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 Bionanotechnology		
	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 learning outcomes

After completing their Masters' degree in Microbiology, the students are equipped with advanced theoretical and practical skills that help them in their doctorate study at various renowned National and International universities and career in various industries.

PO1	Subject skills: • Microbial taxonomy and Bioinformatics: it mainly involve studying diversity and classification of microbes with special emphasis on extremophiles, advanced methods of identification like nucleic acid sequencing techniques that involves bioinformatics. • Cell and Molecular Biology • Biochemistry and Metabolism • Advanced Environmental Microbiology: the taxonomic, ecological, and genetic relationships among microorganisms, including such topics as nutrient cycling, microbial diversity, and the biotechnological application of microorganisms to solve environmental problems • Bioprocess development: it includes study of advanced techniques of largescale production of industrially important products, bioreactor design and process variables. • Pharmaceutical Microbiology & Immunology • Scientific Method: hypothesis generation and testing, including the development of theoretical and practical skills in the design and execution of experiments • Scientific Communication: the development and execution of oral and writing skills necessary for effective communication of experimental results, the ability to think critically regarding a discipline topic, and the conveyance of scientific principles to audiences of both scientists and non-scientists.
PO2	**Specialized Knowledge:** • evaluate and respond to a complex question or challenge, using perspectives and scholarship drawn from microbiology and from cognate and non-cognate fields; • construct a summative project or paper that draws on current research, scholarship and/or techniques in microbiology.
PO3	**Intellectual Skills - Communication Fluency:** Within the framework of specialized knowledge developed in our courses, our students will communicate science as assessed by their ability to: • utilize microbiological concepts to summarize, analyze, and synthesize scientific and microbiology-related literature,

	• describe methodological information, • apply microbiological concepts and basic research findings through description, interpretation, and analysis, • articulate conclusions and implications of research, and • communicate with both specialist and non-specialist audiences using genres commonly used in microbiology. complete a substantial research project related to microbiology; seek and employ insights from others in implementing the project; evaluate a significant challenge or question faced in the project in relation to core concepts, methods or assumptions in microbiology; and describe the effects of learning outside the classroom on his or her research or practical skills.

MIC4101: Microbial Diversity and Molecular Taxonomy
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
The student will be acquainted with all the groups of micro-organisms such as bacteria, viruses and fungi	Context based teaching using traditional chalk-and-board method
The student will be well – versed in the various methods used for the determination of the diversity of micro-organisms in diverse habitats	ICT based teaching
The students will learn about the wide variety of micro-organisms found in extreme environmental conditions and also the mechanisms of their survival and growth in these extreme conditions	Post lesson teacher questionnaire
The students will be acquainted with the advanced methods of identification of micro-organisms	Group discussions on reviews pertaining to microbial diversity
The students will be introduced to the concept of metagenomics and the different methods used for studying unculturable micro-organisms	Problem-solving approach

Unit No.	Topics
1	**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
2	**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
3	**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 viii. Construction of phylogenetic trees using softwares such as Mega

	ix. Molecular clocks
4	**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.

MIC4102: Biochemistry
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
Through this fundamental course on bio-organic chemistry students will understand the core principles of the subject which will allow the students to get a better insight on the higher courses related to the subject.	Diverse pedagogical tools ranging from traditional chalk and board method to ICT based learning.
Students should be able to apply the concepts to solve problems based on bio-organic chemistry such as preparation of buffers.	Problem solving session and numericals
Students should be able to apply fundamental thermodynamic concepts and determine feasibility of biological reactions.	Conceptual learning and assignment writing
Students will study the structure, dynamics of biological membranes and transport of molecules by various mechanisms.	ICT based learning and model making
Students will learn the derivations of equations related to enzyme kinetics and apply the same to problem solving.	Graphical representations and calculations

Unit 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 **References** 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.
Unit 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 **References:** 1. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York. 2. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York 3. Garrett, R. H. and Grisham, C. M. (2004) *Biochemistry.* 3rd Ed. Brooks/Cole, Publishing Company, California
Unit 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 **References:** 1. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York. 2. Garrett, R. H. and Grisham, C. M. (2004) *Biochemistry.* 3rd Ed. Brooks/Cole, Publishing Company, California. 4. Berg Jeremy, Tymoczko John, Stryer Lubert (2001) *Biochemistry* 4thEd, W. H. Freeman, New York.
I **Unit 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 **References:** 1. Nelson D. L. and Cox M. M. (2005) *Lehninger's Principles of Biochemistry*, Fourth edition, W. H. Freeman & Co. New York. 2. Palmer Trevor (2001) *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*, Horwood Pub. Co. Chinchester, England. 3. Segel Irvin H. (1997) *Biochemical Calculations* 2nd Ed., John Wiley and Sons, New York

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

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

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

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

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

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

MIC4103: Molecular Biophysics and Instrumentation
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
The student will able to know different chromatographic techniques used in microbiology with respect to its principle, components and working and its applications.	ICT based teaching
The student will able to know different centrifugation techniques used in microbiology with respect to its principle, components and working and its applications.	Class presentations by students
The students will have learnt how to analyze different biomolecules using various spectroscopic techniques.	Problem solving
The students will be acquainted with different biophysical techniques used in microbiology with respect to XRD and NMR	ICT based teaching
The students will have learnt different methods of synthesis and characterization of bio-nanoparticles using various tools.	Class presentations by students
The student will be able to know synthesis of magnetic nanoparticles and its application	ICT based teaching

Learning Resources

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.

MIC4104: Microbiology Practical - I
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
The student will be acquainted with the various methods of cultivation of different groups of micro-organisms such as bacteria (including actinomycetes), cyanobacteria and fungi	Briefing about the need of carrying out a particular experiment
The student will be well – versed in designing culture media for the cultivation of micro-organisms inhabiting extreme habitats	Use of manuals and research papers
The student will have learnt about the various methods used for the determination of the diversity of micro-organisms in various habitats	The students are taught how to design culture and incubation methods for different groups of micro-organisms
The student will have a hands-on experience of basic techniques in molecular taxonomy such as isolation of bacterial DNA and agarose gel electrophoresis.	Actual demonstration hands-on training
The student will have a hands-on experience of using softwares such as BLAST and PHYLIP	Use of computers and internet for teaching the use of softwares such as BLAST and PHYLIP

1. Unit 1	**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.
Unit 2	**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.
Unit 3	**Isolation and identification of Cyano bacteria** Isolationandidentificationofanyonetypeofcyanobacterium from anatural sample. Theidentificationkey mustbedesignedforeachisolatedand identifiedcyanobacterium. Studentsare expectedtoisolate at least one genus ofcyanobacteria.
Unit 4	**Molecular Taxonomy** A. Isolation, purification and checking purity of isolated chromosomal DNA ofbacteria B. Demonstration ofthe following steps, if not possible to perform inyourlab: a. CyclesequencingPCR Purification ofPCRproduct 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

MIC4105 Microbiology Practical - II
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
Students will understand the basics of the Good Laboratory Practices, hazards and safety in lab and preparation of standard buffer solutions.	Teacher constructed charts and use of analytical instruments.
Students will learn the steps in extraction and purification of enzymes from bacteria and fungi and determination of kinetic parameters.	Column chromatography and explanation using ICT
Calibration and operating procedures of analytical instruments for estimation of biomolecules.	Demonstration of operation and calibration of instruments.
Students will study the interpretation of Ramachandran plot and determine the molar extinction coefficients of pure biomolecules.	Use of graphical tools and analytical instruments.
Students will study the formation of microbial communities on natural surfaces and its applications in ecosystem.	Observation in vivo and in vitro
Students will study the role of microorganisms in degradation of xenobiotic compounds, estimation of pollution load of waste water and simulated waste water treatment process.	Illustrations and observation using various natural polluted samples.

Learning Resources:

Unit 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 ii. Preparation of buffers using KH_2PO_4 and K_2HPO_4, acetic acid and sodium acetate, K_2HPO_4 and H_3PO_4
Unit 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.
Unit 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.
Unit 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

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

MIC4106: Applied Microbiology
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
Students will understand the role of microorganisms in biofilm formation which is responsible for destruction of metallic and wooden articles in various fields such as medical, marine and industries.	Diverse pedagogical tools ranging from traditional chalk and board method to ICT based learning.
Students will gain knowledge about the different extraction methods for precious metals that are employed in various countries.	Group discussion
Students will study in detail the biochemical pathways involved in bioremediation of recalcitrant xenobiotic compounds.	Conceptual teaching and learning
Students will visualize the wastewater treatment methods like oxidation ponds, trickling filters, activated sludge process etc.	ICT based learning (animations and videos) and on sight visits
Students will get knowledge about the advanced waste water treatment processes for treating industrial wastes containing toxic chemicals.	Literature review from peer reviewed journals

Unit 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
Unit 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

Unit 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 **References:** 1. Biotechnology for Water and Wastewater Treatment. Dr. Satya Prakash. Navyug Publishers & Distributors, New Delhi. 2009. 2. Industrial Water Pollution Control. 3rd Edition. W. Wesley Eckenfelder Jr. McGraw Hill. 2000. Standard Methods for the Examination of Water & Wastewater. 21st Edition. 2005.
Unit 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. N. S. SubbaRao. (1995). Soil Microorganisms and Plant growth. 3rd Edn. Science Pub Inc
9. Biological Wastewater Treatment. Vol. 5. Activated Sludge and Aerobic Biofilm Reactors. Marcos von Sperling. IWA Publishing. London, New York. © 2007 IWA Publishing

MIC4107: Cell and Developmental Biology
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
Insight on the cell proliferation and cell death mechanisms.	Context based teaching
Students should understand the effect of fundamental activities such as homeostasis and morphogen gradients on the process of cellular development.	ICT based teaching and use of physical models
Study the trafficking of biomolecules in the compartments of an eukaryotic cell.	Teacher constructed concept maps
Study the cellular signaling mechanisms in higher organisms at the molecular level.	Post lesson teacher questionnaire
Understand the architecture of an eukaryotic cell with the use of advanced microscopical techniques considering localization of biomolecules in a cell.	Group student experimental activities
A comparison of vertebrate and invertebrate developmental systems should be understood by students.	Illustrations and analogies in diverse forms

Unit 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
Unit 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
Unit 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
Unit 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. 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
6. Christopher M. Waters and Bonnie L. Bassler (2005) Quorum sensing:cell-to-cell communication in bacteria. Annu. Rev.Cell Dev.
7. Melissa B. Miller and Bonnie L. Bassler (2001) Quorum sensing in bacteria. Annu. Rev. Microbiol. Vol. 55, 165–99.

8. 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,
9. Nelson D. L. and Cox M. M. (2005) Lehninger's Principles of Biochemistry, Fourth edition, W. H. Freeman & Co. New York.
10. Gibert Scott F. (2003). Developmental Biology. 7th Ed. Sinauer Associates Inc. Mass. USA.
11. Muller W.A. (1997) Developmental Biology, SpringlerVerlag, New York,Inc.
12. Wolpert Lewis (1998)Principles of Developmen. Oxford University Press Oxford

MIC4201: Microbial Metabolism
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
Students will study the structural and functional details of proteins and nucleic acids	Diverse pedagogical tools ranging from traditional chalk and board method to ICT based learning.
Students will get to know the details of interactions between proteins and nucleic acids.	Problem solving session and numericals
Students will study the metabolic activities of bacteria under aerobic and anaerobic conditions.	Conceptual learning and assignment writing
Students will study the structure of nitrogenase enzyme, nitrogen fixation and other pathways involving nitrogen metabolism.	ICT based learning
Students will gain knowledge about the comparison between the photosynthesis in plant systems, eubacteria and achaebacteria.	Graphical representations and calculations

Unit 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
Unit 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
Unit 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
Unit 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.

MIC4202: Immunology
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
Cell surface receptor structures and its relationship with respect to immunological response should be understood	Context based learning and Learning with day to day examples
Mechanisms of immunological tolerance, suppression and immunological regulation should be understood	Engaging students with authentic scientific tools which can improve scientific skills and conceptual thinking
Understanding of various mechanisms of tumor development, escape mechanisms from the host and cancer chemotherapy	LCD based teaching with recent examples of pathogenic organisms
Mechanisms of autoimmunity development, pathophysiology and treatment mechanisms shouldbe understood	Conceptual learning by using chalk and board method, Adaptive teaching to create a personalized path through educational content.

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 gravi**s** 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.

MIC4203: Molecular Biology
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
Students should be able to understand the concepts of epigenetic and the changes which affect the gene expression	Conceptual teaching
Students should be able to understand the difference with prokaryotic and eukaryotic transcription	Context based teaching learning
Students should be able to understand different control mechanisms involved in prokaryotic transcription	Visual representation Using chalk and board and diagrams
Students should be able to understand the concepts of transposons	ICT based learning using presentations and animations
Students should be able to understand the structure and organization of chromatin	Learning by doing experiments in Laboratory

Unit 1	**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
Unit 2	**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

Unit 3	**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 trp operon: - control of trp 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.
Unit 4	**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 tumorogenesis, 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

MIC4204: Microbiology Practical - III
Credits: 4

Learning Outcomes	Suggested pedagogical processes
Student should be able to understand the use of minimal media to cultivate microorganisms capable of degrading different carbon sources	Conceptual teaching
Student should be able to understand the cultural conditions and techniques required for the cultivation of Anaerobic microorganisms	Context based teaching learning
Student should be able to understand the desirable properties associated with use of microorganisms as biofertilizers	Visual presentation using chalk and board and diagrams
Student should be able to isolate, identify and characterize plasmid DNA	ICT based learning using presentations and animations
Student should be able to demonstrate the lactose operon activity and select the recombinants based on its induction	Learning by designing and performing experiments in laboratory

Unit 1	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*
Unit 2	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
Unit 3	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
Unit 4	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 PseudomonasfluorescensandBacillus subtilisand 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. 1. 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. 2. 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. 3. Sethi S. et al. (2013) Optimization of Cellulase Production from Bacteria Isolated from Soil. International Scholarly Research Notices

MIC4205: Microbiology Practical - IV
Credits: 4

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.

MIC4206: Virology
Credits: 2

Learning Outcomes	Suggested Pedagogical Processes
The student will be able to understand the correlation between the structure and classification of viruses, if any.	Context based teaching using traditional chalk-and-board method
The student will have understoodthe various methods by which viruses replicate in their hosts	ICT based teaching and use of physical models
The student will be acquainted with the various methods of cultivation of viruses required for vaccine production	Teacher constructed concept maps
The student will be able to understand the various methods of detection of viruses in clinical samples	Post lesson teacher questionnaire
The student will be aware of the factors responsible for emergence and re-emergence of viruses	Group discussions on newspaper articles pertaining to Virology
The student will be well – versed with the mechanisms of viral vaccines and the mode of action of anti-viral chemotherapeutics	Illustrations and analogies in diverse forms Problem-solving approach

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. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, American Society Microbiology.
3. Burton E .Tropp (2008). Molecular Biology Genes to proteins (3rd edition). Jones and
4. Bartlett Publishers.Hull R (2002) Matthew's Plant Virology, 4th edition. Academic Press.
5. Mahy B. WJ. And Kangro H.O., (1996), Virology Methods Manual, Academic Press.

MIC4207: Advanced Bionanotechnology
Credits: 4

Learning Outcomes	Suggested Pedagogical Processes
The student will able to understand use of food nanobiomaterials and biocompatibility	ICT based teaching
The student will able to introduce surface physics and biomaterials	ICT based teaching
The students will have learnt different examples and production of various types of nanostructured materials	Problem solving
The students will have learnt different applications within bioseparation, diagnostics, the drug delivery and bioimplants.	ICT based teaching
The students will be acquainted with theory for how lipid/polymer nanoparticles can be utilised	Class presentations by students

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.