Fergusson College (Autonomous) Pune

Learning Outcomes-Based Curriculum

M.Sc. I - Microbiology

With effect from June 2019

Program Structure

Semester	Course Code	Course Title	Course	No. of Credits
SEM-1	MIC4101	Microbial diversity and Molecular Taxonomy	T-Core-1	04
	MIC4102	Biochemistry	T-core-2	04
	MIC4103	Molecular Biophysics and Instrumentation	T-core-3	04
	MIC4104	Microbiology Practical – I	P-Core-1	04
	MIC4105	Microbiology Practical – II	P-core-2	04
	MIC4106	Applied Microbiology	Elective- 1	04
	MIC4107	Cell and Developmental Biology		
	MIC4108	MOOCS – I		
SEM-II	MIC4201	Microbial Metabolism	T-Core-4	04
	MIC4202	Immunology	T-Core-5	04
	MIC4203	Molecular Biology	T-Core-6	04
	MIC4204	Microbiology Practical – III	P-Core -3	04
	MIC4205	Microbiology Practical – IV	P-Core-4	04
	MIC4206	Virology	Elective-2	04
	MIC4207	Advanced Bio nanotechnology		
	MIC4208	MOOCS – II		
SEM-III	MIC5301	Biostatistics	Special-1	04
	MIC5302	Bioprocess development	Special-2	04
	MIC5303	Practical course based on Biostatistics, Microbial Ecology and Applied Molecular Biology	P-Special-1	04
	MIC5304	Practical course based on Bioprocess development, Food technology and Pharmaceutical Microbiology	P-Special -2	04
	MIC5305	D: Microbial Ecology	Elective- 3	04
	MIC5306	G: Applied Molecular Biology		
	MIC5307	M: MOOCS		
	MIC5308	D: Pharmaceutical Microbiology	Elective - 4	04
	MIC5309	G: Food Technology		
	MIC5310	M: MOOCS		
SEM-IV	MIC5401	Project work and Dissertation-1	P-Special-3	04
	MIC5402	Project work and Dissertation-2	P-Special-4	04

Program Outcomes (POs) for M. Sc. Programme	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the discipline that form a part of an postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	**Social competence :** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise and help reach conclusion in group settings.
PO4	**Research-related skills and Scientific temper:** Infer scientific literature, build sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge**: Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence**: Perform independently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics**: Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability**: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

Program Specific Outcomes (PSOs) for M. Sc. Microbiology	
PSO No.	**Program Specific Outcomes (PSOs)** **Upon completion of this programme the student will be able to**
PSO1	**Academic competence:** **i)** Describe microbial processes that can be used for the development of biochemical and immunological tools to improve the quality of human life. **ii)** Study the cytology, biochemistry, growth as well as application of environmentally and industrially important microbes with a specific emphasis on improving environmental sustainability and human health. **iii)** Describe and understand the concepts of role of microorganisms in geochemical processes like leaching of metals and bioremediation methods.
PSO2	**Personal and Professional competence:** **i)** Apply tools of molecular taxonomy and bioinformatics to the study of diverse microbial groups. **ii)** Evaluate industrially important microbial products in terms of their purity, safety and ethically acceptable application for the benefit of mankind. **iii)** Combine public presentation skills of effective articulation and nonverbal communication with a sound understanding of microbial science to effectively communicate ideas.
PSO3	**Research competence:** **i)** Validate scientific hypothesis and editorialize experimental scientific data by using statistical tools applicable to biological sciences. **ii)** Integrate principles of biology and physical sciences to standardize detection and quantification methods using sophisticated techniques.
PSO4	**Entrepreneurial and Social Competence:** **i)** Employ skill sets related to Quality assurance and testing of pharmaceutically important products in accordance with internationally accepted standards. **ii)** Evaluate the importance of new groups of consumer goods such as prebiotics, probiotics and nutraceuticals. **iii)** Apply the concepts of microbial interactions in basic and advanced treatment of waste water treatment processes.

Course Outcome (CO)		
F.Y. M.Sc. Semester I		
Title of the Course and Course Code	**Microbial Diversity and Molecular Taxonomy (MIC4101)**	**Number of Credits : 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	List the various methods used for sequencing the genomes of micro-organisms and state the reasons for their entry into the unculturable state.	
CO2	Differentiate between Bergey's manuals of Determinative and Systematic Bacteriology. Explain the mechanisms used by extremophiles to survive under extreme conditions.	
CO3	Apply the knowledge of extremophiles and predict their presence in different unexplored environments.	
CO4	Relate the unculturable microbial diversity to different problems such as disease outbreaks.	
CO5	Evaluate the microbial diversity of a habitat using culture dependent as well as the metagenomics approach.	
CO6	Construct a hypothetical phylogenetic tree based on the given characteristics of microorganisms.	

Unit No.	Title of Unit and Contents
I	**Microbial Diversity and Introduction to Bergey's manuals:** **A. Microbial Diversity** i. The expanse of microbial diversity ii. Measurement of microbial diversity using culture – dependent and culture – independent molecular methods **B. Introduction to Bergey's manuals** i. The 5-Kingdom classification system, the 3-Domain classification system ii. Determinative bacteriology (Phenetic approach) iii. Systematic bacteriology (Phylogenetic approach) iv. Chemotaxonomy v. Numerical Taxonomy vi. Polyphasic approach
II	**Study of Extremophiles and extreme environments:** **A. Study of Extremophiles**: Isolation, classification, adaptation mechanisms

	and biotechnological applications of extremophiles i. Thermophiles ii. Psychrophiles iii. Alkaliphiles iv. Acidophiles v. Halophiles vi. Barophiles vii. Methanogens **B. Study of extreme environments** i. Deep Subterranean habitat ii. Thermophilic environment
III	**Identification of Micro-organisms:** **A. Gene sequencing** i. Objectives and challenges of gene sequencing ii. Vectors used in gene sequencing iii. Maxam Gilbert's method of sequencing, iv. Sanger's method of sequencing and automated sequencing v. Newer methods of sequencing such as Pyrosequencing, Ion torrent sequencing, Solexa Illumina Sequencing vi. Strategies for whole genome sequencing vii. Whole Genome Shotgun Sequencing viii. Applications of gene sequencing (identification of organisms) **B. Introductory Bioinformatics**

	i. Types of Databases- primary, secondary, sequence, structure, metabolic ii. Biological data retrieval iii. Pairwise and multiple sequence alignment iv. Scoring matrices v. Needleman-Wunsch Algorithm and Smith-Waterman Algorithm vi. BLAST and FASTA vii. Concept of phylogenetic trees and related terminology iii. Construction of phylogenetic trees using softwares such as Mega ix. Molecular clocks
IV	**Exploration of Un-culturable bacteria** **A.** Concept of unculturable bacterial diversity **B.** Methods of extracting total bacterial DNA from the environment **C.** Concept of metagenomics **D.** Culture-independent molecular methods for identification of unculturable bacteria

Learning Resources

1. Jacquelyn G. Black (2013). Microbiology: Principles and Explorations, 6th Edition. John Wiley and sons Inc.
2. Keller M. and Zengler K. (2004). Tapping in to Microbial Diversity. Nature Reviews 2, 141-150.
3. Pace N. (1997). A Molecular View of Microbial Diversity and the Biosphere, Science, 276, 734-740.
4. John G. Holt et al. (1994). Bergey's manual of determinative bacteriology 9th edition. Lippincott Williams and Wilkins.
5. Bergey's manuals of Systematic bacteriology - 1st edition – all volumes.
6. Michael T. Madigan et al. (2012). Brocks Biology of Microorganisms. 13th Edition Prentice Hall International Inc.
7. Dhamodharan Ramasamy et al. (2014)A polyphasic strategy incorporating genomic data for the taxonomic description of novel bacterial species. International Journal of Systematic and Evolutionary Microbiology, 64, 384–391
8. Horikoshi K. and Grant W. D. Extremophiles (1998). Microbial Life in extreme environments. Wiley Liss Publications
9. Horikoshi K. and K. Tsujii. Extremophiles in deep sea environments (1999). Springer Japan Publications Horikoshi K. Alkaliphiles – Genetic properties and applications of enzymes (2006). Kodansha Springer.

Title of the Course and Course Code	**Biochemistry (MIC4102)**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Recall and use fundamental thermodynamic laws and equations applicable to biological systems	
CO2	Compare the types of noncovalent chemical bonds important in the stability of biomolecules in terms of their prevalence, strength and focus on their importance in biological processes.	
CO3	Apply the knowledge to represent the data obtained from inhibition of enzymes graphically to predict the nature of the inhibitor and its significance. Calculate the thermodynamic transactions occurring in biological systems.	
CO4	Categorize the use of biomolecules as buffering agents based on their dissociation properties and isoelectric pH values.	
CO5	Evaluate the use of molecular transducers and transport proteins in biological systems based on their energy requirements, prevalence and relate the constitutive use of these mechanisms with their biological functions.	
CO6	Specify important allosteric enzymes from biochemical pathways and propose their importance as key regulators of metabolism in biological systems.	

Unit No.	Title of Unit and Contents
I	**Bioorganic Chemistry** **A.** Chemical reactivity: Concept and factors affecting reactivity (Inductive effect, Resonance / Mesomeric effect, Conjugation and Hyper-conjugation,etc.) **B.** Concept of isomerism in biomolecules- tautomers, epimers, enantiomers, stereo isomers etc. **C.** Bonding other than covalent: i. H-bonds ii. Van der Wall's interaction iii. Ionic bonding, Ion dipole iv. Hydrophobic interactions v. Host-guest interactions **D.** Reactions of organic molecules: A brief overview of important reactions in Organic chemistry:Substitution, Addition, Elimination, Rearrangement, Oxidation, Reduction, etc. **E**. Bioorganic mechanism of enzyme catalyzed reactions:

	i. Acid – base ii. Covalent catalysis iii. Metal ion catalysis with examples of respective enzymes **F.** Stereochemistry: i. Three dimensional shape of molecules, ii. Conformation and configuration, **iii.** Structure and biological activity **G.** Concept of pH of weak acids and weak bases i. Henderson- Hasselbalch equation, ii. Concept of buffer, Strength and buffer value iii. Important biological buffers. **H.** Properties of water Problem solving on above topics
II	**Bioenergetics** **A.** Laws of thermodynamics, entropy, enthalpy, Free energy i. Free energy and equilibrium constant, ii. Gibbs free energy equation, iii. Determination of free energy of hydrolytic and biological oxidation reduction reactions, under standard and non-standard conditions, Determination of feasibility of reactions, **B.** High energy compounds, **C.** Coupled reactions, **D.** Atkinson's energy charge, **E.** Phosphorylation potential and its significance Problem solving on above topics
III	**Membrane Transport** **A.** The composition and architecture of Membrane and membrane dynamics **B.** Solute transport across membranes: i. Passive diffusion, ii. Facilitated transport, iii. Primary and secondary active transport using P, V and F type ATPases iv. Ionophores, v. Ion mediated transport, vi. Transport of ions across membranes (ion pumps) **C.** Ligand and voltage gated ion channels **D.** Liposomes and model membranes Problem solving on above topics

IV	**Enzyme Kinetics** **A.** Kinetics of single substrate-enzyme catalyzed reaction. **B**. Kinetics of reversible inhibitions enzyme catalyzed reactions, **C.** King Altman approach to derive – two substrate enzyme catalyzed reactions, **D**. Types of two substrate enzyme catalyzed reactions, **E.** Concept of allosterism, positive and negative co-operativity **F.** Models of allosteric enzymes (Monod, Wyamann and Changuax model, Koshland, Nemethy and Filmer model), **G**. Kinetics of allosteric enzyme, Hill plot, examples of allosteric enzymes and their significance in allosteric regulation Problem solving on above topics

Learning Resources

1.Clayden, Greeves, Warren and Wothers, *Organic Chemistry*, Oxford Press

2. Jerry March, *Advanced Organic Chemistry*, John Wiley

3. Voet Donald and Voet Judith G. (1995) Biochemistry, 2nd Ed. John Wiley and sons, New York.

4. Conn Eric, Stumpf Paul K., Bruuening George, Doi Roy H., (1987) *Outlines of Biochemistry* 5th Ed, John Wiley and Sons, New Delhi.

5. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York.

6. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York

7. Garrett, R. H. and Grisham, C. M. (2004) Biochemistry. 3rd Ed. Brooks/Cole, Publishing Company, California

8. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*, Horwood Pub. Co. Chinchester, England.

9. Berg Jeremy, Tymoczko John, Stryer Lubert (2001) *Biochemistry* 4thEd, W. H. Freeman, New York.

10. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York

Title of the Course and Course Code	**Molecular Biophysics and Instrumentation (MIC4103)**	**Number of Credits : 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Describe the theoretical aspects of UV-Visible, IR, NMR, XRD and mass spectroscopy.	
CO2	Articulate and differentiate working principles, instrumentation and applications of various techniques used to analyze properties and structures of biomolecules.	
CO3	Outline the importance of different biophysical techniques in microbiology.	
CO4	Analyse the structure of biomolecules using XRD and NMR.	
CO5	Review and characterize metal and magnetic nanoparticles using microorganisms.	
CO6	Plan and propose the techniques and underlying theory of UV-Visible, IR, NMR, XRD and mass spectroscopy used to study biomolecules.	

Unit No.	Title of Unit and Contents
I	**Biomolecular Separation and Detection** **A.** Chromatography- Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms **B.** Principle, components of instrument, operation and application of: Gel filtration chromatography, Ion-exchange Chromatography, Affinity chromatography, Gas chromatography, High Performance Liquid Chromatography. **C.** Ultra centrifugation, Differential centrifugation, Isopycnic and Rate zonal centrifugation. • Problem solving on above topics
II	**Spectroscopies of Biomolecules** **A.** Electromagnetic spectrum, Atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra. **B.** UV/Visible spectroscopy- Instrumentation, Molar Absorptivities, Beer and Lamberts Law, Bathochromic and hypsochromic shifts. **C.** Fluorescence spectroscopy- Instrumentation, Quantum Yield, Quenching, FRET, Binding and Folding studies,

	D. Infrared Spectroscopy-Principle, Instrumentation, Absorption bands, FTIR and its advantages, **E.** Circular Dichroism (CD) – Instrumentation, Circular polarization, Cotton Effect. **F.** Mass spectroscopy- Principles of operation, Ionization, Ion fragmentation, Mass Analyzers, GC-MS, MALDI-TOF • Problem solving on above topics
III	**Biophysical Techniques** **A.** X-ray crystallography: Purification of proteins, Crystallization of proteins, Instrumentation, acquisition of thediffractionpattern,basicprinciplesofx-ray diffraction, working and applications **B.** NMR spectroscopy: Basic Principles of NMR, Chemical shift, Intensity, Line width, Relaxation parameters, Spin coupling, Nuclear Overhauser Effect Spectroscopy, Correlation Spectroscopy, Approach to structure determination by2D-NMR •Problem solving on above topics
IV	**Synthesis and Characterization of Bio-Nanoparticles** **A.** Biogenic nanoparticles – Synthesis and applications. **B.** Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; **C.** Significance of the physical properties of nanoparticles **D.** Characterization of nanoparticles, Imaging techniques like TEM (Transmission Electron Microscope), SEM (Scanning Electron Microscope), AFM (Atomic Force Microscopy), Dynamic Light Scattering (DLS), Scanning Probe Microscopy (SPM), EDAX analysis, Zeta analysis. • Problem solving on above topics

Learning Resources

1. Clive Dennison (2002) *A guide to protein isolation*, Kluwer AcademicPublishers.
2. Pattabhi, V. and Gautham, N. (2002) Biophysics. Kluwer AcademicPublishers, New York and Narosa Publishing House, Delhi.
3. David J Holme, Hazel Peck (1998) *Analytical Biochemistry*, 3rd ed.,Prentice Hall, Pearson Education Limited, Harlow England.
4. Nölting, B. (2006) *Methods in modern biophysics.* Second Edition.Springer, Germany.
5. Cotterill, R. M. J. (2002) Biophysics: An Introduction. John Wiley & Sons,England.
6. Pattabhi, V. and Gautham, N. (2002) *Biophysics.* Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.

7. Cavanagh John *et.al.* (1995) *Proteins NMR Spectroscopy: Principles and Practice*, Academic Press.
8. Keeler, J. (2002) *Understanding NMR Spectroscopy*. John Wiley & Sons, England.
9. Drenth, J. (2007) *Principles of protein X-ray crystallography.* 3rd Ed. Springer, Germany.
10. Christof M. Niemeyer and Chad A. Mirkin (2000) *Nanobiotechnology*, John Wiley & Sons.
11. Daniel L. Feldheim and Colby A. Foss, Jr. (2002) Metal nanoparticles synthesis and characterization and application.
12. Marcel Dekker, Inc. MahendraRai and Nelson Duran (2011) *Metal nanoparticles Microbiology*, Springer Verlag Berlin Heidelberg.

Title of the Course and Course Code	**Isolation and Identification of Micro-organisms (MIC4104)**	**Number of Credits: 04**
Course Outcome (CO) **On completion of the course, the students will be able to:**		
CO1	Tell the different methods, culture media and culture conditions used for the cultivation of different microorganisms.	
CO2	Classify the microorganisms into different categories based on their characteristics.	
CO3	Examine the culture conditions or media to obtain the expected results.	
CO4	Analyze the results of the different conducted experiments and relate them.	
CO5	Evaluate the microbial diversity of a habitat using culture dependent methods.	
CO6	Formulate culture media for the cultivation of microorganisms. Construct a hypothetical phylogenetic tree based on the given characteristics of microorganisms using MEGA and PHYLIP software.	

Unit No.	Title of Unit and Contents
I	**Isolation and identification of Eubacteria** Isolationofthefollowing types ofbacteriafromnatural samples.Identificationof the bacteria toatleastthe Genus level usingtheBergey'sManuals: A. Mesophilic bacteria B. Actinomycetes C. Thermophiles D. Halophiles Theidentificationkeymustbedesignedforeachisolatedand identifiedbacterium.Studentsareexpectedtoisolateatleastone genus from

	eachgroup.

II	**Isolation and identification of Fungi** Isolationofthefollowingtypesoffungifromnaturalsamples. Identification ofthefungi. A. MoldsSaprophytic) B. Yeasts The identification key must be designed for each isolated and identified fungus. Students aree xpected to isolate atleast one genus from Moldand Yeast each.
III	**Isolation and identification of Cyano bacteria** Isolationandidentificationofanyonetypeofcyanobacterium from anatural sample. Theidentificationkey mustbedesignedforeachisolatedand identifiedcyanobacterium. Studentsare expectedtoisolate at least one genus ofcyanobacteria.
IV	**Molecular Taxonomy** A. Isolation, purification and checking purity of isolated chromosomal DNA of bacteria B. Demonstration of the following steps, if not possible to perform inyourlab: a. Cycle sequencing PCR Purification of PCR product Sequencingusing automated machine C. SequencematchingbyBLAST analysis. D. Drawing phylogenetictree using related sequences (Using standard softwarelikePhylip, Megaetc)

Learning Resources:

1. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 8th Edition, 1974.
2. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 9th Edition, 1982.
3. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5) (2001 – 2003).
4. Sykes, G. and F. A. Skinner (Eds). Actinomycetales: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series No. 2, Academic Press. 1973.
5. LodderJ. (1974). The Yeasts: A TaxonomicStudy, North Holland PublishingCo. Amsterdam

6. Bergey's Manual of Systematic Bacteriology (2nd Edition) Volume One: The Archaea and the Deeply Branching and Phototrophic Bacteria. Boone, David R.; Castenholz, Richard W. (Eds.). Originally published by Williams & Wilkins, 1984
7. Barnett, H. L. and Hunter, B. B. 1960. Illustrated Genera of Imperfect Fungi. Burgess Publishing Co., Minnesota.
8. Sandy Primrose, Richard Twyman, Bob Old (2001), Principles of Gene Manipulation 6th Edition, Blackwell Science Ltd.
9. Sambrook, J., Fritsch, E. F. And Maniatis, T. (1989) Molecular Cloning: A laboratory Manual, 2nd ed. Cold Spring harbour NY: Cold Spring Harbour Laboratory Press.
10. Ausbel F. M and Brent R. (1994) Current Protocols in Molecular Biology, John Wiley & Sons Inc, New York
11. **URL:**

i. National Center for Biotechnology Information
ii. www.ncbi.nlm.nih.gov/
iii. Ribosomal Database Project - Release 10 rdp.cme.msu.edu/ rdp.cme.msu.edu/seqmatch/
iv. Building phylogenetic trees www.itu.dk/~sestoft/bsa/dinaws/phylogeny.html Reading a Phylogenetic Tree - Nature

Title of the Course and Course Code	**Practicals Based on Biochemistry, Molecular Biophysics, Applied Microbiology, Cell and Developmental Biology (MIC4105)**	**Number of Credits: 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Outline Good Laboratory Practices (GLPs) and laboratory safety with day to day working in microbiology laboratory.	
CO2	Describe protocols to prepare buffers of biological importance.	
CO3	Construct enzyme purification methods from biological sources like bacteria and fungi and determine ion exchange capacity of resins.	
CO4	Analyze kinetic parameters of enzyme action on its substrate by carrying out appropriate experiments and evaluate the allowed conformation of proteins using Ramachandran plot.	
CO5	Test the ecological potential of microorganisms such as degradation of recalcitrant compounds and evaluate various parameters of compost samples. Choose experiments to isolate bacterial pigments and to assess biofilm formation by bacteria.	
CO6	Design experiments for the degradation of natural wastewater and artificial wastewater by microorganisms. Infer different stages of mitosis and stages of development in Drosophila embryos.	

Unit No.	Title of Unit and Contents
I	**Biochemistry I** **A.** Good laboratory practices: Laboratory safety, hazard from chemicals, handling of chemicals, disposal of chemicals and cultures, recording of scientific experiments. **B.** Standardization of laboratory procedures, preparing / designing SOP for the same, maintenance of instruments **C.** Buffer: i. Determination of pKa of a monoprotic weak organic acid by tirimetric and graphical method Preparation of buffers using KH_2PO_4 and K_2HPO_4, acetic acid and sodium acetate, K_2HPO_4 and H_3PO_4
II	**Biochemistry II** **A.** Purification of enzyme from bacteria and fungi by ammonium sulfate precipitation **B.** organic solvent precipitation, gel filtration **C.** Establishment of enzyme purification chart **D.** Determination of Km and Vm values of any hydrolytic enzyme **E.** To determine the ion-exchange capacity and nature of given resin using anion exchange chromatography.
III	**Molecular Biophysics** **A.** Interpretation of Ramchandran Plot. **B.** Determination of molar extinction coefficient of biological molecule. **C.** Calibration of analytical instruments: Colorimeter and spectrophotometer by estimation of biomolecules and statistical analysis of data generated.
IV	**Applied Microbiology** **A.** Isolation and characterization of pesticide/ hydrocarbon degrading bacteria **B.** Comparison of various parameters of compost samples **C.** Estimation of pollution load of a natural sample (e.g. riverwater/ industrial wastewater) **D.** Setting up a laboratory experiment to assess degradability of synthetic wastewater. **OR** **Cell and Developmental Microbiology** **A.** Studying the stages of mitosis in growing tips of onion roots. **B.** Isolation and characterization of any one bacterial pigment **C.** Demonstration of mounting of embryos of fruit fly at various stages of development

	D. Biofilm preparation: **i.** Observation of biofilms on natural samples **ii.** Development of biofilms and testing of biofilm production

Learning Resources:

1. Naphade S.R. et al., (2012) Isolation, characterization and identification of pesticide tolerating bacteria from garden soil. Pelagia Research Library, 2 (5):1943-1951
2. Azim K. et al., (2018) Composting parameters and compost quality: a literature review. Organic Agriculture, 8 (2) 141–158
3. Heusch S et al., (2010) Simulation of wastewater treatment plant within integrated urban wastewater models. Water Sci Technol, 61(10):2645-52
   Haddix PL and Shanks RMQ (2018) Prodigiosin pigment of Serratia marcescens is associated with increased biomass production. Arch Microbiol, 200(7):989-999
4. Segel Irvin H. (1997) Biochemical Calculations 2nd Ed., John Wiley and Sons, NewYork
5. Sandy Weinberg (2002) Good Laboratory Practice Regulations, Revised and Expanded, CRC Press
6. Robert K. Scopes (2013) Protein Purification: Principles and Practice, 3rd Ed., Springer Science & Business Media
7. Clive Dennison (2002) A guide to protein isolation, Kluwer Academic Publishers Pattabhi, V. and Gautham, N. (2002) Biophysics. Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.
8. David J Holme, Hazel Peck (1998) Analytical Biochemistry, 3rd ed., Prentice Hall, Pearson Education Limited, Harlow England.
9. Nölting, B. (2006) Methods in modern biophysics. Second Edition. Springer, Germany.
10. Parton RM et al., (2010) Collection and mounting of Drosophila embryos for imaging. Cold Spring Harb Protoc., (4) prot5403
11. Cotterill, R. M. J. (2002) Biophysics: An Introduction. John Wiley & Sons, England.

Title of the Course and Course Code	**Applied Microbiology (MIC4106D)**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the role of microorganisms in biofilm formation which is responsible for destruction of metallic and wooden articles in different fields.	
CO2	Explain different extraction methods for precious metals that are employed in various countries.	
CO3	Outline biochemical pathways involved in bioremediation of recalcitrant xenobiotic compounds.	
CO4	Explain different wastewater treatment methods.	
CO5	Appraise the advanced waste water treatment processes for treating industrial wastes containing toxic chemicals.	
CO6	Write a report on the general principles of wastewater treatment processes.	

Unit No.	Title of Unit and Contents
I	**Geo microbiology:** **A.** Biofouling and Biocorrosion **B.** Bioleaching i. Principles of Microbial Metal Leaching: Copper, Iron ii. Leaching Mechanisms iii. Models of Leaching Mechanisms iv. Factors Influencing Bioleaching v. Bacterial Attachment on Mineral Surfaces
II	**Bioremediation:** **A.** Definition, Role and pathways of plants & Microbes in Bioremediation of: i. Hydrocarbons ii. Industrial Wastes iii. Xenobiotics iv. Role of microorganisms in ocean processes **B.** Bioaugmentation: i. microbial cultures and enzymes for bioaugmentation ii. Applications **C.** Biosorption **D.** Biomagnification: Role of Mercury in Biomagnification

III	**Principles of Wastewater Treatment** **A.** The need for Wastewater Treatment **B.** Measuring Pollution Load of wastewater **C.** Methods for estimating parameters used for determining treatment efficacy **D.** Layout of typical wastewater treatment plants
IV	**Advanced, Combined and Innovative wastewater treatment processes** **A.** Submerged Aerobic Fixed Film reactors (SAFF) **B.** Membrane bioreactors (MBRs) **C.** Rotating Biological Contactors (RBCs) **D.** Mixed Bed Bioreactors (MBBRs)

Learning Resources

1. Klaus Bosecker (1997)Bioleaching: Metal solubilisation by microorganisms, FEMS Microbiology reviews
2. Axel Schippers and Wolfgang Sand (1998) Bacterial Leaching of Metal Sulfides Proceeds by Two IndirectMechanisms via Thiosulfate or via Polysulfides and Sulfur, Applied and Environmental Microbiology p. 319–321 Vol. 65, No. 1
3. Ajay Singh, Owen P. Ward, 2004 edition, Applied Bioremediation and Phytoremediation (Soil Biology). Springer
4. Charles R. Lane, Paul Beales, Kelvin J. D. Hughes (2012). Fungal Plant Pathogens.1st Edn. CABI Publishing
5. John Postgate, (1998). Nitrogen Fixation. Cambridge UniversityPress
6. Martin Alexander (1999). Biodegradation and Bioremediation. Academic Press
7. Matthew Dickinson, (2003). Molecular Plant Pathology. Garland Publishing Inc.
8. Biotechnology for Water and Wastewater Treatment. Dr. Satya Prakash. Navyug Publishers & Distributors, New Delhi. 2009.
9. Industrial Water Pollution Control. 3rd Edition. W. Wesley Eckenfelder Jr. McGraw Hill. 2000. Standard Methods for the Examination of Water & Wastewater. 21st Edition. 2005.
10. N. S. SubbaRao. (1995). Soil Microorganisms and Plant growth. 3rd Edn. Science Pub Inc
11. Biological Wastewater Treatment. Vol. 5. Activated Sludge and Aerobic Biofilm Reactors. Marcos von Sperling. IWA Publishing. London, New York. © 2007 IWA Publishing

Title of the Course and Course Code	**Cell and Developmental Biology (MIC4107G)**	**Number of Credits : 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Describe various events in the cell cycle.	
CO2	Explain diagrammatically the ultrastructure of eukaryotic cells. Outline the cellular signalling mechanisms in higher organisms at the molecular level.	
CO3	Illustrate the effect of fundamental activities such as homeostasis and morphogen gradients on the process of cellular development.	
CO4	Explain diagrammatically trafficking of biomolecules in the compartments of eukaryotic cells.	
CO4	Compare vertebrate and invertebrate developmental systems.	
CO6	Write the application of advanced microscopic techniques for localization of macromolecules in eukaryotic cells.	

Unit No.	Title of Unit and Contents
I	**Ultra structure and Organization of Eukaryotic Cell** **A.** Structural organization of: i. Cytoskeleton ii. Endoplasmic Reticulum iii. Golgi apparatus **B**. Protein trafficking among various cellular compartments **A.** Events in cell cycle, Regulation of cell cycle, apoptosis **B.** Localization of macromolecules using: i. Electron microscopy ii. Immunoelectron microscopy iii. Confocal microscopy Problem solving on above topics
II	**Communication in prokaryotic and eukaryotic system** **A.** Communication and coordination in prokaryotes i. Life cycle and Molecular mechanism of quorum sensing in myxobacteria. ii. Quorum sensing in Gram positive (*Staphylococcus aureus* virulence factors) and Gram negative bacteria (*Vibrio fischeri* lux operon) iii. Biofilms:

	a. Organization and Signals involved in biofilm formation and dispersal b. Applications of study on biofilms in pathogenic (*Pseudomonas aeruginosa*) and non-pathogenic environments (dental plaque) iv. Secretory systems in bacteria, competence development, sporulation **B.** . Communication and coordination in eukaryotes i. Life cycle and Molecular mechanism of quorum sensing in *Dyctiostellium discoidum*. ii. Signaling in higher eukaryotes: autocrine, paracrine, endocrine, neurotransmitters iii. Pathways in cell signaling: GPCRs- a. adenylate cyclase pathway b. regulation of cytosolic Ca^{2+} Problem solving on above topics
III	**Basic principles of developmental biology** A. Concept and principles of developmental biology, B. Hox code in different systems, Morphogen gradients, Apoptosis and PCD pathways C. Signal transduction pathways in PCD Changes in membrane architecture in PCD. D. Homeostasis and its significance in biological systems. Types of rhythms: Circardian and other examples. E. Types of cleavages and their presence in biological systems. Differentiation, tran-differentiation and de-differentiation
IV	**Development in Drosophila and Xenopus** A. Drosophila: Fertilization, blastulation and gastrulation events, segmentation,details of events. B. Xenopus: Fertilization and control over the process of fertilization, organizer and its significance, blastulation, epiboly, invagination and gastrulation events.

Learning resources

1. Alberts Bruce (1985) Molecular Biology of Cell. Garland Pub
2. Metzler David E. (2001) Biochemistry: The chemical Reactions of Living Cells, Volume 1&2, Academic Press, California.
3. Harvey Lodish, Arnold Berk, S. Lawrence Zipursky, Paul
4. Matsudaira, David Baltimore, and James Darnell (2000) Molecular Cell Biology, 4th edition, W. H. Freeman & co.,NewYork.
5. Reactions of Living Cells, Volume 1&2, Academic Press California.
6. Hamilton W. Allan, (1987) Biofilms: Microbial Interactionsand Metabolic activities, in Ecology of Microbial Communities, (Eds. M. Fletcher, T. R. G. Gray and J. G. Jones) Cambridge University Press, Cambridge
7. Peters J. E. (1969) Isolation, cultivation and maintenance of Myxobacteria, Methods in Microbiology (Eds. Norris J. R. and W. Ribbons) Vol. 3B, Academic Press London, 185-210.
8. Toole 'O' George, H. B. Kaplan, R. Kolter,(2000) Biofilm formation as microbial development Annual Review of Microbiology, Vol. 54, 49-79
9. Christopher M. Waters and Bonnie L. Bassler (2005) Quorum sensing:cell-to-cell communication in bacteria. Annu. Rev.Cell Dev.
10. Melissa B. Miller and Bonnie L. Bassler (2001) Quorum sensing in bacteria. Annu. Rev. Microbiol. Vol. 55, 165–99.
11. Munehiko Asayama and Yasuo Kobayashi (1993) Signal transduction and sporulation in Bacillus subtilis: autophosphorylation of SpoOA, a sporulation initiation gene product. Molecular and General Genetics. Vol. 238,
12. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W. H. Freeman & Co. New York.
13. Gibert Scott F. (2003). Developmental Biology. 7th Ed. Sinauer Associates Inc. Mass. USA.
14. Muller W.A. (1997) Developmental Biology, SpringlerVerlag, New York,Inc.
15. Wolpert Lewis (1998) Principles of Developmen. Oxford University Press Oxford

	F.Y. M.Sc. Semester II	
Title of the Course and Course Code	**Microbial Metabolism (MIC4201)**	**Number of Credits : 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Recall key steps in the biological fixation and assimilation of nitrogen along with the biocatalytic agents involved and focus on the regulation of nitrogen turnover in microbial communities.	
CO2	Discuss the composition of electron transport chains present in various biological systems with energy conservation in the form of high energy compounds and compare their efficiency.	
CO3	Compute the energy output for a variety of respiratory and fermentative pathways in microbial systems and explain their ecological significance.	
CO4	Categorize inhibitors and uncouplers of phosphorylation in biological energy conservation mechanisms.	
CO5	Compare the photosynthetic potential and evolution of photosynthetic bacteria with higher photosynthetic systems.	
CO6	Write the interactions between proteins and nucleic acids and justify the importance of these interactions in biological systems.	

Unit No.	Title of Unit and Contents
I	**Biochemistry- proteins and nucleic acids** **A.** Biochemistry of Proteins: i. partial double bond nature of peptides, determination of primary structure of polypeptide (N-terminal, C-terminal determination method of sequencing of peptides) ii. Physical and chemical properties of amino acids iii. Ramchandran plot **B.** Biochemistry of nucleic acids: i. Tm value Cot curves ii. structure of t-RNA, r-RNA, and m-RNA **C.** Interactions between proteins and nucleic acid i. Histones and DNA ii. SSBPs and DNA iii. Transcription Factors and DNA – Helix Turn Helix iv. Transcription Factors and DNA – Helix Loop Helix v. Translation –Initiation/ Elongation Factors and RNA Problem solving on above topics

II	**Aerobic and Anaerobic respiration** **A.** Aerobic respiration i. Sites of aerobic respiration in eukaryotes and prokaryotes ii. Components and organization of bacterial and mitochondrial electron transfer system, iii. Structure and function of F1F0 ATPase iv. Generation and maintenance of proton motive force v. Energetics of Oxidative phosphorylation vi. Inhibitors and un-couplers of electron transport chain and oxidative phosphorylation vii. Types of Chemolithotrophs: Energy conservation **B.** Anaerobic respiration:Concept of anaerobic respiration i. Components of electron transfer system ii. Energy conservation in bacteria where nitrate, sulfate and carbonate act as terminal electron acceptor iii. Assimilatory and dissimilatory mechanisms. a. Ammonia oxidizing bacteria b. Methanogens: Mechanism of methanogenesis and energy conservation
III	**Nitrogen metabolism** **A.** Biochemistry of biological nitrogen fixation i. Properties of nitrogenase and its regulation ii. Ammonia assimilation with respect to glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation **B.** Biosynthesis of five families of amino acids and histidine **C.** Biosynthesis of purine and pyrimidine bases **D.** Mechanism of denirification Problem solving on above topics
IV	**Photosynthesis** **A.** Energy considerations in photosynthesis, light and dark reactions **B.** Plant systems: electron carriers in photosystems, I and II, cyclic and noncyclic flow of electrons, Z scheme, Hills reaction and photolysis of water **C.** Eubacterial photosynthesis: scope, electron carriers, photosynthetic reaction centres, cyclic flow of electrons, bacterial photophosphorylation in various groups of phototrophic bacteria, electron donors other than water in anoxygenic photosynthetic bacteria **D.** Archaebacterial photosynthesis: Bacteriorhodopsin

	Problem solving on above topics

Learning Resources:

1. Cox M. M., Nelson D. L., (2008) Lehninger Principles of Biochemistry, Fifth edition, W. H. Frreman and Company New York Berg Jeremy, Tymoczko John, Stryer Lubert (2001)
2. *Biochemistry* 4th Ed, W. H. Freeman, New York.
3. Garrett, R. H. and Grisham, C. M. (2004) *Biochemistry.* 3rd Ed. Brooks/Cole, Publishing Company, California
4. Segel Irvin H. (1997). *Biochemical Calculations*. 2nd Ed.John Wiley and Sons, New York.
5. Campbell M. K. (1999) Biochemistry. 3rd edition Harcourt Brace College Publishers
6. Moat Albert G. and Foster John W. (1988) *Microbial Physiology* 2nd Ed. John Wileyand Sons New York.
7. Michael T. Madigan, John M. Martinko, David A. Stahl, David P. Clark (2012) *Brock Biology of Microorganisms*, 13th edition, Benjamin Cummings, San Francisco.
8. White David (2000) *Physiology and Biochemistry of Prokaryotes.* 2nd Ed. Oxford University Press, New York.
9. Mandelstam Joel and McQuillen Kenneth (1976) *Biochemistry of Bacterial Growth*, Blackwell Scientific Publication London.

Title of the Course and Course Code	**Immunology (MIC4202)**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe different cell surface molecules, receptors and label different proteins involved in signal transduction pathways.	
CO2	Represent T and B cell receptors, G protein coupled receptors diagrammatically.	
CO3	Classify different methods for regulation of immune response.	
CO4	Analyze different methods for regulation of the complement system.	

CO5	Review different escape mechanisms of tumor from the host cells and methods for diagnosis of tumor.
CO6	Write a report on different immunodeficiency disorders.

Unit No.	Title of Unit and Contents
I	**Cell cell interaction through surface receptors and signal transduction pathways** **A.** Structure and function of Toll-like receptors, Cytokine receptors, TCell receptor, B Cell Receptor, Tyrosine kinase linked receptors, adhesion molecules in immune activation **B.** TCR-CD3 complex, Signal transduction pathways: IL-2 pathway(JAK/STAT and Ras/MAP Kinase Pathways)
II	**Regulation of Immune response** **A.** Immunological tolerance and suppression:Negative regulation - Immunological tolerance, Mechanisms of tolerance induction (relatedexperimentation using transgenic animals), T cell mediated suppression of immune response **B.** Network theory and its experimental evidence **C.** Cytokine mediated cross regulation of immune response -Regulation of T_H subsets(TH1-TH2) **D.** Regulation of complement system – Classical and alternative pathway **E.** Immunomodulation: BRMs for therapy
III	**Tumor Immunology** **A.** Cellular transformations during neoplastic growth, Classification of tumors based on histological,physiological, biochemical and immunological properties, Tumors of lymphoid system (lymphoma,myeloma, Hodgkin's disease) **B.** Escape mechanisms of tumor from host defense, Host immune response to tumor – Effector mechanisms, Immuno- surveillance theory **C.** Diagnosis of tumors – biochemical and immunological tumor markers

	D. Approaches in cancer immunotherapy: Immune adjuvant and tumor vaccine therapy
IV	**Immunological disorders** **A. Autoimmunity**-Mechanism, theories, pathophysiology and therapeutic approaches for Rheumatoid arthritis, Systemic Lupus Erythematosus (SLE), Neurologic disease- Myasthenia gravis **B. Pathophysiology, diagnosis, prognosis and therapeutic approaches to:**Immunodeficiency disorders – humoral deficiencies, T-cell deficiencies, and combined deficiencies, complement deficiencies

Learning Resources

1. Akihiko Yoshimura, Tetsuji Naka and Masato Kubo, (2007), *SOCS proteins, cytokine signaling and immune regulation*, Nature Reviews, Immunology, **7:**454-465
2. Austyn J. M. and Wood K. J. (1993) *Principles of Molecular and Cellular Immunology*, Oxford University Press,
3. Barret James D. (1983) *Text Book of Immunology* 4th edition, C. V. Mosby & Co. London.
4. Boyd William C. (1966) *Fundamentals of Immunology*, Interscience Publishers, NY.
5. Christopher K. Garcia and Erin J. Adams, (2005), How the T Cell Receptor Sees Antigen—A Structural View, Cell, Vol. 122: 333– 336, Elsevier Inc.
6. David A. Hafler, (2007), *Cytokines and interventional immunology*, Nature Reviews, Immunology, **7**: 423
7. GangalSudha and SontakkeShubhangi (2013), Textbook of Basic and Clinical Immunology Paperback, University Press, India
8. Kindt, Osborne, Goldsby, (2006), *Kuby Immunology*, 6th Ed., W. H. Freeman & Co.
9. Abbas A. K. and Litchman A. H. (2004), *Basic Immunology, Functions and Disorders of Immune System*, 2nd Ed., Elsevier Inc.
10. Michael C Carroll, *(*2004), *The complement system in regulation of adaptive immunity*, Nature Immunology **10**:981-986
11. Michael C Carroll, (2004),*The complement system in regulation of adaptive immunity*, Nature Immunology, 5(10):981-986.
12. Roitt I. M. (1988) *Essentials of Immunology*, ELBS, London.

Title of the Course and Course Code	**Molecular Biology (MIC4203)**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Describe the concepts of epigenetic and the changes which affect the gene expression and the structure, organization and regulation of chromatin.	
CO2	Compare the complexity of genomes in different species and differentiate between prokaryotic and eukaryotic transcription.	
CO3	Illustrate different control mechanisms involved in prokaryotic transcription.	
CO4	Explain the fine control of prokaryotic transcription in metabolism of sugars and amino acids	
CO5	Distinguish between the controlling elements of different types of transposons	
CO6	Justify the importance of retroviral transposons and other eukaryotic transposable elements	

Unit No.	Title of Unit and Contents
I	**Chromatin organization and function** **A.** Structure of chromatin, nucleosome, chromatin organization and remodeling, Higher order organization - chromosome, centromere, telomere **B.** Concept of epigenetics: DNA methylation, histone modifications, epigenetic inheritance, genomic imprinting, effect of environment on epigenetic changes **C.** C value paradox and genome size, cot curves, repetitive and non-repetitive DNA sequence, Cot ½ and Rot ½ values **D.** Pseudogenes, Gene families, Gene clusters, Super-families
II	**Eukaryotic transcription and processing of RNA** **A.** Eukaryotic RNA polymerases I, II and III and their promoters, Enhancers, TATA box Binding Protein (TBP) **B.** Processing of RNA: RNA splicing- group I, group II introns, Capping of mRNA and polyadenylation **C.** mRNA processing: splicing (with example of immunoglobulin heavy or light chain genes), capping, polyadenylation, coordination of mRNA processing **D.** rRNA processing: tRNA processing

	E. Non-coding RNAs and their role: RNA interference; siRNA, micro-RNA role in gene silencing, RNA editing
III	**Fine Control of Prokaryotic transcription** **1.** Lactose operon: repressor-operator interactions, mechanism of repression, Positive control of lac Operon-Mechanism of CAP action **2.** The Arabinose operon: Ara operon repression loop, evidence for repression loop, auto regulation of Arabinose operon **3.** The tryptophan operon: - control of tryptophan operon by attenuation, defeating attenuation, Riboswitches **4.** Galactose operon, Lambda lytic lysogenic interconversion **5.** Sigma factor Switching: - Phage infection- T4, T7 infection in *E. coli*, SPO1 infection in *B. subtilis*.
IV	**Mobile DNA elements** **A.** Transposable elements in bacteria, IS elements, composite transposons **B.** Replicative, non-replicative transposons, and Mu transposition **C.** Controlling elements in Tn A, Tn 5 and Tn 10 transposition **D.** Transposons in Maize and Drosophila **E.** Retroviruses and retrotransposon, Ty elements in yeasts **F.** SINES, LINES and Alu elements. **G.** Significance of transposons

Learning Resources

1. James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Loswick (2004) Molecular Biology of the Gene, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.
2. Lewin's Genes XI, (2014) Jones and Bartelett Publishers Inc.
3. Bruce Albert et. al., Molecular Biology of the Cell, 6th Edn., Garland Sciences.
4. Lodish H, Berk A, Zipursky SL et al. (2012) Molecular Cell Biology, 7th edition. New York: W H Freeman
5. Weaver R., (2007) Molecular Biology, 4th Edition, McGrew Hill Science.
6. Mechanism of subcellular mRNA localization, 2002, CSH, 108:533-44.
7. Micro RNAs in cell proliferation, Cell death and tumorigenesis, B.J. of Cancer, 2006, 94.
8. Taft et.al., Recent progress in structure, biology and tRNA processing and modification. Mol Cell., 19(2), 2005, 157-66
9. W.S. Klug and M.R. Cummings, Concepts of Genetics, (2005) Pearson education

Title of the Course and Course Code	**Practical Course Based on Microbial Metabolism and Molecular Biology (MIC4204)**	**Number of Credits: 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Identify the microorganisms which can degrade complex polysaccharides like cellulose and chitin.	
CO2	Transform bacterial cells with recombinant DNA, determine the efficiency of transformation and selection of recombinants	
CO3	Examine the ability of rhizosphere flora to exhibit PGP traits.	
CO4	Analyze different methods of isolation of anaerobic bacteria.	
CO5	Measure the quantity of extracted plasmid DNA using analytical techniques.	
CO6	Design an experiment for induction of lactose operon and determine the activity of β- galactosidase	

Unit No.	Title of Unit and Contents
I	**Microbial metabolism I** **A.** Different methods of isolation and cultivation of anaerobic bacteria **B.** Isolation and characterization of (as nitrogen fixers) *Azospirillum* and detection of IAA by *Azospirillum* **C.** Detection of siderophore production by *Azospirillum* and *Pseudomonas*
II	**Microbial metabolism II** **A.** Isolation and characterization of phosphate solublizing bacteria **B.** Isolation and characterization of chitin degrading bacteria **C.** Isolation and characterization of cellulose degrading bacteria
III	**Molecular biology I** **A.** Extraction and purification of Plasmid DNA **B.** characterization of plasmid DNA **C.** Competence development in non-competent bacterial culture **D.** Transformation of bacteria **E.** Determination of transformation efficiency
IV	**Molecular biology II** **A.** Induction of lac operon **B.** Determination of beta-galactosidase activity **C.** Identification of recombinants by blue and white colony screening

Learning Resources:

1. K. Wilson and J. Walker, 'Principles and techniques of biochemistry and Molecular Biology', (2005), 7th Edition, Cambridge university Press,
2. Sambrook and Russel, 'Molecular cloning: A laboratory manual', Volume 1, 2 and 3 (2001), 3rd Edition, Cold spring harbor laboratory press, New York
3. D. Scott Witherow, H. Miller and Sue Carson, 'Molecular biology Techniques: A classroom laboratory manual', 3rd edition, Elsevier
4. Reetha S. et al., (2014) Isolation of indole acetic acid (IAA) producing rhizobacteria of *Pseudomonas fluorescens* and *Bacillus subtilis* and enhance growth of onion (Allim cepa.L) Int.J.Curr.Microbiol.App.Sci, 3(2): 568-574
5. Louden et al.(2011) Use of Blue Agar CAS Assay for Siderophore Detection, J Microbiol Biol Educ. 12(1): 51–53.
6. William J. Martin (1971) Practical Method for Isolation of Anaerobic Bacteria in the Clinical Laboratory. Appl Microbiol. 22(6): 1168–1171.
7. Zhu R. et al. (2011) Isolation and Characterization of a Phosphate-Solubilizing Halophilic Bacterium *Kushneria* sp. YCWA18 from Daqiao Saltern on the Coast of Yellow Sea of China. Hindawi.
8. Saima M. et al. (2013) Isolation of novel chitinolytic bacteria and production optimization of extracellular chitinase. Journal of Genetic Engineering and Biotechnology. 11(1) 39-46
9. Sethi S. et al. (2013) Optimization of Cellulase Production from Bacteria Isolated from Soil. International Scholarly Research Notices

Title of the Course and Course Code	**Practical course based on Immunology and Virology/ Bionanotechnology (MIC4205)**	**Number of Credits : 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Describe the different types of antigen - antibody interactions using simple immunological techniques such as Ouchterlony technique, Radial immunodiffusion test, Rocket immunoelectrophoresis and latex agglutination slide test	
CO2	Estimate the titres of isoantibodies to human blood group antigens	
CO3	Illustrate advanced immunological techniques like ELISA and MTT assay by demonstration.	
CO4	Analyze separation and proliferation of lymphocytes and response to mitogen stimulus. Explain the working principle of sophisticated instruments such as ELISA reader and FACS seen during the visit to a research institute.	
CO5	Estimate the virus titre in hemagglutination tests and plaque assays and study phage infectivity in bacteria. Test the ability of biological sources to form nanoparticles and quantitate the same using biophysical techniques.	
CO6	Plan an experiment to understand the various routes of inoculation in embryonated eggs. Develop basic skills to prepare and standardize different inorganic solutions. Validate the observations of chemical analysis using Spectrophotometer, conductometer, potentiometer and pH meter and match the experimental results with standards.	

Unit No.	Title of Unit and Contents
I	**Antigen –antibody Interaction** A. Detection of antigen antibody specificity by Ouchterlony test B. Determination of antigen concentration from the sample by using- Single Radial immunodiffusion test C. Determination of antigen concentration from the sample by using Rocket

	immunoelectrophoresis D. Latex agglutination slide test for detection of IgM Rheumatoid factors in human serum
II	**Agglutination techniques** A. Titer determination of isoantibodies to human blood group antigens B. Enzyme Linked Immunosorbent Assay C. Latex agglutination slide test for detection of C-Reactive protein in human serum D. Cytotoxicity test: MTT assay
III	A. Lymphocyte culturing B. Detection of proliferation of lymphocytes on mitogenic stimulus C. Lymphocyte separation by using density gradient centrifugation(Ficollhypaque chemical) D. Visit should be organized to research institute for ELISA, ELISPOT Cell cultures, FACS
IV	**Virology (Animal, Bacterial and Plant Viruses)** A. Egg inoculation technique for virus cultivation by various routes-embryo, yolksac, allantoic fluid, amniotic cavity, chorioallontoic membrane B. Animal virus titration by Hemagglutination test C. Qualitative and quantitative detection of bacteriophage D. One step growth curve of bacteriophage E. Chloroplast agglutination test OR **Advanced Bionanotechnology** A. Biosynthesis of metal nanoparticles B. Characterization of nanoparticles using UV- visible spectroscopy C. Determination of anti-microbial activity of nanoparticles D. Partial purification of nanoparticles

Learning Resources:

1. Kindt T. J., Goldsby R. A., Osborne B. A., 2007, Kuby Immunology 6th Ed. W. H. Freeman & Co., New York

2. ACT Laboratory Procedure Manual, 1980, section 2, pgs.70-77 and 2nd edition, 1991, chapter 2 pg 24-30.

3. ATCC Animal Cell Culture Guide: tips and guide for continuous cell lines
4. Practical Plant Virology- Protocols and Exercises (1998). Jeanne Dijkstra and Cees P. De Jager. Springer.
5. Bacteriophages: methods and protocols Volume 4 (2018). Martha Clokie et al. Springer.
6. Nanotechnology in Biology and medicine: methods, devices and applications. 1st edition (2007). Tuan Vo-Dinh. CRC Press.

Title of the Course and Course Code	**Virology (MIC4206)**	**Number of Credits : 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	List the various emerging, re-emerging viral diseases and their causative agents. State the reasons for their emergence and re-emergence.	
CO2	Illustrate the structure of viruses. Explain the methods for cultivating viruses.	
CO3	Illustrate the different methods of replication of DNA and RNA viruses.	
CO4	Compare different aspects of the life-cycles of different viruses and classify them according to Baltimore's and ICTV methods of classification.	
CO5	Summarize the mode of actions of different anti- viral agents. Compare the different types of viral vaccines.	
CO6	Compile the various diagnostic methods for viral infections.	

Unit No.	Title of Unit and Contents
I	**General Virology:** **A. Structure of viruses** i. Enveloped and Non enveloped viruses ii. Capsid symmetries – Icosohedraland Helical iii. Structural components of virus – Protein - Envelope proteins, Matrix proteins and Lipoproteins, Genome – dsDNA, ssDNA, dsRNA, ssRNA (positive sense, negative sense and ambisense), linear, circular, segmented

	iv. Virus related structures – Viroids and Prions **B. Unique features of viral:** w.r.t genome and its organization, size, shape, growth and multiplication **C. Classification & nomenclature of viruses** i. ICTV nomenclature ii. Baltimore classification
II	**Replication of viruses:** A. Mechanism of virus adsorption and entry into host cell B. Genome replication C. Reverse transcription and Integration D. Post transcriptional processing E. Synthesis of viral proteins: polyprotein and proteolytic cleavage F. Protein nucleic acid interactions and genome packaging G. Assembly, exit and maturation of progeny virions
III	**Principles of Practical Virology:** **A. Cultivation of viruses:** i. In ovo: using embryonated chicken eggs ii. In vivo: using experimental animals iii. Ex vivo / In vitro: using various cell cultures – primary, secondary cell lines, continuous cell lines and suspension cell cultures **B. Diagnostic and detection methods:** i. Direct methods of detection – Light microscopy (inclusion bodies), Electron microscopy and Fluorescence microscopy ii. Immnuodiagnosis, Hemagglutination and Hemagglutination-inhibition tests, Complement fixation, Neutralization, Western blot, Radioactive Immuno Precipitation Assay (RIPA), Flow Cytometry and Immunohistochemistry iii. Nucleic acid based diagnosis: Nucleic acid hybridization, Polymerase Chain Reaction (PCR), Microarray and Nucleotide sequencing, LINE probe assay iv. Infectivity assay for animal and bacterial viruses - Plaque method, Pock counting, End point methods, LD50, ID50, EID50, TCID50 v. Infectivity assays of plant viruses
IV	**Control of viral diseases:** **A. Life cycle of representative viruses** i. Human virus – Human Immunodeficiency Virus ii. Baculovirus – *Autographacalifornica* Nuclear polyhedrosis virus iii. Plant virus - Tobacco Mosaic Virus iv. Bacteriophages -T 4 phage, Lambda phage, P1 phage, M13 phage

	B. Emerging and re-emerging viruses i. Causes of emergence or re-emergence of viruses ii. Life- cycles and epidemiology of emerging and re-emerging viruses such as Zika Virus andNipah virus iii. Prevention measures for emergence and re-emergence of viruses **C. Antiviral chemotherapy and viral vaccines** i. Role of interferons in viral infecrtions ii. Anti-virals - Nucleoside inhibitors, Reverse transcriptase inhibitors, Protease inhibitors iii. History of viral vaccines **iv.** Viral Vaccines- Live attenuated vaccines, inactivated vaccines, sub-unit vaccines, Anti-idiotype vaccines, DNA vaccines

Learning Resources

1. Flint S. J., V. R. Racaniello, L. W. Enquist, V. R.Rancaniello, A. M. Skalka, (2015).
2. Edward K. Wagner, Martinez J. Hewlett, (2004), Basic Virology, Blackwell Publishing
3. Baltimore D. (1971), Expression of Animal Virus Genomes, Microbiology and molecular Biology Reviews, 35(3), 235 – 241.
4. Prusiner S. B. (1995) The Prion Diseases, Scientific American (1):48-57.
5. Reisner D. & Gross H.J. (1985).Viroids Ann. Rev. Biochem.54:531-64
6. Fenner F (1976) The Classification and Nomenclature of Viruses Summary of Results of Meetings of the International Committee on Taxonomy of Viruses in Madrid, September 1975, Journal of General Virology, 31, 463-470.
7. http://ictvonline.org/codeOfVirusClassification_2012.asp
8. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, American Society Microbiology.
9. Burton E. Tropp (2008). Molecular Biology Genes to proteins (3rd edition). Jones and
10. Bartlett Publishers. Hull R (2002) Matthew's Plant Virology, 4th edition. Academic Press.
11. Mahy B. WJ. And Kangro H.O., (1996), Virology Methods Manual, Academic Press.
12. Dimmock N. J. et al. (2007). Introduction to modern virology 6th edition. Blackwell Publishing.
13. Peter. J. Russell (2011). iGenetics- molecular approach. Pearson Education.
14. Hull R (2002) Matthew's Plant Virology, 4th edition. Academic Press.
15. Gibbs Adrian & Bryan Harrison, Plant Virology -The Principles. Edward Arnold Press.
16. Strauss J. H. and Strauss E. G. (2002), Viruses and Human Disease, Academic Press
17. Knipe David M., Peter M. Howley, Diane E. Griffin, Robert A. Lamb, Malcolm A. Martin, Bernard Roizman, Stephen E. Straus, (2007), Field's Virology, 5th Ed. Lippincott Williams & Wilkins

Title of the Course and Course Code	**Advanced Bionanotechnology (MIC4207)**	**Number of Credits : 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Describe the use of food nano biometerials and biocompatibility	
CO2	Articulate theoretical aspects of surface physics, biomaterials, and methods of the interaction with surfaces and fibres of biomolecules.	
CO3	Write the processes for production of various types of nanostructured materials.	
CO4	Explain applications of nanomaterials in bioseparation, diagnostics, drug delivery and bioimplants.	
CO5	Select the technique for applications within bioseparation, diagnostics, drug delivery and bioimplants.	
CO6	Design a membrane model by utilization of lipid/polymer nanoparticles for formulation/ administration of drugs.	

Unit No.	Title of Unit and Contents
I	Nanobiomaterials and biocompatibility, structural & functional principles of bionanotechnology, protein and dna based nanostructures, nanobio-analytics, nanotechnology in food, medicine and health science.
II	Examples and production of various types of nanostructured materials [Carbon Nanotubes (CNT), Fullerenes (C60, C300) Nano Peapods, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide Nanoparticles), Nanowires Polymer-based Nanostructures (Dendrimers), Nanorods, Nanocages, Nanoshells] with usage and potential within biotechnology. Using biomaterials and biomolecules as bases for inorganic structures.
III	Introduction to surface physics and biomaterials. Methods for derivatisation and characterisation of surfaces and other carrying structures. Theory and methods for studies of the interaction with surfaces and fibres of biomolecules. Applications within bioseparation, diagnostics, the drug delivery and bioimplants.

IV	Theory for how lipid/polymer nanoparticles can be utilised as model membranes and forformulation/administration of drugs. Molecular prints of biomolecules. Production and applications of inorganic replicas of biological materials. Enzyme reactors based on nanostructured materials.

Learning Resources

1. Nanobiotechnology: Concepts, Applications and Perspectives (2004), Christof M. Niemeyer (Editor), ChadA. Mirkin (Editor), Wiley VCH.
2. Nanobiotechnology - II more concepts and applications. (2007) - Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH.
3. Nanotechnology in Biology and Medicine: Methods,Devices, and Applications.
4. Nanobiotechnology, Edited by C. Niemeyer, C. Mirkin, Wiley-VCH (2007). ISBN: 978-3-527-30658-9
5. Introduction to Protein Structure, 2nd ed. Carl Branden & John Tooze (1999) Garland Publishing, Inc., New York.