Y.(2004). Modern Microbial genetics. 2nd edition.Wiley- Liss Publications.
6. Sinustad, (1997). Principles of Genetics, John Wiley publications.
7. Hemant, K.G and Rajarshi, K.G. (2013). Molecular biology of bacteria. Nova Science Publisher.
8. Ashok, K. Rathoure, Arun Bhatt, ShaliniVerma and Jyoti Gupta.(2018). Basics oof Molecular Biology.Brillion Publishing.
9. Agarwal V.K and Verma P.S (2009). Molecular Biology.1st edition. S.Chand Limited.
10. Rastogi, V.B. (2008). Fundamentals of Molecular Biology,1st edition. Ane Books India.

REFERENCE BOOKS:

1. Gardener, E.J.Simmon, M.J. and Sinustad, D.P. (2006).Principles of Genetics.8th edition John Wiley & Sons.
2. Griffiths A. J, Miller J. H, Suzuki D. T, Lewontin R. C and Gelbart W. M. (2000). An Introduction to Genetic Analysis, W. H. Freeman and company.
3. Trun N and Trempy J. (2004). Fundamental Bacterial Genetics, Blackwell publishers.
4. Watson J.D, Hopokins N.H, Roberts J.W, Stettz J.A and Weiner A.M. (2004). Molecular Biology of Gene, The Benjamin/ Cummings Publishing company.
5. Jocelyn E. K, Elliott S. Gand Stephen T. K. (2017). Lewins Genes XII. Jones & Bartlett Learning.

6. Larry Snyder, Joseph E.P, Tina M.H and Wendy C. (2020). Molecular genetics of bacteria.ASM Press.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	3	3	9	3	9	9
CO6	9	9	9	9	9	9
Weightage	38	36	36	42	48	54

SEMESTER - I		CODE - P22MB4P
Core Course IV: LAB I: MICROBIAL PHYSIOLOGY, MOLECULAR BIOLOGY, MICROBIAL GENETICS AND IMMUNOLOGY & IMMUNOTECHNOLOGY		
CREDITS - 4		HOURS – 6

GENERAL MICROBIOLOGY AND MICROBIAL PHYSIOLOGY

1. Growth of bacteria on liquid and solid media and their cultural characters.
2. Pure culture and subculture techniques.
    a. Biochemical tests for bacterial identification – catalase test –oxidase test – IMVIC test – TSI test – Gelatin liquefaction – starch degradation – carbohydrate fermentation.
3. Antibiotic Sensitivity Test (Kirby-Bauer Method)
4. Bacterial Growth Curve.

MOLECULAR BIOLOGY & MICROBIAL GENETICS

1. Isolation of Plasmid DNA.
2. Isolation of genomic DNA.
3. Estimation of nucleic acids
    a) UV - VIS spectrophotometer analysis.
    b) Analysis of nucleic acids by agarose gel electrophoresis.
4. Detection of proteins by SDS-PAGE.
5. Transformation experiment.

IMMUNOLOGY & IMMUNOTECHNOLOGY

1. Blood Grouping
2. Total WBC and RBC
3. Estimation of Haemoglobin
4. Preparation of Serum components
5. Radial Immunodiffusion test
6. Double Immunodiffusion test
7. Immunoelectrophoresis
8. ELISA

Reference Books:

1. Cappuccino J.G and Sherman N. (2004). Microbiology. A laboratory manual, Pearson Education.
2. Ed. Murray R.G.F, Wood W.A and Krieg N.B. (1994). Methods for Genetics and Molecular Bacteriology. American society for Microbiology.
3. Jayaraman J. (1988). Laboratory Manual of Biochemistry, Wiley Eastern.

4. Kannan N. (2003). Handbook of Laboratory culture media- Reagents- Stains and Buffers, Panima Publishers, New Delhi.
5. Miller J.H. (1992). A short course in Bacterial Genetics, Cold Spring Harbor Laboratory.
6. Rodney Boyer. (2003). An Introduction to Practical Biochemistry, Pearson Education.
7. Sambrook J and Russell D. W. (2001). Molecular Cloning, Cold Spring Harbour Lab. Press.
8. Wilson and Walker. (1994). Practical Biochemistry, Cambridge University Press.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	6	3	9	9
CO5	9	9	9	9	9	9
CO6	6	9	9	9	9	9
Weightage	45	42	42	48	48	54

SEMESTER – I		CODE - P22MBE5
Elective Course I: IMMUNOLOGY & IMMUNOTECHNOLOGY		
CREDITS - 4		HOURS – 6

Objectives

- To understand the cells and organs of the immune system.
- To discuss the process involved in immune responses.
- To acquire knowledge on antigen-antibody interactions.
- To study the autoimmunity reactions.
- To analyse the various types of vaccines.
- To learn the various principles of immunological techniques.

Course Outcomes:

On successful completion of the course, learner will be able to:

Cognitive level	Course Outcomes	Knowledge level
CO1	List out the components of the immune system	K1
CO2	Demonstrate Antigen-Antibody interactions and their applications in diagnosis	K2
CO3	Identify the autoimmunity reactions	K3
CO4	Compare the various types of vaccines	K4
CO5	Reveal the principles and applications of immunological techniques	K5
CO6	Compile immunotolerance, transplantation, tissue injury and inflammation.	K6

Unit 1: The Immune System:

Introduction - Cells of the Immune system - Innate and Acquired immunity - Primary and secondary lymphoid organs – Nature of antigens - Chemical and molecular basis of antigenecity – Immunogenecity - Haptens - Adjuvants - Primary and Secondary Immune Responses - Theory of Clonal selection.

Unit: II Humoral Immunity:

B-lymphocytes and their activation - Structure and function of Immunoglobulin - Isotypes of immunoglobulins - Antigen-Antibody interactions - Antibody affinity- avidity; Agglutination – Precipitation - Idiotypic antibodies - monoclonal antibodies - antibody engineering – Generation of antibody diversity - Major Histocompatibility Complex.

Unit:III Cell Mediated Immunity:

Biology of T lymphocyte - Classification of T lymphocytes - Structure of T Cell Receptor (TCR) - TCR diversity and genetics - Antigen presenting cells (APC) – macrophages - dendritic cells -

Origin and functions of APC - Antigen processing and presentation – Cytokines - Cell mediated cytotoxicity - mechanism of Tcell and NK cell mediated lysis – Complement - Hypersensitivity.

Unit:IV Immunity And Infection Mechanism:
Tissue injury and Inflammation – Immunosuppression - Immunological Tolerance - Immunity to infectious agents – Transplantation – Autoimmunity - Tumor Immunology - Vaccines: Conventional- Molecular vaccines -Types of vaccines - Recent trends in Immunology of Infectiousdiseases.

Unit:V Experimental Immunology:
Immunodiffusion and Immunoelectrophoresis – Hemagglutination - production of polyclonal and monoclonal antibodies - Western Blotting – ELISA - Radio Immunoassay - FACS.

TEXT BOOKS:

1. Parija, S.C. (2016). Text Book of Microbiology and Immunology. 3rd edition. Elsevier India.
2. Apurba S. S and Bhat S. K. (2016). Review of Microbiology and Immunology. Jaypee Brothers Medical Publishers Pvt. Limited.
3. Rao, C.V. (2017) An Introduction to Immunology. 3rdEdition, NarosaPublishing House, India.
4. Kannan I. (2019). Immunology. MJP Publisher.
5. Mohanty S.K and SaiLeela K. (2013). Text book of Immunology. Jaypee Brothers Medical Publishers Pvt. Limited.
6. Joshi, K.R., Osama, N.O. (2012) Immunology, 5th edition, Agrobios Ltd, India.
7. MadhaveeLatha P. (2012). Text book of Immunology. S. Chand & Company.
8. Tizard, I.R. (2000). Immunology: An Introduction. 4th edition. Saunders College Publishing.
9. Peter Wood. (2011). Understanding Immunology. 3rd edition. Prentice Hall.
10. NandiniShetty. (2005). Immunology Introductory textbook. New Age International(P) Limited, Publishers.
11. Ashim K. Chakravarty. (2006). Immunology and Immunotechnology. Oxford University Press.
12. Sharma. (2019). Immunology: An Introductory Textbook, Taylor & Francis.

REFERENCE BOOKS:

1. Delves, P.J., Martin, S.J., Burton, D.R. &Roitt, I.M. (2016). Roitt's Essential Immunology. 13th edition. Wiley-Blackwell Publishers.
2. Punt, J., Stranford, S., Jones, P. & Owen, J. (2018). Kuby Immunology. 8thedition. W.H Freeman Publication

3. Elgert K.D. (1996). Immunology - Understanding Immune system, John Wiley and sons publications.
4. David Male, R. Stokes Peebles and Victoria Male. (2020). Immunology. 9th edition, Elsevier.
5. Thomas J Kindt, Barbara A Osborne, and Richard A Golds. (2006) Immunology online, University of South Carolina.
6. William E Paul. (2012) Fundamental Immunology. 7th revised edition, Raven press, New York.
7. Abul K. A, Andrew H. L and ShivPillai. (2017). Cellular and Molecular Immunology. Elsevier Health Sciences.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	9	3	9	3	9	9
CO6	6	9	9	9	9	9
Weightage	45	36	36	42	48	54

SEMESTER - II		CODE -P22MB6
Core Course V: BACTERIOLOGY		
CREDITS - 5		HOURS – 6

Objectives

- To provide the basic outline of bacteriology.
- To understand the characteristic features and pathogenesis of bacterial pathogens.
- To study the bacterial cell communications.
- To explain human gut microbiome.
- To describe bacterial pathogen control methods.

Course Outcomes (CO)

At the completion of the Course, the student would be able to:

Cognitive level	Course Outcomes	Knowledge level
CO1	Recall the bacterial infections and sources of infections.	K1
CO2	Demonstrate bacterial diseases, their diagnostic methods, prevention & control measures.	K2
CO3	Categorize the Quourum sensing and biofilm.	K3
CO4	Compare the immune regulation of gut microbiota	K4
CO5	Delineate the mechanism of antibiotic resistance.	K5
CO6	Discuss the antimicrobial chemoprophylaxis	K6

C1–Remember C2-Understand C3 –Apply

Unit – I: Introduction to bacteriology:

Significance of bacteriology in Medicine, Koch's postulate, Classification of medically important bacteria, Infections - sources of infections, Types of infections - methods of infections - Definitions - epidemic, pandemic, endemic, Acute, Chronic, systemic and opportunistic diseases. Virulence factors - Adherence Factors, Invasion of Host Cells and Tissues, toxins, enzymes, antiphagocytic factors- human infections-carriers and types. Normal flora of human- skin, respiratory tract, intestinal tract, urogenitary tract.

Unit II: Gram Positive Bacterial Pathogens:

Morphology, cultural characteristics, pathogenesis, clinical symptoms,laboratory diagnosis, treatment, prevention and control of diseases caused by gram positive bacteria: *Staphylococci*, *Streptococci*, *Bacillus anthracis*. *Corynebacterium diptheriae, M. Leprae.*

Unit III: Gram Negative Bacterial Pathogens:

Morphology, cultural characteristics, pathogenesis, clinical symptoms,laboratory diagnosis, treatment, prevention and control of diseases caused by gram negative bacteria *Neisseria* (*Gonococci*&*Meningococci*), *Mycobacterium tuberculosis*, *Clostridium tetani*, *Salmonella*, *Vibrio cholerae*, *E. Coli* – Nosocomial infections- Zoonotic diseases.

Unit IV: Human gut microbiome:

Composition and structure of human GI microbiota- Metabolic functions of the microbiota- Immune Regulation of Gut Microbiota- Gut Dysbiosis and Immune Dysregulation- gut microbiome associated diseases - Probiotics, Prebiotics, Synbiotics- Human probiotics- Probiotic *strains* - *Lactic acid bacteria* (LAB): *Lactobacillus, Leuconostoc, Pediococcus*, *Lactococcus* and *Streptococcus* – *Bifidobacteria*- Genetically modified probiotics (GMP)- mechanism of probiotics -probiotics as therapeutic agents- - Infectious diarrhoea - Lactose intolerance –- Irritable bowel syndrome (IBS) - Allergy - Atopic dermatitis - Bacterial vaginosis - Anticancer effects - Tooth decay and periodontal disease - Probiotics as drug delivery systems – faecal microbiota transplantation (FMT).

Unit V: Control of bacterial pathogens:

Mechanism of action of antibacterial drugs –inhibition of cell wall synthesis,cell membrane function, protein synthesis, nucleic acid synthesis- antibiotic resistance- mechanism of antibiotic resistance - Methicillin resistant *Staphylococcus aureus* (MRSA)- vancomycin resistant *Enterococci faecium* (VREfm)- multidrug resistant *Pseudomonas aeruginosa*-Factors Affecting Antimicrobial Activity - Measurement of antimicrobial activity - disc diffusion, well diffusion, dilution method – agar dilution, broth dilution method - antimicrobial chemoprophylaxis- Antibacterial drugs for Systemic Administration - Penicillins - Cephalosporins - Other Beta-Lactam Drugs- Tetracyclines - Chloramphenicol - Erythromycins- Clindamycin &Lincomycin - Glycopeptides -Bacitracin, Polymyxins - Aminoglycosides - Quinolones - Sulfonamides& Trimethoprim - antimycobacterial drugs.

Text books

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Micro-organisms. 14th edition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht.
6. Riedel, S., Morse, S. A., Mietzner, T. A., & Miller, S. (2019). JawetzMelnick&Adelbergs Medical Microbiology 28th edition. McGraw Hill Professional.

Reference books

1. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.

2. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.

3.Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

4. Patricia Tille (2013) Bailey & Scott's Diagnostic Microbiology, 13th Edition. Elsevier Health Sciences Division.

5. Ananthanarayan, Paniker and ArtiKapil (2013) Textbook of Microbiology, 9th Edition. Universities Press.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	9	9	3	3	9	9
CO5	9	9	9	9	9	9
CO6	9	9	9	3	9	9
Weightage	54	42	31	42	48	54

SEMESTER – II		CODE - P22MB7
Core Course VI: VIROLOGY		
CREDITS - 5		HOURS –6

Objectives:

- To learn distinctive properties of viruses.
- To acquire knowledge on viruses infecting prokaryotes.
- To learn different types of plant diseases caused by viruses.
- To acquire knowledge on different types of viruses causing diseases in animals.
- To learn their methods of cultivation, diagnosis, preventive and treatment measures.

Course Outcomes:

On successful completion of the course, learner will be able to:

Cognitive level	Course Outcomes	Knowledge level
CO1	List the basic properties, classification of viruses and related agents	K1
CO2	Explain about bacteria, viruses and its life cycle	K2
CO3	Classify viral infections, their diagnosis and therapy	K3
CO4	Analyze the general characteristics of plant viruses	K4
CO5	Reveal the clinical aspects of animal viruses	K5
CO6	Elaborate the Identification of viruses by immunological and molecular techniques	K6

C1 – Remember C2- Understand

UNIT I

History and General Properties of viruses – Morphology, ultrastructure and chemical composition- proteins and nucleic acids; Nomenclature and classification. Detection of viruses and antigens in clinical specimens – Serological diagnosis of virus infections. Cultivation of viruses – Vaccines and Interferons – Antiviral agents.

UNIT II

Different classes of bacterial viruses: bacteriophages (T7, lambda and M13 phage) and cyanophage; Life cycle - lytic and lysogenic; Lysogenic repression; Viral genetics: RNA, DNA, single strand and double strand genomes, and their general characteristics.

Unit III

Plant viruses: Morphology, general characteristics, propagation & purification; Plant-viral disease epidemiology, symptoms, diagnosis, prevention and treatment; DNA virus-Cauliflower

mosaic virus, RNA virus- Tobacco mosaic virus, control of plant viruses by CRISRP. Application of Plant Viruses.

Unit IV

Animal viruses: morphology, general properties, classification of Viruses, culture- cell line & embryonated egg; Animal-viral diseases: epidemiology, clinical symptoms, lab diagnosis and treatment; DNA viruses-Orthopox, Adeno, Herpes; RNA viruses- Corona and Polio virus, HIV Viruses, Viral vaccines- Preparation and their immunization schedule.

Unit V

Identification of viruses; Interferons & Antiviral agents; Immune & molecular diagnosis: sero-diagnosis, antibody assay, hemagglutination, complement fixation test, immunofluorescence test, immunoassay, Western blot, and Nucleic acid-Based Amplifications Techniques, RT-PCR; Viral vaccines and phage therapy.

TEXTBOOKS

1. Levy JA, Conrat HF, Owens RA. (2000). Virology. 3rd edition. Prentice Hall publication, New Jersey.
2. Oarsman S.N.J., van Zyl G.U., Nutt L., Anderson M.I. and Preiser W. (2012) Virology Illustrated colour text, 1st Edn. Elsevier Health Sciences.
3. Singh V. (2010) Text book of Virology, 1st Edn. IBDC publishers.

REFERENCE BOOKS

1. Wagner EK, Hewlett MJ. (2004). Basic Virology. 2nd edition. Blackwell Publishing
2. Carter J and Saunders V. (2007). Virology: Principles and Applications. John Wiley and Sons.
3. Diagnostic Microbiology, Bailey and Scott's., 1990. Eighth edition. The Mosby Company.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	9	3	3	3	9	3
CO6	9	3	9	9	9	9
Weightage	48	30	30	42	48	48

SEMESTER – II		CODE -P22MB8
Core Course VII: MYCOLOGY AND PARASITOLOGY		
CREDITS - 5		HOURS – 6

Objectives:

- To acquire knowledge on different types of fungi.
- To learn fungal taxonomy, growth and metabolism.
- To learn about fungal diseases.
- To understand the concepts in parasitological and host-parasite interaction.
- To gain knowledge on parasitic diseases.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcomes	Knowledge level
CO1	Define the General characteristics and classification of fungi and Diversity	K1
CO2	Explain about the Plant fungal interactions	K2
CO3	Categorize animal diseases caused by fungi	K3
CO4	Examine the concept of parasitism and host-parasite Interaction	K4
CO5	Elaborate the History and scope of parasitology. Evolution of parasites	K5
CO6	Examine General Parasitology, Classification, general morphology, biology, mode of transmission, pathogenicity, laboratory diagnosis	K6

C1 – Remember C2- Understand

Unit I

Elements of mycology- fungal physiology, structure, morphology, classification, taxonomy (conventional and molecular) and diversity. Fungal spores. General characteristics and growth requirements of yeast, molds and mushrooms. Life cycle of major fungal phyla (Asco-, Basidio-, Glomero-, Chitridio- and Zyco-mycota). Economic importance of fungi with special reference to antibiotics, organic acids, enzymes, fungal SCP, edible mushrooms.

Unit II

Plant fungal interactions- Plant diseases caused by fungi: General aspects, effects, symptoms, causal organisms, disease cycle and control measures of wart disease of potato, white rust of crucifers, leaf curl of peaches, smut disease of onion and leaf spot disease of groundnut.

Beneficial interactions- fungal endophytes – its influences in plant survival, growth, defenses and phyto-harmone production. Mycorrhizal symbiosis – molecular mechanism behind the establishment. Role of fungi in agriculture. Fungal biocontrols.

Unit III

Animal fungal interactions - Animal Diseases caused by Fungi. Opportunistic fungal infections. Causative agents, mode of infection, control and treatment for Aspergillosis, Mucormycosis, Candidiasis, Cryptococcosis. Infections due to zoophilic pathogens with near-direct transmission – Chytridiomycosis. Zoonotic outbreaks with direct animal to human transmission - Microsporumcanis from cats. Mycotoxins and mycotoxicoses. Antifungal resistance in animals with fungal infections, Mechanisms of antifungal resistance. Mutualistic relationship of fungi and fungivores – ants & fungi, anaerobic fungi in ruminant's gut.

Unit IV

General Parasitology: History and scope of parasitology. Evolution of parasites. Zoogeography of Parasites. Niches, habitats and environments. Parasite fauna in different phyla. Parasitism. Phoresis. Hyperparasitism. Parasitoides. Mechanism of parasitic invasion. Ecology of parasitism - Relation of parasite fauna with food, age and migration of the host and seasons of the year. Host specificity. Emerging and re-emerging parasitic diseases. Host-parasite interaction, Host resistance and defense mechanisms against parasites.

Unit V

Medical Parasitology: Protozoa: Classification, general morphology, biology, mode of transmission, pathogenicity, laboratory diagnosis and prophylaxis of protozoan parasites: *Giardia lamblia*, *Trypanosoma*spp, *Plasmodium* spp. Nematodes: Classification, general account, biology, mode of transmission, pathogenicity, laboratory diagnosis and prophylaxis of *Trichuristrichura*, *Strongyloidesstercoralis*, *Dracunculusmedinensis*. Drug resistance in parasites: Apicomplexan parasites, kinetoplastids.

TEXT BOOKS

1. Manoharachary, C., Tilak, K.V.B.R. Mallaiah, K.V. Kunwar I.K. (2016). Mycology and microbiology, Scientific Publishers (India).
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013). Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication.
3. Chatterjee KD, (2019). Parasitology, Protozoology and Helminthology. 13th Edition, CBS Publisher, India.

REFERENCE BOOKS

1. GopinathHait (2017). A Textbook of Mycology. New Central Book Agency (NCBA), India.

2. Subash, C. (1996). Textbook of Medical Parasitology. Pariya and All India Publishers & Distributions, Madras.
3. Jagdish Chander (2018). A Textbook of medical mycology, Fourth Edition, Jaypee Brothers Medical Publishers.
4. Alexopoulos C.J., Mims C.W., Blackwell M.M., (1996). Introductory Mycology, 4th Edition, Published by Wiley.
5. Jayaram Paniker C.K. (2018). Textbook of Medical Parasitology, 7th Edition, Jaypee Brothers Medical Publishers.
6. Chakraborthy, P. (2006). A TextBook of Microbiology. New Central book agency, Kolkata.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	3	9	9
CO3	9	3	3	9	3	9
CO4	3	9	1	3	9	9
CO5	3	1	3	3	3	3
CO6	9	3	9	9	9	9
Weightage	42	28	28	36	42	48

SEMESTER – II		CODE -P22MB9
Core Course VIII: rDNA TECHNOLOGY		
CREDITS - 5		HOURS – 6

Objectives:

- Focused to understand the strategy of recombinant DNA technology
- Discrimination of the molecular tools and cloning strategies
- For future concern important application and the current affairs and understanding the genetic engineering

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcomes	Knowledge level
CO1	Understand the enzymes and their applications.	K1
CO2	Understand the Cloning vectors and the concept of cloning strategies.	K2
CO3	Apply the techniques of blotting and restriction mapping	K3
CO4	Examine the concept of Protein engineering	K4
CO5	Understand the recombinant DNA technology and its applications	K5
CO6	Production of recombinant proteins	K6

C1 – Remember C2- Understand

Unit-I:

Basic techniques involved in rDNA technology: DNA modifying enzymes and their applications. Restriction Enzymes; Types and properties; Enzymes used in cloning (DNA polymerases, RNA Polymerases, Reverse Transcriptase, Ligases, terminal polymerase, RNAase, DNAase, phosphatase).

Unit-II:

Cloning vectors: Plasmids, bacteriophage based vectors: M13 phage based, phagemid. High capacity vectors: Cosmids, YAC, BAC, PAC, and HAC, Baculo virus based vectors, shuttle vectors.

Cloning strategies: Genomic and cDNA libraries. Sequence dependent and independent screening. Expression of cloned genes (Prokaryotic and eukaryotic system). Expression vectors (lac promoter, tryptophan promoter, Lambda promoter, arabinose promoter based).

Unit-III:

Hybridization: colony and plaque hybridization, insitu chromosomal hybridization and chromosome walking. Blotting: Southern, Northern, Western, dot and slot blot. Restriction mapping: DNA sequencing (dideoxy chain termination, Chemical degradation, shotgun sequencing, contig assembly and Pyrosequencing). DNA fingerprinting, SNPs, RFLPs and RAPD.

Unit-IV:

Site directed mutagenesis, Protein engineering. Comparative genomics: analysis and comparison of size and complexity of genomes. RNA level expression profiling with microarrays, MPSS, Chromatin immuno precipitation. Protein level expression - yeast two hybrid system, yeast surface display, phage display. Loss of function Knockout, knockdown, antisense RNA and RNAi, CRISPR-Cas system. Expression analysis by Real Time - PCR.

Unit-V:

Production of recombinant proteins in bacterial and eukaryotic cells: Recombinant insulin, growth hormone (HGH), factor VIII, recombinant vaccines etc. Identification of genes responsible for human diseases, diagnostics and gene therapy. Ethical, legal and social issue.

TEXT BOOKS

1. Brown TA (2016) Gene cloning and DNA analysis: an Introduction. 7th Edition. John Wiley & Sons.
2. Dale JW, Von Schantz M and Plant N (2019) From genes to Genomes: Concepts and Applications of DNA Technology. 3rd Edition. Wiley India Exclusive (CBS).
3. Primrose SB and Twyman R (2014) Principles of Gene Manipulation and Genomics. 7th Edition. John Wiley Blackwell.

REFERENCE BOOKS

1. Saunders VA (2012) Microbial Genetics Applied to Biotechnology: Principles and Techniques of Gene Transfer and Manipulation. Springer Science & Business Media.
2. Watson JD, Tania AB, Stephen PB, Alexander G, Michael L, Richard L (2017) Molecular Biology of the Gene. 7th Edition.Pearson Education.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	3	9	9
CO3	9	3	3	9	3	9
CO4	3	9	1	3	9	9
CO5	3	1	3	3	3	3
CO6	9	3	9	9	9	9
Weightage	42	28	28	36	42	48

SEMESTER – II		CODE -P22MB10P
Core Course IX: LAB II: BACTERIOLOGY, VIROLOGY, MYCOLOGY AND rDNA TECHNOLOGY		
CREDITS - 4		HOURS – 6

BACTERIOLOGY

1. **Processing of clinical specimen, Isolation, Identification and Antibiogram of unknown Bacterial pathogens in specimens.**
   (a) *Staphylococcus* spp.,
   (b) *Streptococcus* spp.,
   (c) *Bacillus* spp.,
   (d) *Escherichia* spp.,
   (e) *Klebsiella* spp.,

VIROLOGY

1. Studying isolation and propagation of animal viruses by chick embryo technique.
2. Isolation of coli phage from sewage

Cultivation of viruses

(a) Egg inoculation methods (all routes)
(b) Animal tissue culture (demonstration)

Serological tests: Serodiagnosis of various viral diseases.

- ELISA – HBV and HIV.
- Complement fixation test.

MYCOLOGY

1. Standard operating procedures of mycology laboratory
2. Preparation of fungal media, pouring of plates and preparation of agar slants
3. Nutritional requirements and culturing molds- Isolation, purification and identification of plant endophytes, plant pathogenic fungi, plant tissue culture contaminating fungi, soil fungi and air-borne fungus
4. Preservation of molds – glycerol stocks, agar slants, agar-water preservation
5. Isolation, purification and identification of yeast from selective sources-Nutritional requirements and culturing yeast, Yeast culture techniques, Preservation of yeast cultures
6. Nutritional requirements and culturing mushrooms-Mushroom culture techniques and Preservation of mushroom
7. Microscopical examination of molds and yeast -Mounting molds from agar media, Lactophenol cotton blue staining of molds, Crystal violet staining of yeast cells
8. Assessing the viability of yeast cells using methylene blue stain
9. Observation of Mycorrhizae-Scanning electron microscopic observation of fungal spores

10. DNA isolation and purification from molds & yeast- PCR amplification of fungal barcode gene

rDNA TECHNOLOGY

1. Bacterial Transformation
2. Bacterial Conjugation
3. Transduction
4. Isolation of chromosomal DNA from bacteria.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	3	9	9
CO3	9	3	3	9	3	9
CO4	3	9	1	3	9	9
CO5	3	1	3	3	3	3
CO6	9	3	9	9	9	9
Weightage	42	28	28	36	42	48

SEMESTER – III		CODE -P22MB11
Core Course X: MICROBIAL TECHNOLOGY		
CREDITS - 5		HOURS – 6

Objectives

- To understand the industrially important microbes.
- To acquire knowledge on fermented and its operation.
- To learn screening of enzyme producing microbes.
- To describe production of microbial products from agricultural wastes.
- To understand the process of biotransformation.

Course Outcomes (CO)

At the completion of the Course, the student would be able to:

Cognitive level	Course Outcomes	Knowledge level
CO1	List the methods for screening of industrial important microbes.	K1
CO2	Outline the strategies for the formulation of fermentation media.	K2
CO3	Apply the method for assay of enzymes.	K3
CO4	Analyze the production of therapeutic proteins.	K4
CO5	Evaluate the mechanism of downstream processes.	K5
CO6	Predict the method for strain selection and seed preparation.	K6

C1–Remember C2-Understand C3 –Apply

UNIT- I

Industrially important microbes and their improvement: Screening methods for industrial microbes – detection and assay of fermentation products– classification of fermentation types – strain selection and improvement. Mutation and recombinant DNA techniques for strain improvement. Preservation of cultures after strain improvement.

UNIT -II

Design of a fermenter, types of fermenters and basic functions. Up-stream processes – Strain selection, cultivation, seed preparation, fermentation media formulation strategies, role of physical and other parameters for microbial growth, types of fermentation- Down-stream processes - The recovery and purification of fermentations products (intracellular and extracellular), cell disruption, precipitation, filtration, centrifugation, solvent recovery, chromatography, ultrafiltration, drying and etc.

UNIT III

Biofertilizer production technology-strain selection, sterilization, growth and fermentation, standards and quality control –Biopesticides– history of development, production of biopesticides from bacteria, fungi and viruses and their applications against different types of pathogens- Production of microbial enzymes -Strain selection and development, fermentation process and composition of the medium- large scale applications of microbial enzymes-amylases- proteases- lipase- glucose oxidase- cellulose-xylanase- subtilisins- chymosins-enzyme immobilization-.Methods for assay of microbialenzymes.

UNIT IV

Production of alcohol from agricultural wastes:Sugarcane molasses and beetroot- Use of *Zymomonasmobilis*and *Clostridium* for ethanol production-advantages and drawbacks-Production of organic acids-citric acid - acetic acid- lactic acid-Gluconic acid- itaconic acid-microbial production of aminoacids -L-Glutamic acid – L-lysine - L-Tryptophan- Microbial polysaccharides -xanthan, dextran, alginate, gellan, cellulose, curdlan

UNIT V

Microbial production of vitamins: Vitamin B12; Riboflavin-Antibiotic fermentations – production of β lactams (penicillins), semi-synthetic penicillins and cephalosporins, amino-glycosides (streptomycin), macrolids (Erythromycin), quinines – production of therapeutic proteins - interferon, insulin-growth hormone - bioplastics –PHB-PHA- biotransformation of steroids- SCP.

Text Books

1.Baumberg. S., Hunter. I.S. and Rhodes, P.M. 1989. Microbial Products -New approaches. Cambridge Univ. Press. Cambridge.

2. Demain, A.L , Davies, J.E. 1999. Manual of Industrial Microbiology & Biotechnology, ASM press.

3. Prescott ,L.M. Harley, J.P, Klein, D.A .1999. Microbiology , WCB Mc Graw Hill.

4. Robinson ,R.K. 1990. Dairy Microbiology, Elsevier.

5. Tortora, G.J, Funke, B.R, Case, C.L .2001. Microbiology – An introduction , Benjamin Cummings.

6. Creuger and Creuger. Biotechnology, A textbook of industrial Microbiology, Sinaeur associates.

7. Frazier, W.C, Westhoff, D.C. 1988. Food Microbiology, TATA Mc Graw Hill.

Reference Books

1.GIick BR and Pasternak JJ. Molecular Biotechnology – Principles and Applications of Recombinant DNA. ASM Press, Washington DC. 2003.

2. Winnacker EL. From Genes to Clones – Introduction to Gene Technology.First Indian reprint, PANIAMA publishing Co-operation, New Delhi. 2003.

3. Old RW and Primrose SB. Principles of Gene Manipulation – AnIntroduction to Genetic Engineering 5th Ed. Blackwell ScientificPublications, London. 1995.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	9	9	1	3
CO4	9	3	9	9	1	9
CO5	9	3	9	9	9	9
CO6	9	9	9	9	3	9
Weightage	54	18	40	54	16	36

SEMESTER – III		CODE -P22MB12
Core Course XI: SOIL AND AGRICULTURAL MICROBIOLOGY		
CREDITS - 5		HOURS – 6

Objectives

- To understand the distribution of soil microbes.
- To provide the microbial transformation process.
- To discuss the biological nitrogen fixation.
- To acquire knowledge on diseases caused by microbe in crop plants.
- To explain about transgenic plants.

Course Outcomes (CO)

At the completion of the Course, the student would be able to:

Cognitive level	Course Outcomes	Knowledge level
CO1	Define the interactions among soil microorganisms	K1
CO2	Explain about the nitrogen and phosphorus cycles.	K2
CO3	Categorize the bioinoculants and plant growth promoting rhizobacteria.	K3
CO4	Examine the symptoms of various bacterial, fungal and viral plant diseases.	K4
CO5	Assess the mechanism of biological nitrogen fixation.	K5
CO6	Elaborate the process of gene transfer in plants.	K6

C1–Remember C2-Understand C3 –Apply

UNIT I: Soil microbiology:

Distribution of microorganisms in soil, Factors influencing the soil microflora- Interactions among microorganisms: Mutualism, commensalism, ammensalism, synergism, parasitism, predation and competition. Interaction of microbes with plants: Rhizosphere, phyllosphere, mycorrhizaal association – ecto and endomycorrhizae, actinorrhizae.

UNIT II: Microbial transformation and Biogeochemical Cycle:

Carbon cycle- organic matter decomposition- carbon assimilation –C:N ratio- anaerobic decay – humus- microbial degradation of cellulose, hemicellulose, lignin- nitrogen cycle – ammonification- nitrification- denitrification-nitrate reduction- nitrogen assimilation- phosphorus cycle - Solubilization of inorganic phosphorus - Mineralization of organic phosphorus- sulphur cycle.

UNIT III: Biological Nitrogen fixation:

Symbiotic - root nodulation, non symbiotic, organisms -*Azotobacter*sp and *Azospirillum*sp and their functions - Cyanobacteria (BGA) and their associations in Nitrogen fixation. Genetics and Biochemistry of nitrogen fixation- factors influencing nitrogen fixation –Importance of nitrogen fixation. Bioinoculants- Phosphate solubilizing microbes. Mycorhizae and plant growth promoting rhizobacteria (PGPR)-Cultivation, mass production and inoculation of biofertilizers - – Rhizobium, Azotobacter, Azospirillum, Azolla- Carrier based inoculants, methods of application.

UNIT IV: Microbial diseases of crops:

Mechanism of pathogenesis, symptoms and control measures of the following diseases: *Bacterial* - Citrus canker, Red stripe of sugar cane- Fungal diseases; wheat rust, Tikka disease of groundnut, Late blight of potato, cotton wilt (Fusarium) - Viral diseases; TMV and Bunchy top of banana – Plant defense against pathogens: phytoalexins, elicitors and role of salicylic acid- Microbial pesticides- types, mechanisms, advantages and limitations. Brief conception of Integrated Pest Management (IPM).

Unit V: Plant Disease Management:

Promoters/enhancers- Reporter genes- Vectors- Ti plasmid- Ti plasmid derived vectors- disarmed Ti plasmid- Co-integrate vector- Binary vectors- virus vectors - Cauliflower mosaic virus (CaMV)- Gemini Viruses- Transformation techniques in plants - Agrobacterium-mediated gene transfer - Direct gene transfers - electro-portion, particle bombardment, microinjection, liposome fusion- Chemical Gene Transfer – PEG- Calcium Phosphate- transgenic plants- Insect resistant- disease resistant- drought resistant- plantibodies-edible vaccines.

Text Books

1. Borkar, S.G., 2015. Microbes as Bio-fertilizers and their Production Technology (Woodhead Publishing India in Agriculture), WPI Publishing, ISBN: 9380308574.
2. Subba Rao, N.S., 1995. Soil Microorganisms and plant growth, Oxford and IBH, New york.
3. Totawat, K.L., Somani, L.L., Sharma, R.A., Maloo, S.R., 2004. Biofertilizer Technology, Agrotech Publishing Academy. Udaipur, Rajasthan.
4. Subba Rao, N.S., 1995. Biofertilizer in agriculture and forestry, Oxford and IBH, New york.
5. Christon J Hurst, 2002. Manual of Environmental Microbiology. 2nd edition. American Society for Microbiology, Washington.
6. Clescri, L.S., Greenberg, A.E., Eaton, A.D., 1998. Standard Methods for Examination of Water and Waste Water, 20th Edition, American Public Health Association.

Reference books

1. Dirk, J. Elasas, V., Trevors, J.T, Wellington, E.M.H., 1997. Modern Soil Microbiology, Marcel Dekker INC, New York, Hong Kong.
2. Duncan Mara, Nigel Horen, 2003. The Handbook of water and waste water Microbiology. Academic press-An imprint of Elsevier.
3. Gareth M. Evans, Judith C Furlong, 2003. Environmental Biotechnology-Theory and Application, John Wiley and sons Ltd.
4. Kannaiyan. S. (2002), Biotechnology of Biofertilizers, Alpha science international, 1stedition.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	3	9	9
CO3	9	3	3	9	3	9
CO4	3	9	1	3	9	9
CO5	3	1	3	3	3	3
CO6	9	3	9	9	9	9
Weightage	42	28	28	36	42	48

SEMESTER – III		CODE -P22MB13
Core Course XII: FOOD AND DAIRY MICROBIOLOGY		
CREDITS - 5		HOURS – 6

Objectives:

- To gain knowledge about the microorganisms involved in food.
- To gain the knowledge in Microbial spoilage and food preservation.
- To study the food borne infections.
- To study the rules and regulations of food sanitation.

Course Outcomes:

On successful completion of the course, learner will be able to:

Cognitive level	Course Outcomes	Knowledge level
CO1	List the factors affecting the growth of microorganisms in food	K1
CO2	Explain about Spoilage and preservation of food materials.	K2
CO3	Classify food borne diseases, their preservation methods.	K3
CO4	Enrichment culture technique and Food sanitation methods.	K4
CO5	Elaborate the Biosafety cabinets and HACCP	K5

UNIT I

Foods as a substrate for microorganisms – Importance of microorganisms in food - Bacteria, Mold and Yeasts. Sources of food contamination. Factors affecting the Growth - Intrinsic factors - (pH, moisture, oxidation - reduction potential, and nutrient content), extrinsic factors - (temperature, relative humidity, gases and microbial activities) and inhibitory substances.

UNIT II

Importance of food and dairy Microbiology; Factors influencing microbial growth in Foods; Microbial spoilage of various foods - General Principles underlying food spoilage and contamination - Spoilage and preservation of vegetables and fruits, meat and eggs, dairy products and sea foods.

UNIT III

Food borne diseases; Intoxication and food poisoning; Staphylococcus, Clostridium, *Escherichia coli* and Salmonella infections; Principles, physical methods of food preservation: temperature (low, high, canning and drying), irradiation, chemical methods of food preservation: salt, sugar, organic acids.

UNIT IV

Microbes in Milk, Source of contamination, microbiological changes in milk during production and processing, Antimicrobial system in milk, Micro flora of milk – Sources of milk contamination – Milk borne diseases – Ascertaining microbial quality of milk by MBRT. Microbiological standards and quality of dairy products (Cream Butter dried and evaporated milk). Food sanitation and control. Food control agencies and its regulations.

UNIT V

Hazard analysis of critical control point (HACCP) – Principles, flow diagrams, limitations. Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water. PFA, FPO, AGMARK, BIS, Legal Metrology, Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL –1, BSL –2, BSL –3. Environment and Pollution Control Board, Factory License.

TEXT BOOK

1. Vijaya Ramesh K (2007). **Food Microbiology**. First edition, MJP Publishers, Chennai.
2. Adams MR Moss MO (2004). **Food Microbiology**, 2nd Edition, Panima Publishing House, New Delhi.
3. James M Jay (2003). **Modern Food Microbiology**. 4th Edition, CBS Publishers & Distributors, New Delhi

REFERENCE BOOK

1. Frazier WC and Westhoff DC (1988). **Food Microbiology**, 4th Edition, Mc Graw Hill, New York
2. Banwart JM. (1987). **Basic Food Microbiology**. 1st edition. CBS Publishers and Distributors, Delhi, India.
3. Jay JM, Loessner MJ and Golden DA. (2005). **Modern Food Microbiology**. 7th edition, CBS Publishers and Distributors, Delhi, India.
4. Sivashankar B – Moss (2011). **Food Processing and Preservation**. Eighth edition,PHI Learning P.Ltd., New Delhi.
5. Roday, S. (1998). **Food Hygiene and Sanitation**. Tata Mcgraw Hill Publications.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	9	3	9	9
CO5	9	3	3	3	9	3
CO6	9	9	9	9	9	9
Weightage	48	36	36	42	48	48

SEMESTER – III		CODE – P22MBE14
Elective Course II: BIOINFORMATICS		
CREDITS - 4		HOURS – 4

At the completion of the course, the student would be able to:

Cognitive level	Course outcomes	Knowledge Level
CO1	Define basic concepts of bioinformatics, cheminformatics, system biology and find various resources of biological databases	K1
CO2	Explain different formats of biological databases	K2
CO3	Apply different algorithms to compute the similarity and identity of biological data	K3
CO4	Analyze the biological sequences with different tools to infer the evolutionary change.	K4
CO5	Evaluate the biological datasets with various web resources and standalone tools	K5
CO6	Predict the structure and functions of biological data and study their interactions.	K6

UNIT I

Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases. Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.

UNIT II

DNA sequence analysis: DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pair wise alignment techniques; motif discovery and gene prediction; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

UNIT III

Multiple sequence analysis: Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

UNIT IV

Protein modelling: Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.

UNIT V

Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of in silico drug design.

TEXT BOOK

1. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
2. David W. Mount, Bioinformatics – Sequence and Genome analysis, Cold Spring Harbor Laboratory Press, New York, 2001.
3. G. Gibson &S.V.Muse, A Primer of Genome Science, Sinauer Associates, Inc. Publishers, 2002.
4. A. Baxevanis and B.F. Ouellette. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiley- Interscience, Hoboken, NJ, 2005.
5. A. M.Campbell& L. J. Heyer, Discovering Genomics, Proteomics & Bioinformatics, CSHL Press, 2003.

REFERENCES

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., &Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.

6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press

WEB RESOURCE LINKS

1. www.Bioinformatics.org
2. www.bioinfo.mbb.yale.edu/mbb452a/intro/
3. www.biology.ucsd.edu/others/dsmith/Bioinformatics.html

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	9	9	1	3
CO4	9	3	9	9	1	9
CO5	9	3	9	9	9	9
CO6	9	9	9	9	3	9
Weightage	54	18	40	54	16	36

SEMESTER – III		CODE – P22MB15P
Core Course XIII: LAB III: MICROBIAL TECH, SOIL & AGRI. MICROBIO, FOOD & DAIRY MICROBIO AND BIOINFORMATICS		
CREDITS - 4		HOURS – 6

MICROBIAL TECH

1. Screening of antibiotic producing microorganisms by crowded plate method.
2. Screening of enzyme producing microorganisms by plate assay method- amylase, protease.
3. Production of enzyme by submerged fermentation and assay of enzyme.
4. Immobilization of enzyme.

SOIL & AGRI. MICROBIO

1. Isolation of bacteria, fungi and actinobacteria from rhizosphere soil
2. Isolation of Rhizobium from root nodule
3. Isolation and culturing of Azotobacter
4. Isolation of cyanobacteria from paddy field
5. Mass production of Azolla
6. Isolation of cellulose degrading bacteria from compost
7. BOD
8. COD
9. MPN technique

FOOD & DAIRY MICROBIOLOGY

1. Enumeration of microorganisms in food samples- vegetables and fruits.
2. Isolation of fungi from spoiled bread
3. Microbial examination of curd
4. Qualitative testing of milk by MBRT (Methylene Blue Reduction Test) & Resazurin test
5. Isolation, purification and identification of fungi from spoiled foods
6. Detection of aflatoxin contamination in food products

BIOINFORMATICS

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.

7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.
13. Use of tools for mutation and analysis of the energy minimization ofprotein structures.
14. Use of miRNA prediction, designing and target prediction tools.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	9	9	1	3
CO4	9	3	9	9	1	9
CO5	9	3	9	9	9	9
CO6	9	9	9	9	3	9
Weightage	54	18	40	54	16	36

SEMESTER - IV		CODE – P22MB16
Core Course XIV: RESEARCH METHODOLOGY, IPR, BIOSAFETY & BIOETHICS		
CREDITS - 5		HOURS – 5

UNIT I

History of science and science methodologies Empirical science; scientific method; manipulative experiments and controls; deductiveand inductive reasoning; descriptive science; reductionist vs holistic biology.Characteristics and significance of a good research.

UNIT II

Developing a research proposal. Selection and formulation of the research problem. Literature review. Formulation of researchobjectives. Development of workable hypothesis.

UNIT III

Research design. Sampling and sample size. Data sources and collection techniques. Data analysis. Data presentation. Formats for references. Writing a research report/proposal/thesis. Writing a research paper for a journal of international repute.

UNIT IV

Ethics of research and publication. Plagiarism and Self-Plagiarism.

UNIT V

Use of tools / techniques for Research: methods to search required information effectively,Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism.

REFERENCES

1. Gurumnani, N., (2006). Research methodology for biological sciences (1st Edition). MJP Pubsihers. A unit of Tamilnadu Book House, Chennai.
2. Bajpai, S. (Ed.), (2006). Biological instrumentation and methodology. Chand & Company Ltd., New Delhi,
3. Jeffrey A. W. and L. S.Myra, (2002). Statistics for the Life Sciences (3rd Edition). PrenticeHall
4. Essentials of Immunology by Riott I .M. 1998. ELBS, Blackwell Scientific Publishers, London.
5. Glick, B.R. and J.J.Pasternack, (1998). Molecular Biotechnology (2nd Edition). ASM Press, Washington, DC.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	1	9	3	3
CO2	9	3	3	9	1	3
CO3	9	1	9	9	3	3
CO4	9	9	9	9	9	9
CO5	9	3	9	9	9	9
CO6	9	9	9	9	3	9
Weightage	54	29	40	54	28	36

SEMESTER - IV		CODE – P22MBE17
Elective Course XIII: ENVIRONMENTAL MICROBIOLOGY		
CREDITS - 5		HOURS – 5

UNIT I:

Diverse groups of rhizosphere soil microorganisms. Nature of interactions: plant-microbe interactions, microbe-microbe interactions. Molecular mechanisms involved in microbial interactions and sensing molecules. Uncultivable soil microorganisms' identification through molecular techniques. Genetically modified crops adaptation through rhizosphere engineering.

UNIT II: Bioremediations

Definition and concepts bioremediation. Biostimulation of Naturally occurring microbial activities, Bioaugmentation, in situ, ex situ, intrinsic & engineered bioremediation. Solid phase bioremediation - land farming, prepared beds, soil piles, Phytoremediation. Composting, Bioventing &Biosparging; Liquid phase bioremediation - suspended bioreactors, fixed biofilm reactors. Bioremediation of toxic metal ions biosorption and bioaccumulation principles. Concepts of phytoremediation. Microbial leaching of oredirect and indirect mechanisms. Mining and metal. Use of microorganisms in augmentation of petroleum recovery. Biotechnology-with special reference to Copper and Iron.

UNIT III :Biopolymers

Definition of Biopolymers and types of biopolymers, definition of bio-plastics, Types of bio-plastics, such as starch based, cellulose based plastics and some aliphatic polyesters (PLA, PHB), polyamides, Bio-Based Composites from Soybean Oil and Chicken Feathers, bioderived polyethylene and genetically modified bioplastics. Environmental impact such as Bio-plastics and biodegradation. Biodegradable polymer classes, Natural biodegradable polymer, Synthetic biodegradable polymer and modified naturally biodegradable polymer.Non-biological and biological degradable polymer. Measuring of biodegradation of polymers-Enzyme assays, Plate test, Respiratory test, Natural environment.

UNIT IV: Cyanobacterial Applications

Collection and preservation of algal samples.Isolation, purification and maintenance of cultures. Mass culturing methods: open and closed culture system – Various cell harvesting strategies: centrifugation – sedimentation- flocculation- flotation – filtration methods.Environmental importance of algae: CO2 mitigation and sequestration- hydrocarbon degradation – heavy metal biosorption – harmful algal blooms – phycotoxins – toxic effect to aquatic organisms and its application in biomedical field.

UNIT V: Mosquito control

Mosquito borne Disease and Control: malaria- Lymphatic filariasis and Dengue, chikungunya- lifecycle, pathogenicity, Diagnosis, prevention and treatment- Chemical and Biological control of mosquito vector-Production, formulation and evaluation of biocontrol agents- Biological and chemical larvicides, pupicides, repellents for Mosquito, Transgenic mosquitoes. Control programs- Principles of malaria, filarial, Dengue eradication and control in India- NMCP, NMEP, MPO, PfCP, UMS, RBM, EMCP and NVBDCP.

TEXT BOOKS

1.Antonia H and Enrique F(2008). The cyanobacteria: Molecular biology, genomics and evolution, casiter Academic Press, Spain.

2. Bryant DA (1994). The Molecular Biolgy of cyanobacteria, Kluwer Academic Publishers, London.

3.Martina Mackova,; David N. Dowling, Tomas Macek, (2006). Phytoremediation and Rhizoremediation. Springer;

4. Carr NG and WhittonBA (1982). The biology of cyanobacteria, University of California press.

5. Desikachary TV (1959). Cyanophyta Indian council Agricultural Research, New Delhi. pp 686.

6. Dick GJ, Grim SL and Klatt JM (2018). Controls on O2 Production in Cyanobacterial Mats and Implications for Earth's Oxygenation. Annual Review of Earth and Planetary Sciences.

7.Robert AA (2005). Algal culturing techniques, Academic press.

8. Alexander M (1999). Biodegradation and bioremediation. Gulf Professional Publishing.

9. Stanier RY, Ingram JL, Wheelis ML, Painter RR. (1989). General Microbiology, McMillan Publications.

REFERENCE BOOKS

1.Fingerman M (2016). Bioremediation of aquatic and terrestrial ecosystems. CRC Press.

2. Karrely D, Chakrabarty K and Omen G.S. (1989). Biotechnology and Biodegradation,Advances in Applied Biotechnology Series, Vol.4, Gulf Publications Co. London.

3.Ronald M. Atlas, Richard Bartha. (1997). Microbial Ecology: Fundamentals and Applications (4th Edition).Benjamin Cummings.

4. Becker N, Geier M, Balczun C, Bradersen U, Huber K, Kiel E and Rose A (2013). Repeated introduction of Aedes albopictus into Germany, July to October 2012. Parasitology research, 112 (4), 1787-1790.

5.Curtis CF (2000). Medical Entomology for Students, 2nd edn. Mike Service. Cambridge University Press, ISBN 0 521 66659, Epidemiology & Infection, 125 (2), 465-466.

6.Kathleen Walker (2002). A Review of Control Methods for African Malaria Vectors. Infectious Diseases and Nutrition, Bureau for Global Health, U.S. Agency for International Development Washington, DC 20523.

7. Tyagi BK (2012).A Handbook of Medically Important insects and Other Arthropods, Laurier book ltd.
8. VCRC/ICMR (2012). Common protocol for uniform evaluation ofinsecticides/biolaricides for use in vector control.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	1	9	3	3
CO2	9	3	3	9	1	3
CO3	9	1	9	9	3	3
CO4	9	9	9	9	9	9
CO5	9	3	9	9	9	9
CO6	9	9	9	9	3	9
Weightage	54	29	40	54	28	36

National College (Autonomous)

Tiruchirappalli-620 001.

(For the students admitted from the Academic Year 2022-2023 onwards)

CERTIFICATE COURSE- *SPIRULINA* CULTIVATION

PG & Research Department of Biotechnology & Microbiology

National College (Autonomous)

Tiruchirappalli – 620 001.

CERTIFICATE COURSE-*SPIRULINA* CULTIVATION

OBJECTIVES

To enable the students to

i. be familiar with blue green algae
ii. acquire knowledge on taxonomy of blue green algae
iii. know the significance of single cell protein
iv. be familiar with the production of *Spirulina*
v. be acquainted with harvesting of *Spirulina*

UNIT – I

Blue green algae (BGA)- Introduction, morphology and distribution of BGA. Economic importance of BGA. Historical background on the use of Spirulina. Economic importance of Spirulina.

UNIT – II

Taxonomy of BGA-major taxonomic genera of BGA – characters –diagnostic key or the identification of BGA with special reference to Spirulina. BGA collection centers.

UNIT – III

Single Cell Protein (SCP)- Introduction – characteristics of SCP. BGA as a single cell protein: Nutritional value of Spirulina. Therapeutic value of Spirulina. Cosmetic value of Spirulina. Dosage of Spirulina as food and feed. Advantage of algae as SCP.

UNIT – IV

Cultivation of Spirulina - media formulation, indoor cultivation-fish tank method. Outdoor cultivation - inoculum preparation - trough, pit and pot culling method. Large scale production - pond method - Monitoring of production by feeding method, temperature, pH, contamination and density. Spirulina cultivation in waste water.

UNIT – V

Harvesting and Drying of Spirulina, post-harvest technology. Quality control and standards of Spirulina products. Common Spirulina products and their formulations (any three). Socio economic feasibility forSpirulina cultivation.

REFERENCE BOOKS

1. Barsanti,L. and P. Gualtieri, 2006, "Algal-anatomy, biochemistry, and biotechnology", CRC Press, Florida.
2. Baum, A.W., 2013, "Grow your own Spirulina super food",Algaelaborg, USA.
3. Richmond, A., 2004, "Handbook of Microalgal Culture" Blackwell Science Ltd, USA.

LAB IN SPIRULINA CULTIVATION -PRACTICAL

OBJECTIVES

To enable the students to

- Be familiar with isolation of*Spirulina*
- Gain knowledge on media preparation for *Spirulina* cultivation
- Understand indoor cultivation of *Spirulina*
- Be familiar with nutritional analysis
- Be acquired with commercial formulation preparation

LIST OF PRACTICALS

1. Isolation of Spirulina
2. Microscopic examination of *Spirulina*
3. Preparation of Media for *Spirulina* cultivation
4. Inoculation and mass cultivation of *Spirulina* (indoor cultivation)
5. Mass cultivation of *Spirulina* (outdoor cultivation)

REFERENCE BOOKS

1. Andersen, R.A., 2005, "Algal Culturing Techniques", First Edition,Elsevier Academic Press, San Diego.
2. Barsanti,L. and P. Gualtieri, 2006, "Algal-Anatomy, Biochemistry, and Biotechnology", CRC Press, Florida.
3. Richmond, A., 2004, "Handbook of Microalgal Culture: Biotechnology and Applied Phycology", Blackwell Science, Iowa.
4. Sinha, R.K. and R. Sinha, 2008, "Environmental Biotechnology" Aavishkar Publishers, Jaipur.
5. Vonshak, A., 2004, "*Spirulinaplatensis* (Arthrospira)-Physiology, Cell Biology and Biotechnology", Taylor & Francis Ltd., London.