M.Sc. Microbiology Program
(Based on UGC – Learning Outcomes-Based Curriculum Framework)
School of Life Sciences
Department of Microbiology

A. Program Eligibility

- Bachelor‟s degree with Microbiology/Zoology/Botany/Life sciences/Biochemistry/Genetics/ Biotechnology/Medicine/ Pharmacy/any other discipline of Biological sciences as one of the main subjects and Chemistry as one of the optional subjects at least for One year or Two semesters with minimum 50% of marks or equivalent grade in aggregate for general category and 45% or equivalent grade for SC/ST/OBC/PWD candidates.

B. Program Objectives

- The objective of the Master‟s Program in Microbiology is to equip the students to gain bimolecular knowledge and analytical skills at an advanced level.
- The program emphasizes to apply knowledge acquired about prokaryotic and eukaryotic cellular processes, interaction of microorganisms among themselves, with physical and chemical agents and higher order organisms in environment and biological systems to various conditions.
- The laboratory training in addition to theory is included so that the students will acquire the skills to qualify for a broad range of positions in research, industry, consultancy, education and public administration, or for further education in a doctoral program.
- Students will be able to address broad range of fields including biopolymer chemistry, marine biochemistry, environmental biotechnology, food science, microbiology, microbial genetics, molecular biology and systems biology.

C. Program Learning Outcomes (PLOs)

The Masters in Microbiology Program will address the increasing need for skilled scientific manpower with an understanding of research ethics involving microorganisms to contribute to application, advancement and impartment of knowledge in the field of microbiology and molecular biology globally. The laboratory training will empower them to prepare for careers in broad range fields.
The M. Sc. Microbiology students will:

- **PLO-1:** Gain knowledge on tools and techniques used in Microbiology fundamental and applied studies.

- **PLO-2:** Demonstrate ability to use bioinformatics tools and software's related to microbiology
- **PLO-3:** Development of Competency in applied microbiology with project based experience.
- **PLO-4:** Capability to evaluate methods and within the field of Microbiology research and basic practical applications.
- **PLO-5:** Gain basic knowledge on Industrial application of microbes to get products of commercial interest
- **PLO-6:** Gain knowledge to mitigate environmental problems using microbial approach
- **PLO-7:** Development of competency in food and diary microbiology and to understand quality control techniques.
- **PLO-8:** Learn Molecular techniques and its application in microbial genetics.
- **PLO-9:** Gain knowledge in medical microbiology, therapeutic agents and vaccines to be able to work in healthcare Industry.
- **PLO-10:** Understand Agriculture microbiology and its application in field.
- **PLO-11:** Able to compete national level competitive exams for research and Job

D. Employability

- Skilled manpower suitable for academic and research institutions as technicians.
- Suitable for different government and non-governmental and private companies.
- Skilled students who can do PhD and contribute to field of Microbiology.

Course Content: M.Sc. Microbiology (Implemented from academic session 2020-2021 onwards)

Semester I

Course Code	Title of the course	Course	Course Type	Credits
MBY 401	Essentials of Microbiology	Core 1	T	3
MBY 402	Biochemistry	Core 2	T	3
MBY 403	Bioinstrumentation and Biotechniques	Core 3	T	3
MBY 404	Microbial Physiology	Core 4	T	3
MBY 405	Immunology	Core 5	T	3
MBY 431 to 434	Elective-I	DSE 1	T	3
MBY 406	Laboratory for Microbial Physiology, Biochemistry, Bioinstrumentationand Biotechniques	(P-1) Core 6	L	3
MBY 407	Laboratory for Essential Microbiology, Immunology and Elective-I	(P-2) Core 7	L	3
Total Credits				**24**

Semester – II

Course Code	Title of the course	Course	Course Type	Credits
MBY 408	Medical Microbiology	Core 8	T	3
MBY 409	Virology	Core 9	T	3
MBY 410	Enzymology	Core 10	T	3
MBY 411	Microbial Genetics	Core 11	T	3
MBY 435 to 442	Elective -II	DSE 2	T	3
	Elective -III	DSE 3	T	3
	Elective-IV	NDSE 1	T	3
MBY 412	Laboratory for Medical Microbiology, Virology and Elective -II	(P-3) Core 12	L	3
MBY 413	Laboratory for Enzymology, Microbial Genetics & Elective -III	(P-4) Core 13	L	3
Total Credits				**27**

Semester –III

Course Code	Title of the course	Course	Course Type	Credits
MBY 501	Molecular Biology & Recombinant DNA Technology	Core 14	T	3
MBY 502	Food and Dairy Microbiology	Core 15	T	3
MBY 503	Environmental and Agricultural Microbiology	Core 16	T	3
MBY 504	Industrial Microbiology	Core 17	T	3
MBY 531 to 534	Elective-V	DSE 4	T	3
	Elective-VI	NDSE 2	T	3
MBY 505	Laboratory for Food and Dairy Microbiology, Environmental and Agricultural Microbiology, Industrial Microbiology	(P-5) Core 18	L	3
MBY 506	Laboratory for Molecular Biology& Recombinant DNA Technology and Elective-V	(P-6) Core 19	L	3
Total Credits				**24**

Semester IV

Course Code	Title of the course	Course	Course Type	Credits
MBY 581	Concepts of Research Design	AECC 1	Tu/L	2
MBY 582	Paper Writing Skill	SEC 1	Tu/L	2
MBY 583	Journal Club Presentation	AECC 2	Tutorial/ Presentation	2
MBY 507	Major Project (Research Dissertation)		Tutorial/ Laboratory	15
Total Credits				**21**

T: Theory Classes, L:- Laboratory Classes, Tu: Tutorial Classes, P: Presentation

List of Elective to be offered

Discipline Specific Electives (DSE) *

Semester	Paper Code	Name of the Course
I	MBY 431	Developmental Biology
	MBY 432	Functional Genomics & Proteomics
	MBY 433	Biohydrometallurgy and Biomineral Processing
	MBY 434	Microbial Ecology
II	MBY 435	Bioinformatics & Biophysics
	MBY 436	System and Synthetic Microbiology
	MBY 437	Cell Organization and Signaling
	MBY 438	Fungal Biotechnology and Bioprospecting
	MBY 439	IPR and Biostatistics
	MBY 440	Microbes in Sustainable Agriculture &Development
	MBY 441	Petroleum Microbiology
	MBY 442	Pharmaceutical Microbiology
III	MBY 531	Infection Biology and Vaccine Development
	MBY 532	Biomass and EnergySystems
	MBY 533	Extreme Microbiology
	MBY 534	Current Trends in Microbiology

MOOC courses**:** - Courses may be offered by the department from the list of courses made available online before beginning of the semester as per suitability of the M. Sc. Program.

Any other electives offered by the allied Departments**.**

* The subjects in the given list for DSE may change whenever required.
** The content will depend upon recent developments in the area of Microbiology.

Non Discipline Specific Electives (NDSE): As offered by the other departments of the University.

S. No.	Course Name	Course Type	No. of Course	Credits for each course	Total Credits
1	Core Course	Theory	13	03	39
2	Core Course	Laboratory	06	03	18
3	DSE	Theory	04	03	12
4	NDSE	Theory	02	03	06
5	SEC	Tu/L	01	02	02
6	AECC	Tu/L	02	02	04
7	Dissertation	Tu/L	01	15	15
				Total Credits	**96**
8	Fitness/Societal	Practical	1	2	2

Semester I

MBY 401 Essential in Microbiology Credits 3

Course objectives

- Knowledge on Landmark discoveries in Microbiology and different domains classification of living organisms.
- Familiarity with general characters of prokaryotic and Eukaryotic microorganisms for conventional and molecular characterization using modern methods.
- Knowledge of cellular organization, life cycle and economic importance of prokaryotic (Eubacteria, Archaea, Cyanobacteria) and Eukaryotic (Algae, Fungi and Protozoans).

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to……

- **CLO-1:** Explain the taxonomic evolution of the Microbial world.
- **CLO-2:** Discuss and characterize prokaryotes and Eukaryotes
- **CLO-3**: Discuss the microbial nutritional and microbial ecological significance of Gram-positive and Gram-negative bacteria
- **CLO-4:** Capable to use Bergey‟s Manual of Systematic Bacteriology.
- **CLO-5:** Explain the significance of Archaea along with their Evolutionary developments
- **CLO-6:** Describe Algal and Cyano-bacterial diversity along with their structure and reproduction.
- **CLO-7:** Explain economic importance of microbes and their symbiotic relationships.
- **CLO-8:** Describe fungal diversity along with Classification
- **CLO-9:** Discuss the role of Yeasts and Protozoans in the microbiology both on fundamental and applied aspects.
- **CLO-10:** Understand the isolation, characterization and identification of cultivable and non-cultivable microorganisms

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1		3									1
CLO2			2			3		3			
CLO3	2								1		2
CLO4	3			1			2			3	
CLO5											1
CLO6					2						1
CLO7											
CLO8						3					1
CLO9											1
CLO10											2

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above “High level” mapping is denoted as “3”, Medium level mapping is denoted as “2”, and Low level mapping is denoted as “1” respectively.

Course Structure

Unit I

Origin and evolution of microbial world; Pathway of discovery in Microbiology; Haeckel‟s three kingdom concept, Whittaker‟s five kingdom concept, three domain concept of Carl Woese. General characteristics of various groups of prokaryotes: bacteria including, Rickettsiae, Chlamydiae, Spirochaetes and Actinomycetes, Cyanobacteria and Mycoplasmas. Eubacteria: cell structure, nutrition, isolation and cultivation. Diversity, nutrition, ecology, significance of Gram-positive (Firmicutes, Actinobacteria) and Gram-negative [Proteobacteria (cyanobacteria, Rhizobia, methanotrophs, myxobacteria, magnetotactic bacteria), *Deinococcus-Thermus*, Spirochaetes, Bacteroidetes].

Unit II

Classification of bacteria and Archaea according to the Bergey‟s Manual of Systematic Bacteriology. Tools for Systematics: Numerical taxonomy, Phylogenetic analysis, Polyphasic approach; Modern methods of studying microbial diversity; Microbial culture collections. Phyla of Archaea, Significance of Archaea, Evolutionary developments of Archaea, Cell structure Archaea, Metabolism and energetics of Archaea (*Thermoplasma*, *Sulfolobus*, *Pyrococcus)*. Phycology: Algal and Cyanobacterial diversity and distribution; Characteristics: cell structure, pigmentation, thallus organization, nutrition, reproduction, alternation of generations; Identification; Culturing, Classification; Phylogeny; Economic importance and applications; Phycovirus, Symbiotic associations of algae with fungi.

Unit III

Mycology: Fungal diversity and distribution; Cell structures, growth and development, nutrition, reproduction, life cycle; Classification of fungi, Major taxonomic groups of fungi; Identification; Cultivation; Phylogeny; Yeasts: General characteristic, structure, classification, life cycles (important forms), sexual and asexual reproduction of Yeasts; Protozoa: Classification, Morphology, reproduction, modes of nutrition, modes of transmission, locomotory organelles, Life cycle, Cultivation of Protozoa. Structure and significance: *Leishmania*, *Trichomonas, Entamoeba, Plasmodium*

Suggested Readings

1. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012). Brock Biology of Microorganisms, Prentice Hall, USA.
2. Lansing M Prescott, Donald A Klein, John P Harley, Microbiology, Mc Graw Hill.
3. Michael J Pelczar, Microbiology, Tata McGraw, India.
4. Kathleen Park Talaro, Foundations in Microbiology, McGraw Hill.
5. Christiaan Hoek, David Mann, H. M. Jahns (1995). Algae: An Introduction to Phycology. Cambridge University Press
6. Constantine J. Alexopoulos, Charles W. Mims, Meredith M. Blackwell (1996). Introductory Mycology. John Wiley & Sons.
7. John Webster and Roland Weber (2007). Cambridge University Press, USA.
8. William Purvis (2000). Lichens. Smithsonian's Natural World Series.
9. D.R. Khanna (2004). Biology of Protozoa. Discovery Publishing House.
10. Mark F. Wiser. (2010). Protozoa and Human Disease. Garland Science

MBY 402 **Biochemistry** **Credits 3**

Course Objective

- The course learning objectives is to provide the core principles and specialized knowledge of Carbohydrates, Lipids, Proteins, Vitamins, Porphyrin, cellular transport, law of thermodynamics, Lipid and Nitrogen metabolism.

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to……

- **CLO-1:** Develop understanding of bio-molecules such as carbohydrates, proteins and Lipids.
- **CLO-2:** Understand the basic classification proteins and their structural characteristics.
- **CLO-3**: Discuss structure and classification of vitamins as well as porphyrins and porphyrin ring system
- **CLO-4:** Explain the significance of microbial cellular permeability and transport process system.
- **CLO-5:** Understanding the laws of thermodynamics, concepts of entropy, enthalpy and free energy in various biochemical reactions
- **CLO-6:** Describe lipid and nitrogen metabolism
- **CLO-7:** Explain the use of Ramachandran plot in structural biology
- **CLO-8:** Understand the saturated and unsaturated fatty acids together with phospholipids
- **CLO-9:** Discuss the types and functions of microbial lipoproteins as well as lipids present in membranes, micelles and emulsions.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	3	1	2	3	2	2	2	3	1		3
CLO2	3		1	1	1		2			2	
CLO3	3	1	3			3					3
CLO4	3			2	2		3	2	1	3	
CLO5	3	1				2					
CLO6	3		2		3		3		1	1	3
CLO7	3	1		1		1		1			
CLO8	3		2				1		1	1	2
CLO9	3				1	3		1			1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Carbohydrate: Monosaccharide, Disaccharide and Polysaccharide - occurrence, structure, isolation, properties and functions of homoglycans -starch, glycogen, cellulose, dextrin, inulin, chitins, xylans, arabinans. Occurrence, structure, properties, and functions of heteroglycans, Glycoprotein and their biological applications. Lipid: classification, saturated and unsaturated fatty acids, phospholipids: classification, structure and functions of lipids. Types and functions of microbial lipoproteins. Amphipathic lipids: membranes, micelles, emulsions and liposomes.

Unit II

Proteins: classification of proteins on the basis of solubility and shape, structure, and biological functions. Primary structure: determination of amino acid sequence of proteins. The peptide bond: Ramachandran plot. Secondary structure: weak interactions involved, alpha helix, beta sheet and beta turns structure. Super secondary structures: helix-loop-helix. Tertiary structure: alpha and beta domains, quaternary structure. Vitamins and Porphyrins: Vitamins - water soluble - thiamine, riboflavin, niacin. Porphyrins the porphyrin ring system, chlorophyll and cytochrome.

Unit III

Cellular Permeability and Transport process, Bioenergetics of metabolism: oxidation–reduction reactions, coupled reactions and group transfer; enthalpy and free energy of reaction and ATP. Lipid and Nitrogen Metabolism: Oxidation of fatty acid: β-oxidation, activation of a fatty acid, transport and steps of oxidation, α and ω oxidation.

Suggested Readings

1. Nelson D L, Cox M. M. Lehninger s Principle of Biochemistry. 4th ed. Freeman, 2004.
2. Lansing M. Prescott. Microbiology. 5th ed. The McGraw−Hill Companies, β00β.
3. Berg, J. M., Tymoczko, J. L., Stryer, L. Biochemistry. 6th Ed. Freeman, 2006.
4. White David. Physiology and Biochemistry of Prokaryotes. 2nd ed. Oxford University Press, New York, 2000
5. G.N. Cohen (2011), Microbial Biochemistry, Second Edition, Springer Publishers
6. D. Voet, J.G.Voet, C.W. Pratt , Fundamentals of Biochemistry, 3rd Edition by. 2004, John Wiley and Sons, New York.
7. G. Zubay, Biochemistry, , 4th Edition, 1998. Brow Dubuque, Lowa,
8. L. Stryer, Biochemistry, , 5ht, Edition.2002. W.H. Freeman and Co.
9. R.K. Murray, D.K Grammer, P.A. Mayes, V.W. Rodwell, Harper's Biochemistry, 25th Edition. 2000. Appleton and Lange.

MBY 403 **Bioinstrumentation and Bio-techniques** **Credits 3**

Course Objectives

- Introduce the basic concept of qualitative and quantitative analysis of a given sample.
- Study various spectroscopic techniques and its instrumentation.
- Study the concept of separation science and its applications.
- Study the concept of radiochemical analysis along with industrial analyzers.

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to……

- **CLO-1:** Explain fundamental of microscopy and its use along with various types of microscopy.
- **CLO-2:** Understand the qualitative and quantitative analysis andcharacterize functionalities of biomolecules by using spectroscopic techniques.
- **CLO-3**: Explain the various separation and purification techniques and its instrumentation
- **CLO-4:** Describe the principle and working of various radiation detectors.
- **CLO-5:** Define and explain various fundamentals of spectroscopy
- **CLO-6:** Explain the sample preparation for SEM, TEM and AFM
- **CLO-7:** Discuss the Electrophoretic techniques as well as the instrumentation
- **CLO-8:** Learning of handling FTIR, UV-Vis Spectrophotometer, Raman Spectroscopy etc.
- **CLO-9:** Describe Centrifugation technique and explain the use of different type of rotors and learn ultracentrifugation too.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	3	2	2	3	2	2	2	3	3		2
CLO2	3		1	1	1		2			2	
CLO3	2	2				1					3
CLO4			1	2	3		1	3	3	3	
CLO5	1	1				2					
CLO6			3		3		3		1	1	2
CLO7		2		1		1		1			
CLO8	2		3				1		2	1	2
CLO9	3				1	3		1			1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Microscopy: Light Microscopy: simple and compound Microscopy, Phase Contrast, Dark field, Confocal, Atomic force and Fluorescent Microscopy; Electron Microscopy: SEM, TEM, AFM Sample preparation for microscopy; Electrophoretic techniques: Principle of Electrophoresis, Agarose Gel Electrophoresis, Polyacrylamide gel electrophoresis, Counter current Electrophoresis, Immuno-Electrophoresis, Support media; Colony counter, Nephlometry, Isoelectric focussing, colorimetry, Turbidometry.

Unit II

Chromatographic techniques: Basics of Chromatography, Paper, Thin layer and Column chromatography; Protein purification; Liquid chromatography; Gas chromatography, Affinity Chromatography, Gel Filtration, Ion Exchange Chromatography. HPLC; Centrifugation techniques: Basic principle, RCF and Sedimentation Coefficient, Types of Centrifugation - High speed and Ultracentrifugation, Differential and Density-gradient centrifugation, Analytical centrifugation and applications, Factors affecting Sedimentation, Preparative and analytical centrifugation, Safety measures of centrifugation.

Unit III

Spectroscopy: Theory and applications, UV-Visible, Fluorescence, IR, FTIR, NMR, Mass spectroscopy, Raman and Atomic absorption spectroscopy; Fluorescence polarization; Radioactivity measurement: Radioactive decay, Liquid scintillation counter- Û ray detection and its applications; Use of stable isotopes in Biological sciences; Autoradiography and tracer technique. Principle of electrochemical techniques, Redox reaction measurement, pH meter and electrode; Thermal techniques: X-Ray Diffraction, Micro-array.

Suggested Readings

1. Biochemistry by Lubert Stryer
2. Sharma BK, Instrument method of chemical analysis
3. DA Skoog, Instrument method of analysis
4. Plummer, An introduction to practical Biochemistry
5. Chatwal and Anand, Instrumentation
6. Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson,
7. John Walker. Cambridge University Press India Pvt. Ltd.
8. Biochemical Techniques theory and practice: White R
9. Analytical Chemistry: Christion G. D.
10. A Biologist Guide to Principle and Techniques: Willson K. and GoundingK. H.

MBY 404 Microbial Physiology Credits 3

Course Objectives

- To develop understanding about microbial metabolism, growth and energy generation.
- Gain knowledge of various fermentation pathways, microbial communication and energetics.
- Familiarize students with concepts of nitrogen and phosphate assimilation, electron transport chain and transfer of genetic information among microbial communities.

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to……

- **CLO-1:** Explain the Microbial Physiological aspects with respect to Metabolic genetic regulation
- **CLO-2:** Describe oxidation-reduction potential of microorganisms together with fermentation and nitrogen assimilation.
- **CLO-3**: Define microbial growth and rate kinetics of microbial substrate utilization in batch, fed-

batch and continuous culture.

- **CLO-4:** Explain the microbial growth cycle under the influence of factors affecting growth such as pH, Redox potential, temperature, substrate concentration, product inhibition, toxic chemicals etc.
- **CLO-5:** Describe carbohydrate metabolism, lipid degradation and nitrogen assimilation and nitrogen fixation by microorganisms
- **CLO-6:** Explain the microbial regulatory systems during aerobic- anaerobic shifts in respiration.
- **CLO-7:** Discuss the Osmotic control of gene expression in Microorganisms together with SOS response and Heat shock response
- **CLO-8:** Describe microbial phosphate starvation-controlled stimulants along with oxidative stress and Lon system
- **CLO-9:** Understand the bionergetics of chemolithorophs, pH Homeostasis and explain quorum sensing
- **CLO-10:** Describe cellulose and lipid degradation as well as metabolism of aromatic compounds,

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	1	2	3	2	2	2	3	1		3
CLO2	2	1	1	1	1		2			2	3
CLO3	2		3			3					3
CLO4	2	1		2	2		3	2	1	3	3
CLO5	2					2					3
CLO6	2	1	2		3		3		1	1	3
CLO7	2	1		1		1		1			3
CLO8	2		2				1		1	1	3
CLO9	2	1			1	3		1			3
CLO10	2		2	3	2	2	2	3	1		3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Introduction to Microbial Physiology: *E. coli* Paradigm, Metabolic genetic regulation, Energy, oxidation-reduction vs. fermentation, Nitrogen assimilation; Microbial growth: Growth cycle, continuous culture, factors affecting growth. Carbohydrate metabolism and Energy production: Glycolytic pathways, Gluconeogenesis, TCA cycle, glyoxylate cycle, energy production, oxidative phosphorylation.

Unit II

Introduction to two component system, regulatory systems during aerobic- anaerobic shifts. Osmotic control of gene expression, SOS response and Heat shock response, Electron transport (Respiratory pathway), regulation of nitrogen assimilation and fixation, Phosphate starvation-controlled stimulants, oxidation stress, The Lon system (Proteolytic control).

Unit III

Energetics of chemolithorophs, pH Homeostasis, specific transport systems, cellulose degradation, Metabolism of aromatic compounds, Fermentation pathways in specific group of microorganisms: Lactic acid, propionic acid, butyric acid producing fermentation; Characteristics and Metabolism of autotrophs; Biosynthesis of Fatty acids; Biosynthesis of Phospholipids, Degradation of Lipids, Endospore formation (differentiation). Bacterial Quorum sensing.

Suggested Readings

1. Albert G. Moat and John W. Foster, Microbial Physisology, Wiley-Liss, A John Wiley& Sons, Inc. Publications.
2. Roberts, K., Lewis J., Alberts B., Walter P., Johnson A., and Raff. M., Molecular Biology of the Cell, 5th Edition, Garland Publishing Inc., 2008.
3. Pollard, T. D., and Earnshaw, W. C., Cell Biology, 2nd Edition, Saunders Elsevier,2008.
4. Gerald K., Cell and Molecular Biology, Concept and Experiment, 5th Edition, Wiley, 2007.
5. Lodish, H., Berk A., Kaiser C. A., Krieger M., Scott M.P., Bretscher A., Ploegh H., and Matsudaira P., Molecular Cell Biology, 6th Edition, Freeman, W. H. and Co., 2008.
6. James Darnell, Molecular Cell Biology, 6th Edition, W. H. Freeman & Co, 2007.

MBY 405 **Immunology** **Credits 3**

Course Objectives

- To provide overview of immune system, antigen antibody structure and interactions.
- To develop understanding of innate and adaptive immunity along with major cells and molecules involved.
- To integrate immunology with health and enrich the knowledge for autoimmune disorders, hypersensitivity reaction.

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to……

- **CLO-1:** Understand the immune system and the cells involved in it and the complement system as well as autoimmunity
- **CLO-2:** Describe innate and adaptive immunity as well as details about of antigen and antibody together with their interaction.
- **CLO-3**: Theoretical understanding of various microbial diseased conditions generated due to interplay of immune system components.
- **CLO-4:** Understand the role of APCs and MHC molecules in context with Adaptive Immunity

- **CLO-5:** Gain knowledge of PAMPs and PRRs
- **CLO-6:** Describe the immunology in Health and Diseases and B-Cell Activation, T-Cell Activation and Immunological memory.
- **CLO-7:** Discuss the cancer and Immune system along with Immunotherapy, Immunodiagnostic methodologies and techniques
- **CLO-8:** Describe vaccines and process of vaccine development.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	3	1	2	3	2	2	2	3	1	2	2
CLO2	3		1	1	1		2			2	
CLO3	3	1	3			3		1			1
CLO4	3			2	2		3	3	1	3	
CLO5	3	1	1	1		2					
CLO6	3		2		3		3		1	1	3
CLO7	3	1		1		1		1			
CLO8	3		2				1		1	1	2

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Overview of Immune System: Basic concepts of the Immune System, Cells and Organs of the Immune System, Innate Immunity (Inflammation, Complement System, and Cells of the innate immune response) Adaptive Immunity (T lymphocytes, B lymphocytes, Antigen, Super antigens, Immunogens, Adjuvants structure and function of Antibodies, Other cells (NK Cells, macrophages etc.) and molecules such involved in the Immune response, antigen-antibody interactions - principles and applications.

Unit II

Innate and Adaptive Immunity: Antigen presentation, Antigen presenting cells, Major Histocompatibility Complex, Functions and Types of MHC molecules, interferons, Cytokines, Pattern recognition receptor (ex.Toll like receptors (TLR) and NOD-like receptors (NLR), Lymphocytes Development, Activation and Differentiation, B-Cell Activation, Differentiation, and Memory Generation, T-Cell Activation, Differentiation, and Memory, Immunological memory (Passive and Active Memory).

Unit III

Immunology in Health and Diseases: Autoimmunity, autoimmune disorders, Tolerance, and Transplantation, Allergy and Hypersensitivity Reactions, Types of Hypersensitivity reactions, Immunodeficiency Disorders, Diseases of the Immune system, vaccines and Immunization, Immunology of Infectious Diseases, Cancer and Immune System, Immunotherapy,

Immunodiagnostic methodologies and techniques.

Suggested Readings

1. Murphy, Kenneth M., Travers, Paul and Walport, Mark, Janeway‟s Immuno Biology, 7th Edition, Garland Science, Taylor & Francis Group, 2008.
2. Kindt, T. J.,Osborne, B. A. and Goldsby, R. A. Kuby Immunology, 6th Edition, W. H. Freeman, 2006.
3. Paul, W. E., Fundamental Immunology, 6th Edition, Lippincott Williams and Wilkins, 2008.
4. Abbas, A. K., Lichtman, A. H. and Pillai, S., Cellular and Molecular Immunology, 6th Edition, Saunders, 2007.
5. Roitt‟s, Essential Immunology

MBY 431 to 434 Elective- I (Discipline Elective)

MBY 406 Laboratory for Microbial Physiology, Biochemistry and Bioinstrumentation and Biotechniques
Credits 3

Course Objectives

- To understand the microbial growth kinetics and understanding different physiological phenomenon
- To deliver hands-on experience of various enzymatic assays and determination of kinetic parameters
- To give basic understanding of microbial genetic manipulations
- To understand working of different laboratory equipments used in microbiological laboratories
- To make students well verse with analytical approaches to quantify major biomolecules in the samples.

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to……

- **CLO-1:** Develop knowledge and hands on practice to quantify enzymes and determine kinetic parameters along with microbial genetic modification strategies
- **CLO-2:** Understand different gene transfer techniques and methods in microorganisms.
- **CLO-3**: Hand on training of the major and minor equipment's used in microbiology laboratory
- **CLO-4:** Comprehend the major spectrophotometric and titrimetric approaches of quantification in biological and environmental samples.
- **CLO-5:** Discuss microbial growth kinetics study performed on shake flask batch studies.
- **CLO-6:** Understand chromatography techniques and its usage in microbial application.

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Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	1	3			3		1			1
CLO2	2			2	2		3	3	1	3	3
CLO3	2	1	1	1		2					3
CLO4	2		2		3		3		1	1	3
CLO5	2	1		1		1		1			
CLO6	2		2				1		1	1	2

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

List of laboratory practicals

1. Microbial Growth Kinetics.
2. Conjugation in *E. coli*.
3. Transformation in *E. coli.*
4. Characterization of transformant.
5. Prokaryotic transformation.
6. Demonstration of Microscopy, centrifugation,

7. Chromatography, NMR and XRD.
8. Redox measurement and pH measurements.
9. Principles of colorimetry and spectrophotometry, its calibration and estimation of O.D.
10. UV-Vis Spectrophotometry and validating the Beer-Lambert‟s Law.
11. Qualitative and quantitative tests for Carbohydrates- Tests for glucose/starch.
12. Qualitative and quantitative tests for amino acids/ protein.

MBY 407 Laboratory for Essential Microbiology and Immunology and Elective I

Credits 3

Course Objectives

- To impart knowledge on basic microbial isolation and identification approaches.
- Develop understanding about preparation, sterilization of microbiological media.
- Deliver knowledge on microbial quantification methods.
- To learn the techniques pertaining to amplification of biological molecules.
- To provide hands-on experience to basic immunological techniques for determination of microorganisms in biological fluids and other samples.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Describe isolation and enumeration of microorganisms from various samples.
- **CLO-2:** Microbial identification and characterization using different molecular approaches.
- **CLO-3**: Acquaintance with molecular modification approaches that encompass extraction, purification, quantification and augmentation
- **CLO-4:** Able to prepare different types of growth media for microorganism both solid and broth medium
- **CLO-5:** Explain the procedure of pure culture preparation and different types of plating and streaking techniques.
- **CLO-6:** Describe different types of antigen-antibody interaction with special methods in immunology.

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Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	1	2	3	2	2	2	3	1	2	3
CLO2			1		3		2			2	
CLO3	2	1	3	2		3		1			3
CLO4				2	2		3	3	1	3	
CLO5	1	1	1	1		2					2
CLO6			2	2	3		3		1	1	3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above “High level” mapping is denoted as “3”, Medium level mapping is denoted as “2”, and Low level mapping is denoted as “1” respectively.

Course Structure

List of laboratory practicals

1. Methods of sterilization, preparation of Media: Nutrient broth, Nutrient agar, plates, slants, soft agar.
2. Pure culture technique: Streak plate, spread plate and pour plate methods.
3. Isolation, purification, microscopic observations, and enumeration of cyanobacteria, fungi and bacteria.
4. Bacterial and fungal staining, Motility determination.
5. Blood group and Rh typing.
6. Immuno-electrophoresis (Rocket Immuno-electrophoresis), Ouchterlony Double Diffusion
7. Radial Immunodiffusion & ELISA
8. Agglutination and Immunoblotting.

Semester II

MBY 408 **Medical Microbiology** **Credits 3**

Course Objectives

- Develop understanding about immune system, antigen antibody interactions.
- Gain theoretical knowledge of various diseased conditions generated due to interplay of immune system components.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Upon completion, students gained the knowledge of most common medically important pathogens and the infections they cause.
- **CLO-2:** Understand different approaches, techniques and tools used to identify pathogens and control them.
- **CLO-3**: Describe the diagnostic approaches for microbial pathogens
- **CLO-4:** Explain the Development of efficient vaccines and new drugs.
- **CLO-5:** Discuss epidemiology of communicative and non-communicative diseases.
- **CLO-6:** Explain antimicrobial agents and chemotherapeutic agents for Microbial control.
- **CLO-7:** Understand the Collection, transport and processing of clinical samples for cultural, biochemical, serological and molecular methods for investigation.
- **CLO-8:** Describe disease prevention and control measures for emerging and re-emerging diseases.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	1	2	2	1	2	2	2	3	1	2	3
CLO2	1		1	1	1		2			2	3
CLO3	1	2	3			3		1			3
CLO4	1			2	2		3	3	1	3	
CLO5	1	2	3	1		1					1
CLO6	1		2		3		1		1	1	1
CLO7	1	3		2		1		1			
CLO8	1		2				1		1	1	2

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Host-Pathogen Interaction: Distribution and significance of normal human microbial flora, accidental pathogens, oncogenic viruses. Study of following groups of microbial pathogens (Morphological characters, pathogenesis, diagnosis, epidemiology, prophylaxis and treatment) Bacterial- Enteric pathogens (*E. coli, Shigella, Salmonella, Campylobacters, Vibrio*), Pneumococci, Pyogenic organisms (*Staphylococcus, Streptococcus*), *Helicobacter pylori*, *Clostridium* spp., *Mycobacterium* spp.; Viral- HIV,

Dengue, Hepatitis, flu; Fungal-Candida, *Aspergillus*, *Cryptococococus*, *Microsporum*; Parasite-*Plasmodium* & *Entamoeba*.

Unit II

Diagnostic Microbiology: General principles of diagnostic microbiology; Collection, transport and processing of clinical samples; Cultural, biochemical, serological and molecular methods for microbial typing; Physical, biochemical and microscopic examination of clinical samples (Blood, urine, stool etc.); Isolation and identification of pathogens including *E. coli, Salmonella* spp., *Klebsiella* spp., *Shigella* spp., *Staphylococcus, Streptococcus* spp. from clinical samples (Blood, urine, stool, etc.), Antimicrobial agents and mode of action, Antimicrobial drug susceptibility testing, Antimicrobial resistance, mechanisms of Antimicrobial resistance.

Unit III

Epidemiology and Public Health: Epidemiological principles in prevention and control of diseases; Microbial typing methods, Endemic, epidemic, pandemic and sporadic diseases; Concepts of mortality/ morbidity rates, incidence and prevalence; Communicable and non-communicable diseases; Sources and reservoirs of infection-biotic and abiotic; Modes of transmission of infections; Disease prevention and control measures; Emerging and re-emerging diseases: examples of model bacterial, viral, fungal, and parasite diseases.

Suggested Readings

1. Jawetz, Melnick, & Adelberg's Medical Microbiology by Brooks GF, Butel JS, Morse SA, Melnick JL, Jawetz E, Adelberg EA. 23rd edition. Lange Publication. 2004.
2. Cellular Microbiology by Cossart P, Boquet P, Normark S, Rappuoli R eds. 2nd edition. American Society for Microbiology Press. 2005.
3. Bacterial Pathogenesis: A molecular approach by Salyers AA and Whitt DD eds. American Society for Microbiology Press, Washington, DC USA. 2002.
4. Pathogenomics: Genome analysis of pathogenic microbes by Hacker J and Dorbindt U. ed. Wiley- VCH. 2006.
5. Molecular Microbiology: Diagnostic Principles and Practice by Persing DH, Tenover FC, Versalovic J, Tang Y, Unger ER, Relman DA, White TJ eds. American Society for Microbiology Press, 2004.
6. Infectious Disease Epidemiology: Theory and Practice by Nelson KE, Williams CM, Graham NMH eds. An Aspen Publication. 2001.
7. Plant pathology by George N. Agrios: 4th ed., Academic press, New York, 1969.
8. Plant pathology by R.S. Mehrotra: Tata McGraw –Hill publishing company limited. New Delhi.
9. Bacterial plant pathology, cell and molecular aspects by David C. Sigee, Cambridge University Press, 1993.
10. Molecular plant pathology by M. Dickinson: BIOS Scientific Publishers, London,2003.

MBY 409 **Virology** **Credits 3**

Course Objectives

- Knowledge on history, general characters of viruses and how viruses are classified on basis of architecture and genetic material.
- Discerning the plant and animal viruses and their replication strategies inside the host and also methods used in cultivation and detection of viruses.
- Comprehend the bacteriophages and other phages and their application.
- Knowledge on some common plant and animal diseases caused by different viruses, viruses transmission and control.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Describe the characteristics of different types of viruses.
- **CLO-2:** Understand how viruses can be used as biotechnological tool, as cloning vectors and for gene transfer.
- **CLO-3**: Comprehend the complex interaction between viruses and host cells.
- **CLO-4:** Theoretical knowledge on techniques employed for culturing and detection of plant and animal viruses.
- **CLO-5:** Discuss plants viruses and its mode of action and pathogenesis.
- **CLO-6:** Understand infectivity assay for animal and bacterial viruses - plaque method, LD50, ID50, and IED50.
- **CLO-7:** Describe bacteriophage morphology and structure together with genome organization and life cycle (lytic and lysogenic)
- **CLO-8:** Discuss M13, Mu, and Lambda phage along with Phage therapy for control of bacterial diseases.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	2	2	1	2	3	2	3	1	2	1
CLO2		3	1	1	1		2		2	2	1
CLO3	3	2	3			3		1	1		1
CLO4				2	2		3	3	1	3	
CLO5	3	2	3	1		1					1
CLO6			1		2		1		1	1	1
CLO7	1	3		2		1		1			
CLO8	1		2				1		1	1	2

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

General Virology: Brief outline on the history and discovery of viruses, nomenclature and classification of virus, morphology and ultrastructure; capsids and their arrangements; types of envelopes and their composition, Enveloped and non-enveloped viruses, Structural proteins – envelope proteins, matrix proteins and lipoproteins, Viral genomic organization, structure and replication – types of nucleic acid DNA (double stranded and single-stranded), RNA (double stranded, single stranded – positive sense and negative sense), Viral replication, virus related agents (viroids, prions), Viruses of Algae, Fungi and Cyanobacteria. Antivirals agents: Interferons.

Unit II

Animal/Plant/Bacteria Viruses: Plant viruses: classification and structure of common plant viruses. Pathophysiology of common viral diseases of plants (ex TMV and CMV). Transmission of plant viral disease. Control and prevention of plants viral diseases.
Animal viruses: Classification and nomenclature of animal and human viruses. Brief account of some important animal and human disease. Prevention, treatment and control of viral diseases. Viral vaccines including DNA vaccines and interferons. Bacteriophage: Morphology, structure, genome organization and life cycle (lytic and lysogenic) of M13, Mu, and Lambda phage. Phage therapy for control of bacterial diseases.

Unit III

Cultivation and Diagnostic methods of Viruses: General methods for isolation, identification, characterization and cultivation (embryonated eggs, experimental animals, and cell cultures), Direct methods of detection – light microscopy (inclusion bodies), electron microscopy and fluorescence microscopy, serological methods - haemagglutination; complement fixation; immunofluorescence methods, ELISA and Radioimmunoassay, Western Blotting, Nucleic acid based diagnosis: Nucleic acid hybridization, polymerase chain reaction, microarray and nucleotide sequencing, Infectivity assay for animal and bacterial viruses - plaque method, LD_{50}, ID_{50}, IED_{50}.

Suggested Readings

1. Fields Virology Vol 1 and 2. B.N. Fields, D.M. Knipe, P.M. Howley, R.M. Chanock, J.L. Melnick,
   T.P. Monath, B. Roizman, and S.E. Straus, eds.), 3rd Edition. Lippincott-Raven, Philadelphia, PA.
2. Basic Virology Edward K. Wagner, Martinez J. Hewlett, David C. Bloom, David Camerini.
3. Virology: Principles and Applications John Carter, Venetia Saunders.
4. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka.
5. Virology Methods Manual. Brian W.J. Mahy (Editor), Hillar O. Kangro (Editor). Elsevier Science & Technology Books.
6. Methods and Techniques in Virology. Pierre Payment, Trudel (Editor). Publisher: Marcel Dekker.
7. Black JG, 2002 Microbiology-Principles and Explorations. John Wiley & Sons Inc. New York.
8. Dimmock, N. J., Easton, A. J., and Leppard, K. N. 2001. Introduction to Modern Virology. 5th edn. Blackwell publishing, USA.
9. Flint, S.J., Enquist, L.W., Drug, R.M., Racaniello, V.R. and Skalka, A.M. 2000.
10. Principles of Virology- Molecular Biology, Pathogenesis and Control. ASM Press, Washington,D.C.

MBY 410 **Enzymology** **Credits 3**

Course Objectives

- To impart basic knowledge of enzyme kinetics, the parameters of the enzymatic reaction, mechanisms of action of enzymes and inhibitors, dependence on the temperature and pH of the enzymatic activity, knowledge of the structure of enzymes and amino acids that build active sites of enzymes.
- To integrate the practical aspects of enzymology with the kinetic theories to provide a mechanistic overview of enzyme activity and regulation in cells.
- To develop and understanding of enzyme development and rational drug designing.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Describe qualitative and quantitative assay of enzymatic phenomena and processing.
- **CLO-2:** Able to calculate the enzyme-substrate reaction data and interpret the data with mathematical and statistical methods
- **CLO-3**: Understand the importance of key terminologies used in enzymology as well as tools and techniques used in the assessment of enzyme reaction.
- **CLO-4:** Describe the role of enzymes in various applications in industry, health care and environmental protection.
- **CLO-5:** Discuss Enzymes Kinetics of single substrate reaction using Michaelis-Menten equation at steady state.
- **CLO-6:** Linearize Michaelis-Menten equation using Lineweaver-Burk, Eadie-Hofstee and Hanes plot for the calculation of V_{max} and K_m.
- **CLO-7:** Explain Allosteric enzymes and the mechanism of allosteric interactions along with subunit structures and protein assembly in a sequential model.
- **CLO-8:** Discuss Enzyme Immobilization techniques and its use in industrial application and clinical diagnosis.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	1	2	2	3	2	2	2	3	1		1
CLO2		2	1	1	1		2			2	1
CLO3	2		3			3					1
CLO4		3		2	2		3	2	1	3	1
CLO5	2					2					1
CLO6		3	2		3		3		1	1	1
CLO7	3			1		1		1			1
CLO8		1	2				1		1	1	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Enzymes as Biocatalysts: Velocity, Order and Molecularity of a chemical reaction, Kinetic equations for zero, first & second order reactions, Determination of order of the reaction, Remarkable properties of Enzymes as Catalysts, Lock and Key theory, Induced-fit hypothesis, Nomenclature and classification. Enzymes Kinetics: Kinetics of single substrate reaction, Michaelis-Menten equation, steady state kinetics, Kinetic parameters, K_m, V_{max} and K_{cat}, Lineweaver-Burk, Eadie-Hofstee plot, Hanes plot. Variations of velocity with [E], [S], pH and temperature, Bi-substrate reaction kinetics, multi-substrate reactions, uses of kinetic studies in determining enzyme mechanism

Unit-II

Enzyme inhibition: Types of enzyme inhibition- reversible and irreversible, competitive inhibition, non-competitive inhibition, uncompetitive inhibition and kinetics using Lineweaver-Burk and Scatchard plots. Enzyme mechanism: Mode of action of catalysts, different type of catalysis, Nucleophilic, Electrophilic & Acid-Base Catalysis, Proximity and orientation effects, contributions of strain, Mechanism of action of Chymotrypsin, Ribonuclease and carboxypeptidase. Allostery: Allosteric enzymes, mechanism of allosteric interactions, subunit structures and protein assembly, symmetrical and sequential model, Hill‟s coefficients, Cooperativity, positive and negative Cooperativity, Allostery cooperativity in hemoglobin.

Unit-III

Enzyme regulation: Enzyme Regulation of Aspartic transcarbamoylase, metalloenzymes-carboxypeptidase A, Role of Zinc, Feedback inhibition. Enzyme technology: Enzyme purification and recovery, Microbial production and application of lipase, amylase and protease, Enzyme Immobilization techniques, use of immobilized enzymes in industrial processes, Enzymes in clinical diagnosis, Isozymes, Abzymes, Ribozymes, Artificial enzymes, Enzyme engineering for thermostability, directed evolution, Site directed mutagenesis.

Suggested Readings

1. P. F. Cook and W. W. Cleland, Enzyme Kinetics and Mechanism. 3rd Edition, Garland Science,2007.
2. Carnish Bowden, Fundamental of Enzyme Kinetics, 3rd Edition, Portland Press, 2004.
3. Price, N. C. & L. Stevens, Fundamentals of Enzymology, 3rd Edition, Oxford University Press, 1999.

MBY 411 Microbial Genetics Credits 3

Course Objectives

- To understand the basis structure of chromosome, structure of DNA and model.
- To understand the mechanism of genetic transfers in microbes.
- To understand different techniques used to study the microbial genetics and utilizing the microbial phenomenon in different biotechnological applications

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Explain the basic structure and organization of chromosomes and DNA.
- **CLO-2:** Elucidate the importance of mutations and selection of mutants
- **CLO-3**: Describe the genetic regulatory mechanism of gene transfer.
- **CLO-4:** Understand to utilize artificial competency and transformation for production of recombinant genes.
- **CLO-5:** Discuss protein-DNA and protein-protein interactions
- **CLO-6:** Describe Gel retardation assay, DNA footprinting by DNase I, yeast one-hybrid assay, ChIP-chips.
- **CLO-7:** Yeast two hybrids, system. Co-immuno-precipitations, pull-downs and Far-Westerns.
- **CLO-8:** Describe Overexpression of recombinant proteins and tagging of recombinant proteins in E. coli driven by lac, T7 and Tet-regulatable promoters.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	1	3		2	3					1	2
CLO2	1		2			3	2	3			
CLO3	2	2		3	2	1	1		1	1	2
CLO4	3		2	1	1		2			3	
CLO5	1	1						2	2		2
CLO6	2	2	3	3	2	3	3	1		2	2
CLO7	3						3		3		
CLO8		3	1	1	2	3		3		2	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Structure of DNA and RNA: Organization of the Chromosome, Structure of Chromatin - Nucleosomes, Chromatin Domains and Isochores, Structure and Functional Organization of Centromeres and Telomeres, structure of DNA, Watson-Crick model, DNA polymorphism, Chromatin structure and remodeling, Histone code and histone modifications.

Unit II

Genetic analysis and gene transfer in bacteria: Importance and uses of mutation analysis; Types of mutations- spontaneous and induced mutagenesis; selection and isolation of mutants. Complementation and Recombination tests and gene replacements. Gene transfer: Conjugation, transformation and transduction, Molecular mechanism of gene transfers, Natural transformation and competence, DNA uptake competence systems in gram positive/negative bacteria. Artificially induced competence. Generalized versus specialized transduction T4 and lambda phage. Phase variation system in pathogenic bacteria.

Unit III

Overexpression of recombinant proteins: Overexpression and tagging of recombinant proteins in *E. coli,* driven by lac, T7 and Tet-regulatable promoters. Overexpression systems in *S.cerevisiae, P.pastoris*. Baculovirus overexpression system. Analysis of protein-DNA and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I, yeast one-hybrid assay, ChIP-chips. Yeast two hybrids, system. Co-immunoprecipitations, pull-downs and Far-Westerns.

Suggested Readings

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.
2. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
3. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.
4. Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.

MBY 435 to 442 Elective- II (Discipline elective) Credits 3

Elective-III (Discipline elective) Credits 3

Elective-IV (Non-discipline elective) Credits 3

MBY 412 Laboratories for Medical Microbiology, Virology and Elective II Credits 3

Course Objectives

- Program aims to develop students‟ understanding of medical microbiology with hand on experience in the isolation of the bacteria from different sources.
- It gives the knowledge about the pathogenicity, understanding the biofilm formation in bacteria, role of biofilm in pathogenicity and their antibiotics resistance pattern of pathogenic bacteria (Environmental source, Agricultural part), which is useful for public awareness.
- Understanding of application of Virus (bacteriophage) in transduction

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Explain the aseptic techniques and sterilization techniques for the isolation of pure cultures of microorganisms.
- **CLO-2:** Learning methods for antimicrobial susceptibility testing
- **CLO-3**: Viral Disease diagnosis tests using Radio-immunoassays/ELISA and PCR.
- **CLO-4:** Use of PCR technique for Microbial molecular biology application.

- **CLO-5:** Determination of minimum inhibitory concentrations (MICs) of antimicrobial agents.
- **CLO-6:** Describe Measuring biofilm formation by bacteria.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	1	2	3	1	2	2	2	1		1
CLO2	2	3	3	1	1		2			2	2
CLO3	2	3	1			3		1			3
CLO4	2	2		2	1		3	1	1	3	1
CLO5	2					2					1
CLO6	2	1	2		1		3	2	1	1	2

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

List of laboratory practicals

1. Identification of pathogenic bacteria by culture and biochemical methods.
2. Widal Test.
3. Antibiotic susceptibility testing.
4. Determine the minimum inhibitory concentrations (MICs) of antimicrobial agents.
5. Measuring biofilm formation by bacteria.
6. Transduction by Bacteriophage & Determination of Phage Titration.
7. Diagnosis of Viral agents by Radio-immunoassays/ELISA (Demonstration).
8. Identification of Viral agents by PCR (Demonstration).

MBY 413 Laboratory Enzymology, Microbial Genetics and Elective -III Credits 3

Course Objectives

- To provide exposure to design and run batch fermentation experiments for production of microbial enzymes.
- To deliver hands-on experience of various enzymatic assays and determination of kinetic parameters.
- To give basic understanding of microbial genetic manipulations with special emphasis on conjugation, transformation.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Explain the batch fermentation, designing of experiments to produce microbial metabolites and enzymes.
- **CLO-2:** Develop capability to quantify enzymes and determine kinetic parameters
- **CLO-3**: Understand different microbial genetic modification strategies.
- **CLO-4:** Hand on experience of different microbial genetic modification strategies

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1		3	1			2		1		1	1
CLO2	2			2	2	1	3		3		
CLO3		1	1	1	2	1		3		2	1
CLO4	1	2	3	3	2		3	1	1	2	2

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

List of laboratory practicals

1. Batch fermentation for production of microbial enzymes. Yield calculations and kinetics.
2. Enzymatic Assays (eg. Amylase, protease) and Yield calculations.
3. Study of factors affecting enzyme activity-substrate concentration, temperature, pH, inhibitors.
4. Determination of kinetic parameters for enzyme activity (Km & Vmax).
5. Conjugation in *E. coli*
6. Transformation in *E. coli.*
7. Characterization of transformants.
8. Prokaryotic transformation

Semester III

MBY 501 Molecular Biology & Recombinant DNA Technology Credits 3

Course Objectives

- To make student understand about the basic phenomenon of the cell and DNA replication.
- Transcription and Translation. To learn about concept of recombinant DNA technology and cloning of a gene.

Course Learning Outcomes (CLOs)
After completion of this course successfully, the students will be able to……

- **CLO-1:** Describe the basic fundamental process of DNA replication in prokaryotes and eukaryotes.
- **CLO-2:** Elucidate central cell biological processes and their regulation such as Transcription and Translation and its control.
- **CLO-3**: Explain recombinant DNA technology and concept of cloning
- **CLO-4:** Understand how molecular cell biology forms the foundation of biotechnology
- **CLO-5:** Describe Transcription and translation process in microorganisms

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	2	1	2	3	2	2	2	3	1		3
CLO2	2	1	1	1	1		2			2	3
CLO3	2		3			3					3
CLO4	2	1		2	2		3	2	1	3	3
CLO5	2					2					3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

UNIT I

DNA Replication: Prokaryotic DNA Polymerase I, II and III, Eukaryotic DNA Polymerases, Fidelity and Catalytic Efficiency of DNA Polymerases, Replication Origin, Replication Mechanism Involving Leading and Lagging Strands synthesis; Problems associated with linear replicons. Mutations and Repair during replication.

UNIT II

Transcription: Prokaryotic RNA polymerase and sigma factors, Prokaryotic and eukaryotic promoters, Eukaryotic RNA Polymerases, Class I, II and III gene promoters, Enhancers; Prokaryotic and eukaryotic mechanism of transcription, RNA Processing: Processing, Capping, Polyadenylation and

Splicing. Group I and II Introns, Alternate Splicing. Translation: Genetic Code, Ribosome Structure, tRNAs, Aminoacyl tRNA synthetase, Initiation, Elongation, Termination; Translational Control. Regulation of Gene Expression: Prokarytes Operon Concept, Positive and Negative Regulation, Attenuation, Catabolite Repression, Riboswitches. Eukaryotes - Generalized and specialized transcription factors, Transcriptional Activators and regulators.

UNIT III

Techniques and enzymes in genetic recombination: restriction endonucleases, type I, II, III, recognition sequences, properties, nomenclature, classification of type II endonucleases, DNA ligase, Nuclease (S1, BAL 31), DNA polymerase, polynucleotide kinase, phosphatase, reverse transcriptase. Properties of Plasmid vectors (pBR 322, pET28a, pGEX6P2, pMALC2X), incompatibility, isolation and purification of Plasmids, Concept of cloning and expression of gene: Restriction digestion, ligation and transformation. Vectors for library construction, Genomic DNA and cDNA libraries.

Suggested Readings

1. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick, Lewins Genes XII, 12th Edition, 2017.
2. Watson, J.D. Tania A. Baker, Stephen P.Bell, et al., Molecular Biology of the Gene, Benjamin Cummings; 7th Edition, 2013.
3. Robert F. Weaver. Molecular Biology, 4th Edition, McGraw-Hill.
4. Principles of Genetics: Snustad & Simmons
5. Principles of Genetics: Robert Tamarin
6. Genetics: Analysis and Principles: Brooker
7. Genetics: Principles and Analysis: Harlt & Jones
8. Molecular Cell Biology: Lodish
9. Molecular Biology of The Cell: Bruce Alberts
10. Cell & Molecular Biology: Gerald Karp
11. Principles of Gene Manipulations 1994 by Old and Primrose Blackwell Scientific Publications.
12. DNA Cloning: A Practical Approach by D.M. Glower and B.D. Hames, IRL Press, Oxford. 1995.
13. Molecular Biotechnology 2nd Edition by S.B. Primrose. Blackwell Scientific Publishers, Oxford. 1994.
14. Recombinant DNA and Biotechnology: Guide for Teachers. 2nd Edition by Helen Kreuz. 2001.ASM Publications.
15. Molecular Biotechnology: Principles and Applications of Recombinant DNA. 2 nd Edition. 1998 by Bernard R. Glick and Jack J. Pastemak, ASM Publications.

MBY 502 Food and Dairy Microbiology Credits 3

Course Objectives

- The course aims to provide instruction in the general principles of food microbiology.
- The course covers the biology and epidemiology of food borne microorganisms of public health significance, including bacteria, yeasts, fungi, protozoa and viruses,
- Understand food spoilage microorganisms; the microbiology of food preservation and food

commodities; fermented and microbial foods; principles and methods for the microbiological examination of foods; micro biological quality control, and quality schemes.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Understand the principles of microorganisms during various food-processing and preservation steps.
- **CLO-2:** Comprehend the interactions between microorganisms and the food environment, and factors influencing their growth and survival
- **CLO-3**: Understand the significance and activities of microorganisms in food
- **CLO-4:** Recognize the characteristics of food-borne, waterborne and spoilage microorganisms, and methods for their isolation, detection and identification.
- **CLO-5:** Discuss the microbiology of different types of food commodities
- **CLO-6:** Describe the rationale for the use of standard methods and procedures for the microbiological analysis of food.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	3	3	2	3	2	2	2	3	1		1
CLO2		3	1	1	1		2			2	1
CLO3	1	3	3			3					1
CLO4	1			2	2		3	2	1	3	2
CLO5	2	1				2					2
CLO6	2	1	2		3		3		1	1	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Food Microbiology: Micro-organisms and their importance in food microbiology–molds, yeast, bacteria, general features and classification, principles of food preservation, asepsis, control of microorganisms (anaerobic conditions, high temperature, low temperature, drying), factors influencing microbial growth in food–extrinsic and intrinsic factors, chemical preservation and food additives, canning process for heat treatment, Fermented foods. Application of microbial enzymes in food industry.

Unit II

Contamination and spoilage-cereals, sugar products, vegetables, fruits, meat and meat products, fish and sea food, poultry and canned food, detection of spoilage and characterization, methods of food preservation. Food poisoning and foodborne infections; Bacterial toxins and mycotoxins in food;

Quality assurance: Microbiological quality standards of food. Government regulatory practices and policies. FDA, EPA, HACCP, ISI, NABL.

Unit III

Microbiology of raw and pasteurized milk, Biochemical changes in fermented milk, Study on spoilage organisms in dairy industry, probiotics. Classification of various groups of microorganisms associated with diary industry, Acid fermented milks (Yoghurt, cultured butter milk), Starter cultures for fermented dairy products (*Streptococcus thermophilus*, *Lactobacillus bulgaricus*), Cheese production: Steps involved in manufacture of cheese, preservation, classification and nutritional aspects.

Suggested Readings

1. Frazier WC, Westhoff DC (1988). Food Microbiology, Mc Graw-Hill, New York.
2. Banwart GJ (1993). Basic food microbiology, CBS Publishers & Distributors Pvt Ltd.
3. Jay JM (1996). Modern Food Microbiology, Chapman and Hall, New York.
4. Ray B (1996). Fundamentals of Food Microbiology, CRC Press, USA.
5. Dairy Microbiology by Robinson Volume I and II
6. Applied Dairy Microbiology Edited by Elmer Marth and James Steele
7. Food Microbiology 2nd Edition by Adams
8. Fundamentals of Dairy Microbiology by Prajapati
9. The technology of Food preservation. Fourth Edition Norman W. Desrosier. CBI

MBY 503 Environmental and Agricultural Microbiology Credits 3

Course Objectives

- To provide students a basic understanding of environmental and agricultural microbiology including; microbial diversity in the environment in relation to environment and agricultural welfare, ecosystem wellness, microbial interactions with pollutants in the soil and environment and the fate of microbial pathogens in the environment and agricultural fields.
- Topics covered in detail include soil microbiology, aquatic microbiology, aero microbiology, biofertilizers and pesticides, microbial waste recycling and bioremediation etc.
- These topics were elaborated to students with their theoretical and practical use.
- The students will develop set of skills to recognize the ecological problems and critical evaluation of the human impacts on pollution, climate changes and as well as environmental protection.
- Learning the basic principles of environment microbiology and be able to apply these principles to understanding and solving problems in current environmental and agricultural issues.
- Familiarize students with general principles and subject knowledge in the field of environment and agricultural microbiology.
- To make students aware with current research in environmental and agricultural microbiology.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** How to prepare and perform sampling and microbial analyses to determine the abundance, growth rate and microbial community composition together with the basic environmental parameters.
- **CLO-2:** Describe role of microorganism in recycling soil nutrients, biodegradation of complex plant polymers, sustaining and improving plant growth through improving nutrient availability, production of plant growth promoting substances and inhibiting pathogens
- **CLO-3**: Critically discuss the need for environmental microbiology and agricultural microbiology and explain their limitations.
- **CLO-4:** Clarify application of microorganisms in varied fields of agricultural and environmental microbiology like bioremediation, biofertilizers and waste water treatment.
- **CLO-5:** Analyse various aspects of N2 fixation, Phosphate solubilization, PGPR, biodegradation and bioremediation mechanisms provided by microbes

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1		3									1
CLO2			2			3		3			
CLO3	2								1		2
CLO4	3			1			2			3	
CLO5											1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Soil Microbiology: Classification of soil - physical and chemical characteristics, soil as a habitat for micro-organisms, microflora of various soil types, rhizosphere and rhizoplane. Nitrogen fixation: asymbiotic and symbiotic nitrogen fixation systems, root nodulation, symbiotic bacteria (process of root nodule formation), leghemoglobin, nitrification and ammonification. Microbial interactions: Symbiosis, mutualism, commensalism, amensalism, competition, antibiosis, actinorrhiza, mycorrhizal fungi and its effect on plants. Aquatic Microbiology: Water ecosystems (fresh water, pond, lakes), marine habitats (estuaries, deep sea, hydrothermal vents), eutrophication, cyanobacterial and microlagal blooms: ecological implications and human health, toxins produced by cyanobacteria and other microalgae.; Extreme environments and extremophilic microbes: Habitats, diversity, adaptations and potential applications.

Unit II

Aero-microbiology - droplet nuclei, aerosol, assessment of air quality, brief account of air- borne microbes – bacteria, fungi, and viruses, their diseases and preventive measures, phylloplane and phyllosphere microflora, global warming and climate change.

Bio-fertilizers and Biopesticides in agriculture: Principles of crop inoculation with microbial agents, microbial inoculants and production, carriers for inoculants: types and characteristics, strain selection of bacteria, cyanobacteria and microalgae for biofertilizer production, phosphate solubilizing microorganisms, AM fungi, plant growth promoting rhizobacteria, (PGPR), biocontrol agents. Bacterial

and mycopesticides.

Unit III

Microbial waste recycling: organic compost, vermicomposting, Biogas production, microbial sewage treatment, waste water treatment by microbes. Microbial leaching and oxidation of minerals (copper bioleaching, cobalt bioleaching, Uranium bioleaching, biooxidation of gold ores, Nickel leaching, acid mine drainage) Bioremediation of Xenobiotics, petroleum, oil spill, Microbial remediation of heavy metal pollution, tolerance to heavy metal by microbes, resistance developed in microbes to heavy metals,

Microbial deterioration and degradation of plant food materials, leather, store and buildings materials, paper and other cellulosic materials, fuel and lubricants, metals, plastics, cosmetics, pharmaceutical products. Global warming and Climate Change.

Suggested Readings

1. Subba Rao NS (1995). Soil Microbiology, Oxford & IBH Publishing Co. Pvt. Ltd, 4th edition.
2. Rangaswami G, Bhagyaraj DJ (2001). Agricultural Microbiology, Prentice Hall of India, New Delhi, 2nd edition.
3. Dubey RC, Maheswari DK (1999). Textbook of Microbiology, S. Chand & Co. 4. Evans GM, Furlong JC (2011).
4. Environmental Biotechnology- Theroy and application. Wiley-Blackwell.
5. Maier RM, Pepper IL, Gerba CP (2009). Environmental microbiology, Elsevier.
6. Osborn AM, Smith CCJ (2005). Molecular microbial ecology, Taylor & Francis US.
7. Ljungdahl LG, Adams MW, Barton LL, Ferry JG, Johnson MK (2003). Biochemistry and Physiology of Anaerobic Bacteria, Springer. 8. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2012).
8. Brock Biology of Microorganisms, Prentice Hall, USA.
9. Environmental Biotechnology: Principles and Applications by Bruce E Rittman and Perry L McCarty, McGraw-Hill International editions

MBY 504 Industrial Microbiology Credits 3

Course Objectives

- To impart theoretical knowledge of role of microbes in industrial production of different bio-chemicals/bio-molecules.
- The theory syllabus covers area such as design of bioreactors, media formulations and factors affecting the industrial production of bio-chemicals along with approaches that can be used for enhanced production.
- Role of micro-organism in production of organic acids, alcohols, wine, vinegar, enzymes, vitamins, antibiotics, amino-acids and steroids.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Learning of different fermentation techniques, bioreactor design, inoculum development for industrial fermentations, Microbial growth and product formation kinetics, media formulation and sterilization, isolation, preservation and improvement of industrially important micro-organisms.
- **CLO-2:** Understanding of industrial production and purification of organic acids, alcohols, wine and vinegar with help of different microbes.
- **CLO-3**: Understanding of industrial production and purification of antibiotics, enzymes, amino acids and steroids..
- **CLO-4:** Understanding of different pathways followed in or by the microbes involved in production of these bio-chemicals. Method of manipulating these pathways to get desired yield.
- **CLO-5:** Understanding of application of these bio-molecules in benefit of mankind

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	3	3		2	3		3		2	3	3
CLO2			3			3		3			
CLO3	1	2		2	2	2			1	2	2
CLO4	3		1	1	3		2	3		3	
CLO5		1			1	2			2		1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Theory and principles of industrial fermentation, Batch, fed-batch and continuous cultures, Microbial growth and product formation kinetics, media formulation and sterilization, isolation, preservation and improvement of industrially important micro-organisms, inoculum development for industrial fermentations, fermenter design, various types of fermenters used in industrial fermentation. Surface, submerged and solid-state fermentation processes. Basic principal of microbial fuel cells and its application.

Unit II

Alcohol production: Preparation of medium, Fermentation process and recovery; Production of Malt beverages: Production of Beer- malting process, mashing process and finishing; other malt products. Production of Wine: Microbial process, wine from grapes, Fermentation and recovery, types of wine-white and red wine. Production of distilled beverages or liquors- rum, whiskey and brandy; Microbial production of organic acids- vinegar production (substrate, Microbial processing and product recovery); Citric Acid- fermentation, recovery and uses; Lactic acid-fermentation, medium and manufacturing process, recovery and uses.

Unit III

Production of antibiotics-strain improvement for secondary metabolite production; Penicillin-Fermentation and recovery; Tetracycline and Chloramphenicol production; Streptomycin-structure, meia composition, production and recovery, Production of Amino acids: L-Lysine production and strain

improvement for lysine production; L- glutamic acid production-strain improvement for glutamic acid production and recovery process; Tryptophan production and recovery. Production of enzymes: Pectolytic Enzymes-Pectinases production, harvest, recovery and uses; Invertase and Lipase production; Cellulase production and recovery; Production of vitamins: Vitamin B12 (Cyanocobalamine) production; Riboflavin (vitamin B2) production; Biotransformation of steroids. Algal biomass cultivation, harvesting and extraction of value added compounds. Production of lipids and carbohydrate for production of biodiesel and bioethanol from algal biomass.

Suggested Readings

1. Bioprocess Engineering principles by Pauline M Doran, Elsevier Science and technology Books.
2. Bioprocess Engineering- Basic Concepts by Michael L Shuler and Fikret Kargi, Pearson Education, Inc.
3. Bioprocess Technology: Volume 1 by P T Kalaiselvan and I Arul Pandi MJP publisher.
4. Bioprocess Engineering: Systems, Equipment and Facilities by Bjorn K. Lydersen, Nancy A. D'Elia, Kim L. Nelson, Wiley India Pvt Ltd.
5. Stanbury PF, Hall SJ, Whitaker A (1999). Principles of Fermentation Technology, Butterworth-Heinemann, 2nd edition.
6. Creuger and Creuger (2001). Biotechnology- A textbook of Industrial Microbiology, Sinauer Associates, Inc.
7. Waites MJ (2001). Industrial Microbiology: An Introduction, Wiley.
8. Industrial Microbiology, Prescott and Dunn

MBY 531 to 534 **Elective-V (Discipline elective)** **Credits 3**

Elective-VI (Non-discipline elective) **Credits 3**

MBY 505 Laboratory for Food and Dairy Microbiology, Environmental and Agricultural Microbiology, Industrial Microbiology **Credits 3**

Course Objectives

- To give hand on experience on isolation and characterization of microbes from different food sources, different spoiled food sources, agricultural (root nodules) and environmental samples (air water and soil).
- This paper is designed with the objective to impart hand-on experience and laboratory skills to students in area of bioprocess.
- The practical structure is designed so that students are trained to set up different fermentation processes with special emphasis on the downstream processing of bio-molecules purification and characterization.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Know General bacteriology and microbial techniques for isolation of pure cultures of microbes from different food, agricultural and environmental sources
- **CLO-2**: Solid-state fermentation utilizing different agro-residues and food waste as substrates for production of different bio-molecules viz. citric acid.
- **CLO-3:** Comparative study of solid state and submerged fermentation with respect to yield and variation in physical parameters.
- **CLO-4:** Downstream processing of the bio-molecules and characterization such as stability at different pH and Temperature

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	1	1	2	2	2		3	2	1	3	3
CLO2	1				3	2		3		2	3
CLO3	1	1	2		3		3		1	1	3
CLO4	1	1		1	1	1		1			3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

List of laboratory practical

1. Microbiological analysis of food.
2. Isolation and enumeration of microorganisms from milk, Fruits, Vegetables and Fruit Juices
3. Isolation of pathogenic bacteria from food.
4. Isolation of spoilage- associated microbes from food.
5. Isolation and characterization of microorganisms from soil, water and air samples.
6. Isolation of halophiles/acidophiles/methanogens.
7. Isolation of Rhizobia from root nodule using Yeast Extract Agar Medium (YEMA)
8. Batch fermentation for production of microbial enzymes.
9. Solid-state fermentation for production of organic acids and study of effect of moisture content.
10. Production and estimation of citric acid (using *Aspergillus niger*) by titrimetric method.
11. Biosurfactant production.
12. Batch, fed batch and continuous culture growth kinetics studies.

MBY 506 Laboratory for Molecular Biology & Recombinant DNA Technology and Elective V **Credits 3**

Course Objectives

- Provide idea about DNA, protein purification from samples and quantification.
- To learn the techniques pertaining to amplification of biological molecules.
- Demonstrate basic techniques used in recombinant DNA technology
- Demonstrate culture dependent studies of microbiomes, DNA molecular size determination and gel extraction

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Capable of performing basic techniques of Molecular biology techniques.
- **CLO-2:** Capable of performing several RDT techniques.
- **CLO-3**: Capable of performing several techniques used during development of Recombinant DNA

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	3	1	2	3	2	2	2	3	1		3
CLO2	3		1	1	1		2			2	
CLO3	3	1	3			3					3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

List of laboratory practical

1. Polymerase chain reaction and agarose gel electrophoresis.

2. Isolation of recombinant plasmid DNA.
3. Restriction mapping.
4. DNA molecular size determination, Gel extraction.
5. Ligation and cloning in a plasmid vector.
6. Confirmation of the insert.

Semester –IV

MBY 581	**Concepts of Research Design**	**Credits 2**
MBY 582	**Paper Writing Skill**	**Credits 2**
MBY 583	**Journal Club Presentation**	**Credits 2**

Courses Objectives

- This paper is designed to provide an exposure to the students about reading the different ongoing research in area of microbiology.
- The students will learn to read research paper and present in scientific platforms.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Searching research paper from different web sources.
- **CLO-2:** Reading research paper and making PowerPoint presentations.
- **CLO-3**: Giving oral presentations in front of all faculty and the students.
- **CLO-4:** Answering the question raised by the audience during and after scientific presentation.
- **CLO-5:** Impart proficiency of reading research articles, preparing power-point presentation and oral presentation among an audience. It will help in gaining self-confidence and remove stage fear

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	1		3	2	2	2	3	1		3
CLO2		3	1	1	1	1	2	2		2	
CLO3	1	1	1			3	1		3	1	3
CLO4				2	2		3	2	1	3	
CLO5	1	1				2					1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

- Scientific paper published in a respective area of research.
- Power point presentation preparation
- Oral Presentation

Suggested Reading

- Scientific paper published in a respective area of research

MBY 507 **Major Project (Research Dissertation)** **Credits 15**

Course Objective

- The student will present the results of the research work to a panel for evaluation of the project.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Presentation preparation of the different results obtained during the course of project dissertation.
- **CLO-2:** Analyzing the results, correlating it with different experiment performed during the dissertation.
- **CLO-3**: Impart proficiency of designing scientific presentation.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	3	1	1	2	2		3	2	1	3	1
CLO2	3		3		3	2		3			
CLO3	3	1	2		3		3		1	1	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

- The dissertation report prepared by the student based on the project conducted

Suggested Reading

- Scientific presentation/literatures available online

Course contents of Discipline Electives:

Fungal Biotechnology and Bioprospecting **Credits 3**

Course Objectives

- This paper is designed to provide an exposure to the students about the potential of fungi as food and in field of biotechnology as source of different enzymes, secondary metabolites, vitamins, polysaccharides, polyhydric alcohols, pigments, lipids, glycolipids, biofertilizers and biopesticides.
- To understand the methods for Production of industrially important compounds from fungal source.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Overview of fungal diversity, screening and strain improvement and strain development for production of different bio-molecules.
- **CLO-2:** Design of bioreactor with special emphasis on fungal systems.
- **CLO-3**: Introduction about different secondary metabolites antibiotics, organic acids, enzymes, drugs, vitamins, therapeutic peptides and pharmaceutical products, biopesticides and biofertilizers of fungalorigin..
- **CLO-4:** Concept of recombinant technology with special emphasis in fungal system
- **CLO-5:** Role of fungi in food and feed industries *viz.* edible mushrooms, different cultivation and nutritional aspects of mushrooms

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	1	1	3	2	2	2	3	2	1	3	2
CLO2	1				3	2		2	3		1
CLO3	1	1	2		3		3		1	1	2
CLO4	2	1		1		1		1	3		1
CLO5	2	2	2		1	3	1	2	1	1	3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Fungal diversity; habitat relationship; different ecological groups of fungi Ecotaxonomic approach in chemical screening; primary and secondary products of metabolism; Screening of industrially useful fungal metabolites; classification of secondary metabolites; primary and secondary screening of antibiotic producers; auxanography; enrichment culture, Industrial important fungal strains

Unit II

Fungal Biotechnology: Fungal biotechnological processes, Principles of fermenter design and operation with respect to Fungal process, types of fermenters used in Fungal Biotechnology, formulation of fermentation medium, analysis of fermentation products especially for fungal biotechnology. Techniques for strain improvement and strain development; Recombinant technology in fungi: composition of the different types of fungal vectors, selection markers, transformation strategies, gene replacement or inactivation, applications and future perspectives

Unit III

Edible fungi; Mycoproteins. Advancement in mushroom cultivation technology; Commercial mushroom species; strain improvement and cultivation; tropical mushrooms and their cultivation; mushroom spawns; nutritional aspects of mushrooms, Fungi in food processing, Fungus for Biomass pretreatment for ethanol production. Fungi in agriculture application: Fungal biofertilizers and biopesticides , myconematicides Biotechnological applications of fungi and their derivatives. Production of Industrially important productsfrom fungi-organic acids (citric acid), enzymes (cellulase xylanase, amylase, protease) applications of Fungi in medical and pharmaceutical products. Production of antibiotics, drugs, vitamins and therauptic peptides from fungi

Laboratory Practical

1. Demonstration of Principles of fermenter design and operation.
2. Laboratory scale cultivation of mushrooms**:** Preparation of media for raising of pure culture, spawn preparation, compost preparation and casing
3. Isolation of fungal cultures from different sites and its bioprospecting for different biomolecule (enzymes, organic acids, antibiotics) production.
4. Screening of the agriculture waste biomass as potential carbon and nitrogen source in fungal growth.
5. Optimization of medium composition and physical parameters for organic acids/ enzymes production from fungal isolates.
6. Demonstration of the genetic transformation in fungus.

Suggested Readings

1. Fungal Biology, 4th ed Blackwell. by Jim Deacon
2. Alexopoulos & Blackwell, Introductory Mycology, John Willey & Sons
3. B.C.Suman & V.P.Sharma, Mushroom Cultivation in India, Daya PublishingHouse
4. Carlos Alborto brusso, Mohamed Hijri, Mycorrhizal Biotechnology, Capital Publishing
5. D.P.Tripathi, Mushroom Cultivation. Oxford & IBH Publication Company Pvt.ltd
6. Poonam Singh & Ashok Pandey, Biotechnology for agro-Industrial residues utilisation. (2009), Springer.
7. Satyanarayana T. and Johri B.N. (2005). Microbial diversity, Current Perspectives and Potential Applications, IK international
8. Nair, L. N. (2007). Topics in Mycology and Pathology, New Central Book agency, Kolkata.
9. Oliver R. P. and Michael Schweizer (1999). Molecular Fungal Biology, CUP.
10. Berry D. R. (1988). Physiology of industrial Fungi, Blackwell Scientific Publishers.
11. Zhingiang Ann (2005). Handbook of Industrial Mycology, CRC Press.

Biomass and Energy Systems **Credits 3**

Course Objectives

- To provide a thorough understanding of various renewable feedstocks, their availability and attributes for biofuels production.
- To provide a thorough understanding of the broad concept of generations of biofuel production from biomass and other low-cost agri-residues and biowastes, anaerobic digestion and biodiesel production.
- To teach our students to analyze and design processes for biofuel production.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Identify and apply potential biomass feedstocks including energy crops..
- **CLO-2:** Have an understanding of the existing and emerging biomass to energy technologies.
- **CLO-3**: Develop a critical thinking about sustainability & resilience..
- **CLO-4:** Determine potential solutions for energy needs and problems by incorporating the bioenergy technologies being explored

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	1	3	1	2	2		3	1	1	3	2
CLO2	2	3			3	2	1	2			
CLO3	1				3		2		1	1	3
CLO4	1	1	1	2	2			2	1	3	3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Fundamentals of bioenergy/biofuel; terms and concepts, origin, characteristics, advantages and disadvantages, use and cost of different types of biomass resources (renewable feedstocks): agricultural energy crops, agro-horticultural lignocellulosic residual material and other biogenous waste- production, availability and attributes for bioenergy production. General principles of the carbon cycle, greenhouse effect and global climate change. Bioeconomy and sustainable bioenergy system, Current and projected future technologies for producing biofuels such as ethanol, biodiesel from oil crops, microbial fuel cells, biohydrogen.

Unit II

Biofuel generations, Pretreatment technologies, structure and function of lignocellulosic biopolymers, various types of pretreatment technologies (Physical, mechanical, chemical, biochemical, ionic liquids

etcetera) bioconversion of biomass to biofuel; concept of pseudo-lignin and inhibitors, biodiesel production; environmental impacts of biofuel production; concept of Biorefinery, value-added product generation in an integrated approach, processing of biofuel residues- case studies on combined heat and power (CHP) generation. The role of transgenic plants and algae.

Unit III

Anaerobic digestion process for biogas production, Inoculum- its stability and methane potential, Process microbiology, role of microbes, types and characterization, Effect of pH, temperature, nutrients, organic loading rate (OLR) and hydraulic retention time (HRT) on biogas production from biogenous waste, Storage and stability of digestate- health and safety issues, Up-gradation of biogas to methane. Life cycle assessment of biofuels and biofuel technologies, India‟s energy demand and supply management, energy cropping, energy needs for the future: regional prospects and stresses, policy issues.

Laboratory Practical

1. Assessment of the effect of severity factor on biomass degeneration.
2. Quantification of reducing sugars and lignin in biomass.
3. Pretreatment of straw and evaluation of reducing sugar generation and ethanol production.

Suggested Readings

1. Mahesh & Dayal (1992). Renewable Energy Environment and Development, Konark Publishers (P) Ltd.
2. Rao S & Parulakar BB (1994). Energy Technology, Khanna Publishers, New Delhi.
3. David N-S Hon DNS & Nobuo Shiraishi N (2000). Wood and Cellulosic Chemistry, CRC Press.
4. Sorensen B (2010) Renewable Energy, Academic Press.
5. Kasthurirangan G, van Leeuwen J, Robert C (2012). Sustainable Bioenergy and Bioproducts, Springer.

Pharmaceutical Microbiology **Credits 3**

Course Objectives

- To Understand the basics of pharmaceutical microbiology and important microorganism playing role pharmaceutically.
- To understand different products of microbial origin playing key role in pharmaceutical applications.
- To understand role of secondary metabolites in pharmaceutical industry.
- To understand good practices and regulation involved in utilizing microbial product for pharmaceutical application.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Have basic knowledge of pharmaceutical microbiology..

- **CLO-2:** Have well versed with the different microbial products used in pharmaceutical applications.
- **CLO-3**: Better understanding of good laboratory practices and regulations for utilizing microbial product inpharmaceutical applications..

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	2	3	1	2	2		3	2	1	1	3
CLO2	3		1	1	3	2		3			
CLO3	2	2	2	3	3		3		1	1	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

An introduction and application of pharmaceutical microbiology; Basic aspects of pharmaceutical microbiology; Biology of pharmaceutically important microorganisms: Bacteria and fungi (yeast and molds); Study of microbial growth cycle, Microbiological growth media; Assessment of microbial growth; Isolation, identification, and characterization methods of microorganisms; Handling, cultivation, and preservation methods of microorganisms; Physical and chemical factors influencing microbial growth.

Unit II

Microbial products in pharmaceutical industry: impacts and opportunities; antibiotics, production of antibiotics antifungal agents, antiviral, antiprotozoal drugs, small molecules, growth factors, hormones, vitamins, therapeutic enzymes, recombinant proteins, immunological products and vaccines etc.; Microbial sources, contamination and spoilage of pharmaceuticals; Factors affecting microbial spoilage of pharmaceutical products; Microbial control in pharmaceutical industries; Antimicrobial resistance, Methodologies for testing of antimicrobial activity (broth-dilution methods and agar diffusion methods); Antimicrobial/preservative efficacy testing.

Unit III

Microbial production of pharmaceuticals; Primary metabolic products, Secondary metabolic products; basics of fermentation process; History and discovery of microbial natural products; Screening and development approaches for new microbial natural products; Good laboratory/manufacturing practices for pharmaceuticals production, validation and regulation; Government regulatory practices and policies for pharmaceutical industry: Food and Drug Administration (FDA), The Central Drugs Standard Control Organisation (CDSCO), the Drug Controller General of India (DCGI); patenting of pharmaceutical products.

Laboratory Practical

1. Isolation and identification of pharmaceutically-important microorganisms.

2. Sterilization/disinfectants techniques and their validation.
3. Antimicrobial effectiveness testing.
4. Screening of natural microbial products for drug discovery.

Suggested Readings

1. Geoff Hanlon & Norman A (2013). HodgesEssential Microbiology for Pharmacy and Pharmaceutical Science, Wiley-Blackwell
2. Madhu Raju Saghee , Tim Sandle , Edward C. Tidswell (2011). Microbiology and Sterility Assurance in Pharmaceuticals and Medical Devices,Business Horizons.
3. Geoff Hanlon, Norman A. Hodges (2013). Essential Microbiology for Pharmacy and Pharmaceutical Science,Wiley-Blackwell.
4. Stephen P. Denyer , Norman A. Hodges, Sean P. Gorman , Brendan F. Gilmore (2011). Hugo and Russell's Pharmaceutical Microbiology,Wiley-Blackwell.
5. Prahlad Singh Mehra (2011). A Textbook of Pharmaceutical Microbiology,I K International Publishing House

Petroleum Microbiology **Credits 3**

Course Objectives

- To learn about the microbial communities resides in the oil reservoirs and other hydrocarbon resource environments.
- To understand how these microbial communities, impact the oil/energy production and how oil production can be made greener and sustainable by manipulating these communities.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Characterize the microbial communities in hydrocarbon resource environments.
- **CLO-2:** Predict the positive or negative impact of the microbial communities in various petroleum fields.
- **CLO-3**: Design the microbial solutions to the microbiology related problems in the petroleum industry.
- **CLO-4**: Suggest solutions to enhance production of oil/energy by applying concepts of production related petroleum microbiology.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	3	1				2	2	1	3	3
CLO2	1	2	3	1	1	2		2			
CLO3	2	3	2	2			1		1		
CLO4	1	1	1	2	1			1	1	3	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Microbiology of oil fields: Introduction to oil fields, formation of oil reservoirs, oil production, indigenous microbial communities in oil fields, microbiology and molecular biology of sulfate-reducing bacteria, hyperthermophilic and methanogenic archaea in oil fields, fermentative, iron-reducing and nitrate-reducing microorganisms.

Unit II

Detrimental effects of bacterial activity: Biodegradation of petroleum in subsurface geological reservoirs, reservoir souring: mechanisms and prevention, microbial control of hydrogen sulfide production in oil reservoirs, microbial corrosion in the oil industry, biofouling in the oil industry.

Unit III

Application of biotechnology in oil production: Microbially enhanced oil recovery: past, present and future, biotechnological upgrading of petroleum, diversity, function and biocatalytic applications of alkane oxygenases, the microbiology of marine oil spill bioremediation, metabolic indicators of anaerobic hydrocarbon biodegradation in petroleum-laden environments, unconventional gas and oil resources: shale gas, oil sands and coal bed methane (CBM).

Laboratory Practical

1. Preparation of anaerobic medium to enrich and culture anaerobic bacteria form oil field samples
2. Evaluation of souring in oil fields using serum bottle experiment
3. Enumeration of sulfate reducing bacteria in oil field samples using MPN test.

Suggested Readings

1. Bernard Ollivier, Mitchel Magot (2005). Petroleum Microbiology, ASM Press.
2. Corinne Whitby, Torban Lund Skovhus (2011). Applied Microbiology and molecular biology in oil field systems, Springer.
3. Larry L. Barton, W. Allan Hamilton (2007). Sulphate-Reducing Bacteria: Environmental and Engineered Systems, Cambridge University Press.

Extreme Microbiology **Credits 3**

Course Objectives

- Describe different extreme environments and occurrence of organisms in such harsh conditions.
- Describing molecular approaches to explore microbial communities in extreme environments.
- Comprehend adaptations strategies of various extremophilic microorganisms.

- Microbial diversity in toxic environments.
- Knowledge about extremozymes and their application.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Know the types of microbial diversity flourish in extreme environments.
- **CLO-2:** Understand how organisms cope under extreme living conditions with biochemical and molecular adaption of extremphilic microorganisms
- **CLO-3**: Understand modern techniques used for exploration of unculturable extremophiles
- **CLO-4**: Understand potential application of extremozymes in various industries and in functional genomics.

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	3	1	1	2	2		3	2	1	3	1
CLO2	3		3		3	2		3			
CLO3	3	1	2		3		3		1	1	1
CLO4	3	1	1	2	2		3	2	1	3	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Concept of extremophiles v/s conventional microbial forms & archaea, habitats in universe, eco-niches, communities and community associations, biofilms, microbial community analysis of extreme environments using various molecular approaches (DGGE, cloning and next generation sequencing, functional genomics and transcriptomics).

Unit II

Occurrence, Physiological features, adaptation strategies of various extremophilic microbes: a) anearobes, barophiles/ peizophiles, cryophiles & thermophiles; b) oligotrophs, osmophiles, halophiles & xerophiles; c) radiophiles, metallophiles & xenobiotic utilizers; d) alkaliphiles/ basophiles, acidophiles. Potential applications of extremophilic microbes.

Unit III

Microbes in toxic environments: acid mine drainage, waste containing cyanides, xenobiotics, pesticides, heavy metals and radio isotopic materials, extremozymes and their applications, field and case studies.

Laboratory Practical

1. Conventional characterization of Extreme-tolerant heterotrophic prokaryotes.

2. Morphological characterization of cyanobacteria inhabit saline-alkaline lake.
3. Enumeration of eukaryotes thrive in extreme habitats.

Suggested Readings

1. Brock, T. D. (1978). Thermophilic Microorganisms and Life at High Temperatures, Springer, New York.
2. Fred A Rainey and Aharon Oren (2006). Extremophiles, Academic Press.
3. Horikoshi, K. and W. D. Grant (1998). Extremophiles-Microbial Life in Extreme Environments, Wiley, New York.
4. Gerday, C. And Glansdorff, N. (2007). Physiology and biochemistry of extremophiles. Washington, DC: ASM Press.

Infection Biology and Vaccine Development **Credits 3**

Course Objectives

- The goal of this course is to obtain a fundamental knowledge of infectious biology and pathogenicity.
- To assess the impact of environmental/climate change on the incidence, prevalence, geographical distribution, and severity of infectious diseases.
- To understand the basics of vaccines, different vaccinology approach and types of vaccines.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Basic understanding of infectious biology and pathogenicity.
- **CLO-2:** Understand the concept of vaccines and vaccinology approaches
- **CLO-3**: Understanding of the immunization approaches based on types of vaccines developed eg. Whole organisms, DNA based vaccines

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	2	1	3	2	2	3	3	2	1	3	3
CLO2			2		1	2		1			3
CLO3	2	3	2		1		2		1	1	3
CLO4			1	2	2	3	2	2	1	3	

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Infection Biology: History and scope of infection biology, Neglected tropical diseases, medically significant pathogens; Symbiosis between infection and pathogenicity, Microbial surface variation, Regulation of virulence-associated genes, Mice-microbes and models of infection, Therapeutic problems with infectious diseases: current approaches.

Unit II

Classical and Reverse vaccinology approaches: Historical view of classical vaccinology, Reverse vaccinology, Active and passive immunization, Vaccine design approaches, Whole-organism vaccines, purified macromolecules as vaccines, Recombinant-vector vaccines, DNA vaccines, multivalent subunit vaccines, Tools for vaccine design: Immuno-informatics tools for vaccine design, Epitope-driven approach.

Unit III

DNA vaccine approaches: DNA vaccines for infectious disease: introduction, immune-stimulatory activity of DNA vaccines, DNA vaccine delivery systems, physical methods, particle-mediated delivery of DNA vaccines, Use of live viral and bacterial vectors for vaccine delivery for DNA vaccine, virus-like particle vaccines, Advantages and challenges of vaccine development: Human Papillomavirus, HIV/AIDS, Influenza, Developing stable cell lines for the production of vaccine antigens.

Laboratory Practical

1. Detection of Microbial pathogens and cell structure using differential staining procedures: capsule staining, endospore staining, acid fast staining, gram staining
2. Identification of microbial antigens by immunological techniques; ELISA, Immunoelectrophoresis
3. Identification of bacterial pathogens by molecular approaches; PCR, qPCR, western blot
4. Immunoinformatic tools for vaccine design (selection of epitopes).

Suggested Readings

1. Murphy, Kenneth M., Travers, Paul and Walport, Mark, Janeway‟s Immuno Biology, 7th Edition, Garland Science, Taylor & Francis Group, 2008
2. Kindt, T. J.,Osborne, B. A. and Goldsby, R. A. Kuby Immunology, 6th Edition, W. H. Freeman, 2006.
3. Jörg Hacker (Editor), Jürgen Heesemann, Molecular Infection Biology: Interactions Between Microorganisms and Cells, Publisher: Wiley-Spektrum 1st Edition, 2002
4. Feemster Kristen A, Vaccines, Publisher: Oxford, 2017
5. Igor S Lukashevich, Haval Shirwan, Novel Technologies for Vaccine Development, Publisher: Springer, 2014

Microbes in Sustainable Agriculture and Development **Credits 3**

Course Objectives

- To understand the role of microorganisms in soil to enhance its nutritional properties.
- To gain knowledge about biofertilizers, GM crops.

- To have insight about soil microbial consortia and crop improvement.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Understand microbial concepts of soil and role of microorganisms to enhance the soil fertility.
- **CLO-2:** Describe and discuss biocontrol, biofertilizers and genetically modified crops
- **CLO-3**: Develop concepts about employment of novel molecular tools to modify agriculturally important microbes

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	3	1				2	2	1	3	3
CLO2	1	2	3	1	1	2		2			
CLO3	2	3	2	2			1		1		

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil; Mineralization of Organic & Inorganic Matter in Soil; Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium.
Microbial Activity in Soil and Green House Gases: Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control; Microbial Control of Soil Borne Plant Pathogens: Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds

Unit II

Biofertilization, Phytostimulation, Bioinsecticides: Plant growth promoting bateria, biofertilizers-symbiotic (*Bradyrhizobium, Rhizobium, Frankia*), Non Symbiotic (*Azospirillum, Azotobacter*, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs. Secondary Agriculture Biotechnology: Biotech feed, Silage, Biomanure, biogas, biofuels-advantages and processing parameters. GM crops: Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.

Unit III

Microbial technology in agriculture: Crop improvement, molecular methods for improvement of crop yield, shelf life, etc. Microbial Consortia: Promising Probiotics as Plant Biostimulants. Microbe farming: methods, advantages, future in agriculture. From flask to field: Role of microorganisms in improving the soil quality and production, molecular methods for development of agriculturally important microbes.

Laboratory Practical

1. Study microflora of different soil types.
2. Rhizobium and Azotobacter as soil inoculants characteristics and field application.
3. Isolation of cellulose degrading organisms.

Suggested Readings

1. Soil Microbiology, Ecology and Biochemistry 4th edition by Paul E., Academic Press, Elsevier.
2. Microbes and Sustainable Agriculture (2017); Prasad R., Kumar N., I.K. International Publishing House Pvt. Ltd.

Functional Genomics and Proteomics **Credits 3**

Course Objectives:

- Impart basic knowledge about genomes and proteomes and databases that store various data about genes, proteins, genomes and proteomes.
- Students would learn basic knowledge of genome sequencing, major differences between prokaryotic and eukaryotic genomes, basic proteomics and its applications.
- Students would gain skills in comparative, evolutionary and functional genomics. Students will be skilled and can work in core facilities, commercial biological and medical laboratories.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Understand the basic concepts of genomics and proteomics.
- **CLO-2:** Describe and discuss the use of genomics and proteomics in human health.
- **CLO-3**: Able Suggest and outline solution to theoretical and experimental problems in Genomics and Proteomics fields

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1		3	1		3	3	2	2	1	3	3
CLO2	1	2	3	1	1	2		2	1	1	
CLO3		1	2	2	2		1		1		1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

UNIT I

Structure, organization and composition of prokaryotic genomes. Microbial genomics and genome epidemiology.Function genomics, metagenomics and methods of metagenomics Evolution and structure of mitochondrial genomes, mtDNA and mitochondrial diseases. Structure, organization and composition of eukaryotic genomes. Repetitive a transponable genetic elements and their effect on genome. Telomeric and subtelomeric regions. DNA methylations, RNAi and silencing of genes expresion.

UNIT II

History of human genome sequencing. Evolution of human genome and structure variations (STR, VNTR, SNP). Genomics of human diseases, nutritional genomics, epigenomics and methods of epigenomics. Introduction and scope of proteomics; Protein separation techniques: ion-exchange, sizeexclusion and affinity chromatography techniques. Polyacrylamide gel electrophoresis; Isoelectric focusing (IEF); Two dimensional PAGE for proteome analysis; Image analysis of 2D gels.

UNIT III

Introduction to mass spectrometry; Strategies for protein identification; Protein sequencing; Protein modifications and proteomics; Applications of proteome analysis to drug; Protein-protein interaction (Two hybrid interaction screening). Protein engineering; Protein chips and functional proteomics; Clinical and biomedical application of proteomics; Proteome database; Proteomics industry.

Laboratory Practical

1. Designing of primers using different software like Generunner and online tools like Genefisher.
2. Designing of vector using plasmid design tool like GenSmart Design.
3. Learning of tools for gene and protein annotation and promoter analysis.

Suggested readings

1. Jizhong Zhou, Dorothea K. Thompson, Ying Xu , James M. Tiedje (2004) Microbial Functional Genomics. John Wiley & Sons, Inc
2. Holger Uffe and Olaf Philip (2017) Functional Genomics: Novel Insights, Applications and Future Challenges. Nova Science Publishers
3. Ian Humphery-Smith and Michael Hecker (2006) Microbial Proteomics: Functional Biology of Whole Organisms. John Wiley & Sons, Inc
4. Recent articles/published papers published in the field of functional genomics and proteomics

Biohydrometallurgy andBiomineral Processing **Credits 3**

Course Objectives

- To understand basic concept of Hydrometallurgy and Mineral Processing.
- To analyze and interpret various application of Microorganism in Hydrometallurgy and Mineral Processing.
- To simulate industrial application of Biohydrometallurgy with respect to leaching.
- To utilize the mineral processing application of floatation in Microbial catalysis.
- To understand the batch and column leaching for sulphide/oxide minerals with microbial processing.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Understand basic concepts of Biohydrometallurgy and Biomineral Processing.
- **CLO-2:** Estimate and able to understand the possibilities of utilizing microorganisms in Extractive Metallurgy and Mineral processing.
- **CLO-3**: Design experiments for scale up of the process in all kind of sulphide minerals as well as waste recycling.
- **CLO-4**: Understand the functional dynamics of the Microorganisms in mineral industry prevalent in bioheap and bio tank leaching

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1			1				2	2	2	3	3
CLO2	2	2	1	1	1	2		2			1
CLO3	2	3	1	2			1		1	2	
CLO4	2	1	1	2	1			1	1	3	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above “High level” mapping is denoted as “3”, Medium level mapping is denoted as “2”, and Low level mapping is denoted as “1” respectively.

Course Structure

Unit I

Extractive Metallurgy; Hydrometallurgical Phase Diagrams; Pretreatment; Leaching Theory; Leaching Reagents; Leaching Methods; Leaching Objects; Biohydrometallurgy; Solution Purification; Electrolytic Processes; Metal Recovery; Hydrometallurgical Processes; Mineral Processing; Solution equilibria of surfactants; Mineral–solution equilibria; Mineral–flotation reagent equilibria; Application of flotation agents and their structure–property relationships; Biomineral Processing applications.

Unit II

Fundamentals, microorganisms and mechanisms in Mineral Processing; Mechanisms and biochemical fundamentals of bacterial metal sulfide oxidation; Electrochemical techniques used to study bacterial-metal sulfides interactions in acidic environments; Catalytic role of silver and other ions on the mechanism of chemical and biological leaching; Recovery of zinc, nickel, cobalt and other metals by bioleaching; Bioleaching of metals in neutral and slightly alkaline environment; Bioreactors and Bioheaps; Bioleaching of sulfide minerals in continuous stirred tanks; Bioreactor design fundamentals and their application to gold mining; Airlift reactors: characterization and applications in biohydrometallurgy and Biomineral Processing; Principles, mechanisms and dynamics of chalcocite heap bioleaching; Genetics and Molecular Biology in Biomineral Processing and Biohydrometallurgy; Bioinformatics and genome biology to advance our understanding of bioleaching microorganisms; Proteomics and metaproteomics applied to biomining microorganisms; Cell-cell communication in bacteria: A promising new approach to improve bioleaching efficiency; Bioflotation and bioflocculation of relevance to minerals bioprocessing; Hydrogen sulfide removal from gaseous effluents in Biomineral Processing and Biohydrometallurgy.

Unit III

Microorganisms to Industrial Processes; Acidophile Diversity in Mineral Sulfide Oxidation; The Microbiology of Moderately Thermophilic and Transiently Thermophilic Ore Heaps; Mineral-Oxidizing Microorganisms; Bacterial Strategies for Obtaining Chemical Energy by Degrading Sulfide Minerals; Genetic and Bioinformatic Insights into Iron and Sulfur Oxidation Mechanisms of Bioleaching Organisms; Relevance of Cell Physiology and Genetic Adaptability of Biomining; The BIOX™ Process for the Treatment of Refractory Gold Concentrates; Bioleaching of a Cobalt-Containing Pyrite in Stirred Reactors; Study from Laboratory Scale to Industrial Application; Commercial Applications of Thermophile Bioleaching; Development and Current Status of Copper Bioleaching Operations in Chile: Successful Commercial Implementation; The GeoBiotics GEOCOAT® Technology – Progress and Challenges; Whole-Ore Heap Biooxidation of Sulfidic Gold-Bearing Ores; Heap Leaching of Black Schist; Modeling and Optimization of Heap Bioleach Processes.

Laboratory Practical

1. Determination of ferrous iron, ferric iron, total iron, sulphate concentration by spectrophotometric and titrimetric methods.
2. Determination of Cu, Ni, Zn, and Fe by Atomic absorptionspectroscopy.
3. Crushing and grinding of metal sulphides followed by coning and quartering and size fraction analysis.
4. Microbial viable planktonic cell count by haemocytometer.
5. Mineralogy study by X-Ray Diffraction studies.
6. Chemical, batch and fed-batch bioleaching of metal sulphides.
7. Pourbaix diagram studies for metal ions in aqueous phase usingHSC.
8. Solid liquid separation techniques.
9. Solvent extraction of Copper.

Suggested Readings

1. Edgardo R. Donati and Wolfgang Sand, Germany Microbial Processing of Metal Sulfides, Springer ISBN 978-1-4020-5588-1 (HB), ISBN 978-1-4020-5589-8 (e-book)
2. D.E. Rawlings and B.D. Johnson (Eds.). Biomining, Springer, ISBN-13 987-3-540-34909-9 Springer-Verlag Berlin Heidelberg New York

3. Fathi Habashi, Handbook of Extractive Metallurgy- The Metal Industry and Ferrous Metals, Wiley VCH, Germany.
4. Chiranjib Kumar Gupta, Chemical Metallurgy: Principles and Practice. 2003 Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 3-527-30376-6.
5. Christiane Dahl and Cornelius G. Friedrich, Microbial Sulfur Metabolism, 2008, ISBN-13 978-3-540-72679-1 Springer-Verlag Berlin Heidelberg New York.

Cell Organization and Signaling **Credits 3**

Course Objectives:

- To understand the cell (microbial, plant and animal) and its structural organization.
- To gain insight about cell division and cell cycle.
- To gain in depth knowledge of different signaling mechanism and pathways operating within a cell; implications in development of medicines and therapeutics.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Understand about organization of all type of cells including stem cells and its uses in therapeutics.
- **CLO-2:** Describe and discuss the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function.
- **CLO-3**: Represent and illustrate the structural organization of genes and the control of gene expression
- **CLO-4**: Conceptualize and describe cell movement and cell-cell communication and discuss mechanisms of signal transduction
- **CLO-5**: Explain the processes that control eukaryotic cell cycle and cell death

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	2	3	1				2	2		3	3
CLO2	3		3	1	1	2		2			1
CLO3	3		2	2			1		2		
CLO4		1	1	2	1	3		1	1	2	1
CLO5		3	1			2	2	2	1	3	2

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Membrane structure and function (Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes). Structural organization and function of intracellular organelles (Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility)

Unit II

Organization of genes and chromosomes (Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, heterochromatin, euchromatin, transposons). Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle).

Unit III

Cell signaling Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, bacterial chemotaxis and quorum sensing. Cellular communication Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

Laboratory Practical

1. Study the cellular morphology using various staining methods.
2. Study the cell cycle stages in onion root tips and chromosome staining.
3. Staining of nucleus and cell organelles.

Suggested Readings

1. Cell Biology by Pollard, T. D., and Earnshaw, W. C.; Saunders.
2. Cell and Molecular Biology, Concept and Experiment by Gerald K.; Wiley.
3. Molecular Cell Biology by Lodish, H., Berk A., Kaiser C. A., Krieger M., Bretscher A., Ploegh H., and Scott M.P., Freeman, W. H. and Co.
4. Molecular Biology of the Cell by Alberts B., Walter P., Johnson A., Lewis J., Morgan D., and Raff. M., Roberts K., Walter P.; Garland Publishing Inc.
5. Principles of Stem Cell Biology and Cancer: Future Applications and Therapeutics (2015). Eds. Tarik Regad, Thomas J. Sayers, Robert C. Rees, Wiley & Sons

Developmental Biology **Credits 3**

Course Objectives

- To understand the molecular basis of embryonic development and cellular differentiation in living systems
- To gain knowledge about the morphogenesis and organogenesis in plants and animals
- To have insight about programmed cell death, its factors and ageing

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Understand concepts of embryonic development and cellular differentiation in animal and plants
- **CLO-2:** Describe and discuss basic and advanced concepts of developments in both plants and animals
- **CLO-3**: Develop concepts about employment of the knowledge in therapeutics

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	3	2	1	2			2	2	1	3	3
CLO2	1	2	3		1	2		2	3		
CLO3	1	1	2	2			1		1	1	3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination

Unit II

Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in Drosophila, amphibia and chick; organogenesis–vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.

Unit-III

Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum.* Programmed cell death, aging and senescence.

Laboratory Practical

1. Introduction to cell culture, media, function of media components.
2. Cell viability assays.
3. Introduction to pant tissue culture techniques.

Suggested Readings

1. Developmental Biology 11th edition by Scott F. Gilbert; Sinauer.
2. Molecular Genetics of Plant Development (1998); Howell, S.H. Cambridge University Press.

Microbial Ecology **Credits 3**

Course Objectives

- To understand basic concept in the field of microbial ecology.
- To analyze and interpret various ecological and evolutionary principles.
- To design experimental approaches used in the field of microbial ecology.
- To critique and review arguments that researchers in microbial ecology make using evidence based approach.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Understand basic concepts within the field of microbial ecology and environmental microbiology
- **CLO-2:** Interpret the various ecological and evolutionary principles that impact microbes
- **CLO-3**: Analyze and design experimental approaches used in the field of microbial ecology
- **CLO-4:** Grasp how research in microbial ecology is conducted
- **CLO-5:** Gain detailed knowledge about a specific aspect of the microbial ecology chosen for project/report
- **CLO-6**: Recognize functional ubiquity and diversity observed among different microbes
- **CLO-7:** Critique arguments that researchers in microbial ecology make based on evidence
- **CLO-8:** Critically read and write on topics related to microbial ecology
- **CLO-9**: Comprehend how humankind may be able to manage the limited resources in a wise and sustainable fashion

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1		3	2	3	2	2	2	3	1		3
CLO2	1	2	1	1	1		1			2	
CLO3	2	1	2			2		2			2
CLO4				2	2		3	2	3	3	
CLO5	2	1	3			2					
CLO6		3	2	1	3		2	2	2	1	2
CLO7	3	1		1	2	1		3			
CLO8	1		1				1		1	1	2
CLO9					1	3		1			1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Introduction to microbial ecology: overview, motivation, history, applications etc. Concepts of microbial ecology: Ecology of macro- and microorganisms: definitions, terminology, concepts. Individuals and populations: productivity, growth, distribution, activity. Communities: colonization, succession, diversity, structure. Microbial functions in ecosystems and global cycles.
Methods in microbial ecology: Habitat characterization. Characterization of microbial communities: culture-based methods, biomarkers, cell stains. Characterization of microbial communities: PCR, real-time PCR, molecular fingerprints. Characterization of microbial communities: FISH and sequencing. Activity measurements.

Unit II

Microbial interactions: Interactions of microorganisms with their physical and chemical environment. Microbial guilds and biogeochemical cycles. Interactions with the biotic environment: symbiosis, competition, parasitism and predation. Interactions within microbial communities: quorum sensing, syntrophy and antibiotics. Interactions of microorganisms with algae and plants. Interactions of microorganisms with animals and humans

Unit III

Ecology of natural and engineered microbial habitats: Marine ecosystems: ocean surface, tidal flats, estuaries. Marine ecosystems: deep-sea, methane seeps, anoxic basins. Freshwater ecosystems: lakes, rivers, swamps, bogs. Terrestrial ecosystems: rocks and soil, prairie, forest, tundra. Extreme environments: deserts, hot springs, glaciers, deep subsurface, mine drainage. Landfills, wastewater treatment reactors, bioremediation. Culture collections, food ecosystems, agricultural systems, aquaculture. Synthetic communities and applied microbial ecology. Evolving communities: evolutionary ecology and community stability.

Laboratory Practical

1. Preparation of culture medium for the growth of halophiles and thermophiles.
2. Isolation of microbes from any of the extreme environment like desert, hot springs or salt lakes.
3. Isolation of Rhizobium sp. from root nodules of leguminous plant.
4. Characterization of isolated microbes with the help of PCR based techniques.

Suggested Readings

1. Madigan MT, Martinko JM, Dunlap PV, Clark DP (2014). Brock Biology of Microorganisms, Prentice Hall, USA.
2. Larry L. Barton and Diana E. Northup (2014) Microbial Ecology
3. David L. Kirchman. Processes in Microbial Ecology, Oxford University Press
4. Recent articles/published papers published in microbial ecology journals

IPR and Biostatistics **Credits 3**

Learning Objectives:

- Impart basic knowledge of patenting, intellectual property rights, laws available and copyrights.
- Impart basic knowledge of statistics and tools used for several quantitative analysis in microbiology.
- Develop a proper understanding on data collection and interpretation of data by statistical methods.
- Analyze the statistical representation of the data and develop an ability to interpret the results obtained from the statistical analysis.
- Understand various methods to interpret the statistically viable data.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Have knowledge on patents and property rights
- **CLO-2:** Critically analyze the patent applications for novelty and utility
- **CLO-3**: Well versed in writing claims for the new patent
- **CLO-4:** Comprehend how students‟ research can lead to IPR in the respective field
- **CLO-5:** Students are able to predict the significance of the biological phenomenon on the basis of availabledata set

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	2	2	2	2	2	2	2	3	1		3
CLO2	1	3	1	1	2	1	2		2	2	
CLO3						3			1	2	3
CLO4	2		1	2	3		3	2	1	3	2
CLO5	2	2	2	3	1	2				1	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above “High level” mapping is denoted as “3”, Medium level mapping is denoted as “2”, and Low level mapping is denoted as “1” respectively.

Course Structure

Unit I

Definition of IPR, function and importance. Forms of protection: Copyright and related rights, Patents, Industrial Designs, Trademarks, Trade Secrets, Geographical Indicators, Semiconductor layout circuits, Plant breeder, farmer rights etc. Patentable subject matter: Novelty and Application. International conventions and Treaties (WIPO). Importance of IPR in developing world with special reference to India. IPRs in Biotechnology/Microbiology. Intellectual Property Management: Patent application process (national and International), Patent infringement, Patent Claims and Legal decision-making process. Structure of patent application including specifications, claims, prior art and patent designs. Landmark

cases in Indian patent history. Guidelines for examination of biotechnology application for patent (Section 2, 3 and 10). Traditional knowledge digital library (TKDL) and Biological Diversity Act 2002.

Unit II

Statistics for biologist: Sources and Methods of Collection of Data, Processing of Data (Classification and Tabulation of Data), Data Presentation (Graphical and Diagrammatical), Frequency distribution, Descriptive Statistics: Measures of Central Tendency (mean, median and mode), Measures of Dispersion (standard, deviation, mean absolute deviation, Mean difference, Range, Quartile deviation, Relative dispersion, Lorenz curve), Measures of Skewness and Kurtosis.

Unit III

Elementary theory of probability: Probability, Theorems of probability laws, Use of permutation and combination, Bayes Rule; Random variability and probability distributions: Random variable, Probability distribution, Independent random variable, Standard distributions (Binomial, Poisson, Normal distribution); Linear Correlation and Regression: Bivariate data and scatter diagram, Correlation, types of correlation, measurement of linear correlation; Regression; Sampling methods, Time series analysis, Index numbers, Elements of Statistical inference, Student,,s t-test, Fisher's t- test, Chi-square test, Analysis of Variance (ANOVA).

Laboratory Practical

1. Learning and analysis of famous case studies in the field of patent and other IPRs.
2. Design and develop effective patent drafting skills for Indian & International patents.
3. Learning of biostatistics online tools/software for data analysis in life sciences.

Suggested Readings

1. Guidelines for examination of biotechnology application for patent (2013) Office of the Controller General of Patents, Trademarks and Designs.
2. Guidelines for processing patent applications relating to traditional knowledge and biological material (2013) Office of the Controller General of Patents, Trademarks and Designs.
3. Intellectual Property Rights: Legal and Economic Challenges for Development: Cimoli
4. Indian Patent Laws: Kankanala KC, Narasani AK
5. Intellectual Property Rights: P Ganguly, Tata McGraw Hill, 2007
6. A Text book of Biostatistics, by A.K.Sharma, Discovery publishing house
7. Introduction to Biostatistics, By Dr. Pranab Kumar Banerjee, S. Chand Publishers

Bioinformatics and Biophysics **Credit 3**

Course Objectives

- Aimed to provide an overview of various bioinformatics tools, databases available and sequence analysis.
- Provide knowledge on database concept, management, retrieval along with utilization in gene and

protein analysis.

- Aimed to provide the overview of biophysical techniques used in protein and DNA research applications.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** Retrieve the information from available databases and use them for microbial identifications
- **CLO-2:** Gain ability to modify gene and protein structures in simulated systems
- **CLO-3**: Predict the significance of the biological phenomenon on the basis of available bioinformatics dataset
- **CLO-4:** Understand the use of biophysical techniques for protein-protein interaction and DNA-protein interaction
- **CLO-5:** Able to use Fluorescence Microscopy for protein localization and co-localization in the cell
  CLO-6: Design the experiment for protein-protein and protein-DNA interaction by using different mentioned techniques in proposed course
- **CLO-7:** Able to explain the advance sequencing techniques for DNA and proteins
- **CLO-8:** After course completion, students can apply the knowledge in further studies and higher education

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**	**PLO11**
CLO1	2	1	2	3	2	2	2	3	1		1
CLO2	2	2	1				2			2	1
CLO3	2	1	3			3					1
CLO4	2			2	2		2	2	1	3	1
CLO5	2	1	1			2					1
CLO6	2		2	3	3		3	3	1	1	1
CLO7	2	1		1		1		1			1
CLO8	2		2				1		1	1	1

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

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Course Structure

Unit I

Basic introduction of Bioinformatics; An overview of major bioinformatics resources; Various databases (GenBank, EMBL, DDBJ, Swissprot, Ensemble, UCSC genome browser, Plasmo-DB) and bioinformatics tools; Use and application of bioinformatics in research, search and retrieval of biological information. Searching for sequence and analysis by different database BLAST algorithm and CLUSTALW. Phylogenetic studies, alignment of sequences, gene prediction and regulation, protein classification & structure prediction. Genome analysis methods.

Unit II

Biophysical techniques and its application in protein-protein and protein-DNA applications: Surface Plasmon Resonance imaging (SPR), Fluorescence Resonance Energy Transfer (FRET), Circular

Dichroism (CD) and Optical Rotatory Dispersion (ORD). Fluorescence Microscopy: Different chromophores (Green, Red and Yellow), DAPI and its applications. Flocytometry and its applications. Immuno-electrophoresis, immune-precipitation, agglutination, RIA, ELISA, Immune-fluorescence microscopy, Immuno-electron microscopy, Fluorescence In-situ hybridization (FISH).

Unit III

Applications of Spectroscopy: Ultraviolet/Visible Spectroscopy. Mass Spectroscopy: protein sequencing and identification, Matrix Assisted laser desorption / ionization MS (MALDI-MS), MALDI-TOF-MS. Next-generation peptide sequencing. Different Generation DNA Sequencing & its application: First, Second, Third and Fourth generation DNA sequencing, Different NGS platforms: Roche 454 GS-20; Illumina MiSeq and HiSeq; Ion Torrent Personal Genome Machine (PGM); PacBio System and MinION.

Laboratory practical

1. Extraction of DNA/RNA/Protein/Metabolites.
2. Quantification and amplification of DNA/RNA.
3. Cloning and confirmation of insert by phenotypic/molecular methods.

Suggested Readings

1. Achuthsankar S Nair (2007). Computational Biology & Bioinformatics – A gentle Overview, Communications of Computer Society of India.
2. Baxevanis, A.D. and Ouellette, B.F.F. (2004). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, John Wiley & Sons.
3. Hosseini, Samira, Martinez-Chapa, Sergio O. (2017). Fundamentals of MALDI-ToF-MS Analysis, Springer Briefs in Forensic and Medical Bioinformatics.
4. Wilson/Walker (2010) Principles and Techniques of Biochemistry and Molecular Biology.
5. Gupta N., Verma V.K. (2019) Next-Generation Sequencing and Its Application: Empowering in Public Health Beyond Reality. In: Arora P. (eds) Microbial Technology for the Welfare of Society. Microorganisms for Sustainability, vol 17. Springer, Singapore.

System and Synthetic Microbiology **Credit 3**

Course Objectives

- To obtain a fundamental knowledge of the basic principles of system microbiology through different biological system such as genomics, transcriptomics, metabolomics, and proteomics.
- To re-design natural biological system or design new biological system for useful purposes.

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** To understand the dynamic interactions of different biological system to predict the behavior of microbial cell or whole community
- **CLO-2:** How to integrate the information of different biological system that aims at providing the scientific foundation for synthetic biology?

- **CLO-3**: How synthetic microbiology provides new tools to modify the molecular workings of microbial cells to gain advantages in medical, industry, or in agriculture

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	1	2	2	3	2	2	2	2	1	1	1
CLO2	2	2		1	1		2			1	
CLO3	3		3			3		1	2	2	3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Basic introduction of system microbiology; An overview of "Omics" concepts such as genomics, transcriptomics (RNA-Seq), proteomics, metabolomics, and metagenomics; Basics of next-seneration sequencing (NGS) methods and high throughput techniques used in proteomics and metabolmics; Impacts and applications of NGS and high throughput techniques in food-microbiology, industrial microbiology and public health microbiology.

Unit II

An overview of Microbial Genomics; Microbial Genome Structure and organization; Genomics of cultured and uncultured microbial communities Principles of microbial genome assembly, annotation of microbial genomes; Use and application of various bioinformatics databases and tools in Microbial Genomics; Search and retrieval of biological information and databases sequence for Microbial Genomics; Applications of microbial genomics in vaccine and drug designing, agriculture, and in food microbiology.

Unit III

An introduction of synthetic microbiology; Basic principles, methods, and tools for engineering microbes; Genome editing tools and techniques such as CRISPR/Cas9 used to synthetic bacteria; Development of engineered microbes for disease diagnostics, therapeutics, and human pathogens; Synthetic and Designer probiotics; Applications of engineered bacteria in vaccine designing, drug delivery, and in industry; Biosafety and biosecurity issues, concerns, solutions related with synthetic or engineered microbes.

Laboratory practical

1. Extraction of DNA/RNA/Protein/Metabolites.
2. Quantification and amplification of DNA/RNA.
3. Cloning and confirmation of insert by phenotypic/molecular methods.

Suggested Readings

1. Head, Steven R., Ordoukhanian, Phillip, Salomon, Daniel R (2018) Next Generation Sequencing Methods and Protocol. Springer
2. Izard, Jacques., Rivera, Maria. (2014) Metagenomics for Microbiology. Elsevier
3. Kaufmann, Michael., Klinger, Claudia., Savelsbergh, Andreas. (2017) FunctionalGenomics Methods and Protocols. Springer
4. Colin Harwood and Anil Wipat (2013) Microbial Synthetic Biology. Academic Press

Current Trends in Microbiology **Credit 3**

Course Objectives

- The course covers the emerging concepts of microbiology such as antimicrobial resistance, human microbiome, food-safety, and food-security with providing basic informations.
- The course guide the importance of antimicrobial resistance spread and human microbiome in health or in medicine including impact of microorganisms in functional food or in food safety/security

Course Learning Outcomes (CLOs)

After completion of this course successfully, the students will be able to……

- **CLO-1:** How to control the problem of antimicrobial resistance and what are the alternative approaches tofight the drug-resistant pathogens
- **CLO-2:** To better understand the role of human microbiota in health and in medicine including Fecal microbiota transplantation (FMT).
- **CLO-3**: To develop basic knowledge that support food safety through emerging trends and research

Mapping of Course Learning Outcomes (CLOs) with the Program Learning Outcomes (PLOs)

	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
CLO1	1	2	2	3	2	2	1	3	1		3
CLO2	1			1	1		1			2	1
CLO3	1	2	3			3		1	1	2	3

Each Course Learning Outcome (CLOs) is mapped with one or more Program Learning Outcomes (PLOs). In the Mapping table above "High level" mapping is denoted as "3", Medium level mapping is denoted as "2", and Low level mapping is denoted as "1" respectively.

Course Structure

Unit I

Global emergence of antimicrobial resistance in clinical settings, different environments, food-animals

and in agriculture, Factors contributing the emergence and dissemination of antimicrobial resistance; Preventive and control strategies to control antimicrobial resistance, One Health approach, Alternatives to Antimicrobials-Phage therapy, Antimicrobial peptides, Probiotics Antibodies etc.; Antibiotic resistance breakers or antibiotic adjuvants, Drug-repurposing, Screening and methodologies for Drug-repurposing

Unit III

Introduction of human microbiome including microbiome of gut, oral, skin, respiratory tract, and gastrointestinal tract; Conventional and current methods of microbiome analysis including culture-dependent, culture-independent and whole genome vs. 16S rRNA gene analysis; Role of human microbiome in health and communicable or non-communicable diseases such as cancer, diabetes, and malnutrition etc.; Human gut microbiota and immunity; Role of microbiome in drug metabolism, therapeutics and diagnostic.; Fecal microbiota transplantation **(**FMT**).**

Unit III

Emerging trends in food-safety and food-security linked with microorganisms; Emerging foodborne pathogens of food of animal and plant-origin and Public Health; Conventional to current methods for the microbiological examination of foods; Nutrition, Microbiome, and Human Health; From Gut Microbiota to Probiotics; Health-Promoting microorganisms in Fermented Foods Functional Properties including anticancer and antimicrobial effects of Microorganisms in Fermented Foods; Global climate change and food safety or security.

Laboratory Practical

1. Isolation and identification of antibiotic resistant bacteria from different sources.
2. Drug-repurposing screening for drug-resistant bacteria.
3. Culture-dependent analysis of human microbiome.
4. Identification of food-borne bacteria and probiotic bacteria.

Suggested Readings

1. Stefan Schwarz &Lina Maria Cavaco, Jianzhong Shen (2018). Antimicrobial Resistance in Bacteria from Livestock and Companion Animals, ASM Press.
2. Scott H. Podolsky (2015) The Antibiotic Era: Reform, Resistance, and the Pursuit of a Rational Therapeutics, Johns Hopkins University Press.
3. Susan L. Prescott & Alan C. Logan (2017). The Secret Life of Your Microbiome: Why Nature and Biodiversity are Essential to Health and Happiness, New Society Publishers.
4. Angela E. Douglas (2018) Fundamentals of Microbiome Science: How Microbes Shape Animal Biology, Princeton University Press.
5. Ian C. Shaw (2012). Food Safety: The Science of Keeping Food Safe, Wiley-Blackwell.
6. Hal Kin (2013) Food Safety Management: Implementing a Food Safety Program in a Food Retail Business, Springer.
7. Lewis H Ziska (2017). Agriculture, Climate Change and Food Security in the 21st Century Our Daily Bread, Cambridge Scholars Publishing.

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