

Central University of Punjab, Bathinda



M.Sc. Microbiology

Session- 2020-2022

Department of Microbiology

School of Basic and Applied Sciences

Programme Outcome

The students will be able to:

- Develop the skilled scientific manpower with an understanding of research ethics and vast knowledge of microorganisms and translate the basics and current updates of Microbiology into contemporary global issues.
- Analyse the knowledge of microbial, molecular and cellular processes and their applications which can be utilized for conducting research in Microbiology for the betterment of society and careers in the industry , agriculture , and applied research where biological system is increasingly employed.

IQAC

Semester - I

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
LMS.506	Microbial Biochemistry	Core	3	0	0	3
LMS.507	Microbiology	Core	3	0	0	3
LMS.508	Cell Biology	Core	3	0	0	3
LMS.509	Molecular Genetics	Core	3	0	0	3
LMS.525	Microbial Physiology and Metabolism	Core	3	0	0	3
LMS.526	Microbiology Practical-I	Skill Based	0	0	10	5
XXX	Choose from Interdisciplinary Course	Interdisciplinary Course (IDC)	2	0	0	2
LMS.529	Basics of Microbiology	Interdisciplinary Course (IDC) for other department students	2	0	0	2
Total Credits						22

Semester - II

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
LMS.513	Research Methodology and Biostatistics	Compulsory Foundation	3	0	0	3
LMS.521	Immunology	Core	3	0	0	3
LMS.522	Molecular Biology	Core	3	0	0	3
LMS.528	Medical Microbiology	Core	3	0	0	3
LMS 523	Virology	Core	3	0	0	3
LMS.527	Microbiology Practical-II	Skill Based	0	0	6	3
LMS.528	Microbiology Practical-III	Skill Based	0	0	6	3
XXX	Choose from Interdisciplinary Course	Interdisciplinary Course (IDC)	2	0	0	2
LMS.530	Introduction to Immune system	Interdisciplinary Course (IDC) for other department students	2	0	0	2
Total Credits						23

Semester – III

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
LMS.551	Industrial Microbiology	Core	3	0	0	3
LMS.552	Food and Dairy Microbiology	Core	3	0	0	3
LMS.529	Microbiology Practical –IV	Skill Based	0	0	10	5
LMS. 562	Environmental Microbiology	Core	3	0	0	3
XXX	Choose from value based courses	VAC	0	2	0	1
LMS.504	Ethics for Science	VAC	0	2	0	1
Discipline Elective**(opt any one) /MOOC#						
LMS.561	Genetic Engineering and Recombinant DNA Technology	DE	4	0	0	4
LMS.563	Introduction to Cell and Tissue Culture	DE	4	0	0	4
LMS.543	Seminar-I	Skill Based	0	0	0	1
LMS.599	Project	Skill Based	0	0	0	6
Total Credits						26

Semester – IV

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Credits
LMS.571	Microbial Biotechnology	Core	4	0	0	4
XXX	Choose from value based courses	VAC	0	2	0	1
LMS.504*	Ethics for Science*	VAC	0	2	0	1
Discipline Elective**(opt any one)						
LMS.580	Microbial Pathogenicity	DE	4	0	0	4
LMS. 582	Pharmaceutical Microbiology	DE	4	0	0	4
LMS.573	Evolution and Ecology	DEC	2	0	0	2
LMS.574	Human Physiology and Developmental Biology	DEC	2	0	0	2
LMS.544	Seminar-II	Skill Based	0	0	0	1
LMS.599	Project	Skill Based	0	0	0	6
Total Credits						20

**Course will be offered as per availability of facilities and specialization of faculty in the department

*Value based course offered by the department

L: Lectures; T: Tutorial; P: Practical; Cr: Credits, DE: Discipline Elective, VAC: Value Added Course

Evaluation Criteria for Theory Courses

- A. Continuous Assessment: [25 Marks]
- Surprise Test (minimum three) - Based on Objective Type Tests (10 Marks)
 - Term paper (10 Marks)
 - Assignment(s) (5 Marks)
- B. Mid Semester Test: Based on Subjective Type Test [25 Marks]
- C. End Semester Exam: Based on Subjective Type Test [25 Marks]
- D. End Semester Exam: Based on Objective Type Tests [25 Marks]

Semester - I

Course Code: LMS.506

Course Title: Microbial Biochemistry

Total Hours: 45

L	T	P	Cr
3	0	0	3

Learning Outcomes:

Students will be able to:

- Appraise the fundamental knowledge about various biomolecules such as protein, nucleic acid and lipids.
- Utilize the biochemical fundamentals and basic concepts of enzymes with the microbial metabolism and biological systems.

Course Contents

Unit I

12 Hours

Chemistry of Life and Special Microbial Molecules: Bonds: ionic bonding, Ion-dipole. Covalent, H-bonds, Van der Waal's interaction, Hydrophobic and hydrophilic interactions Water as a biological solvent and its role in biological processes pH, Henderson-Hasselbalch equation, concept of buffer, strength of buffer, range of buffer, important biological buffers. **Spectroscopy:** Basic concepts, principles and biological applications of spectroscopy: absorption spectroscopy, fluorescence spectroscopy, phosphorescence, Infrared and Raman spectroscopy, Optical Rotatory Dispersion (ORD), Circular Dichroism (CD) and Nuclear Magnetic Resonance (NMR) & Electron Spin Resonance (ESR).

Unit II

12 Hours

Bioenergetics: Thermodynamics, entropy, enthalpy, free energy, free energy and equilibrium constant, Gibbs free energy equation, determination of free energy of hydrolytic and biological oxidation reduction reactions, under standard and non-standard conditions, high energy compounds, coupled reactions, determination of feasibility of reactions. ATP and other different groups of high energy phosphate compounds.

Unit III

12 Hours

Macromolecules I- Proteins and Nucleic Acids: Proteins: Structural features of amino acids, classification of amino acids, peptide linkage: partial double bond nature, determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides), structural classification of proteins, primary, secondary, tertiary, quaternary structures of proteins. Ramchandran plot. Nature of Nucleic Acids.

Structure of purines, pyrimidines, nucleosides and nucleotides. Physiochemical properties of nucleic acids - Denaturation of nucleic acids. Hyperchromic effect and T_m. Chargaff's rule, Secondary structure of DNA - Watson and Crick model. Secondary structure of tRNA - clover leaf model.

Unit IV

12 Hours

Macromolecules II- Carbohydrates, Lipids: Carbohydrates: Monosaccharides, disaccharides, oligosaccharides and polysaccharides, concepts of epimer, isomer Lipids: Saturated and unsaturated fatty acids, Fatty acid oxidation. Biosynthesis of fatty acids, triacylglycerols and phospholipids. Catabolism of Glycogen. Amino acid catabolism- Urea Cycle Deamination and transamination reactions. de novo biosynthesis of purines and pyrimidines, Ribonucleotide reductase and its role in nucleic acid metabolism.

Suggested Readings:

1. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J., and Stryer, L. (2015). *Biochemistry*, 8th Edition.
2. Geoffrey L. Zubay (2017). *Principles of Biochemistry* by Brown Co, USA.
3. Moat A.G., Foster J. W Spector M. P. (2002) *Microbial Physiology* John Wiley & Sons.
4. Nelson D. L. and Cox M. M. (2017) *Lehninger Principles of Biochemistry* by W. H. Freeman.
5. White, D, Drummond J. Fuqua C (2011) *The Physiology and Biochemistry of Prokaryotes* Oxford University Press.
6. Cohen G. N. (2014) *Microbial Biochemistry* Springer.
7. Ferrier D. R. (2013) *Lippincott's Illustrated Reviews: Biochemistry* Lippincott Williams & Wilkins.
8. Irwin H. Segel (2004) *Biochemical Calculations* Wiley.
9. Palmer, T. Horwood E (1991) *Understanding Enzymes* Wiley.

Modes of transaction

- Lecture
- Problem solving
- Panel discussion
- Tutorial

Course Code: LMS.507

Course Title: Microbiology

Total Hours: 45

L	T	P	Cr
3	0	0	3

Learning Outcomes:

Students will be able to:

- Describe to describe the microbial systematics and their significance.
- Recall the basics of microbial growth and their application in day to day life.
- Classify the beneficial versus harmful micro-organisms.
- Comprehend the microbiological principles that can optimize, enhance or inhibit the microbial growth in different settings viz industrial microbiology, medical microbiology.

Course Contents

Unit I

14 Hours

Microbial Taxonomy: Major characteristics used in taxonomy – morphological, physiological and metabolic, genetic and molecular taxonomy. Classification of bacteria and Archaea according to the Bergey's Manual of Systematic Bacteriology and their economic significance. **Scope and history of Microbiology:** Cell structure, different components, function and their significance in microbes. Detailed account of biogenesis and function of microbial cell structure appendages: flagella-structure, assembly and mechanism of movement; pili and fimbriae- types, structure and their role. External cell surface structures: capsule, glycocalyx, slime layer and S-layer. Overview of gram negative and gram positive bacterial cell wall, outer membrane lipopolysaccharide (LPS). Cell wall synthesis and its inhibitors including different antibiotics.

Unit II

11 Hours

Growth and cell division: Measurement of growth, growth physiology, cell division, growth yields, growth kinetics, steady state growth and continuous growth. Microbial stress response to different environmental conditions. **Archaeal diversity, cell structure and model organisms:** Phylogenetic diversity and key features of different phyla. General characteristics of archaeal cell structure and comparison with eubacteria. Detailed account of model archaeal organisms: *Methanococcus*, *Halobacterium*, *Pyrococcus* and *Sulfolobus*.

Unit III**10 Hours**

Bacterial secretion system: Secretion pathway, SecB secretion pathway, SRP pathway, Tat pathway. Protein secretion and types of secretory systems in Gram-negative and Gram-positive bacteria. Sortases and Injectosome. **Fungal Systematics and Diversity:** General features of fungi- cell structure; growth, environmental conditions for growth; nutrition and life cycle patterns, Endophytic fungi as latent pathogens and biocontrol agents. Economic importance of fungi and yeast.

Unit IV**10 Hours**

Algae: Classification; reproduction and life cycles; algal toxins, algal bloom, algae as a source of antibiotics, importance of algae in production of algal pigments and biofuels. **Protozoa:** General account, structure, reproduction and classification of protozoa. Introduction to important protozoan diseases.

Suggested Readings:

1. Bauman, R.W. (2011). *Microbiology with Diseases by Body System*. Benjamin Cummings, USA.
2. Capuccino, J.G. and Sherman, N. (2004). *Microbiology-A Laboratory Manual*. Benjamin Cummings, USA.
3. Pelczar, M. J., Chan, E.C.S. and Krieg, N.R. (2001). *Microbiology: Concepts and Applications*. McGraw-Hill Inc. USA.
4. Pommerville, J.C. (2010). *Alcamo's Fundamentals of Microbiology*. Jones & Bartlett Publishers, USA.
5. Prescott, L.M., Harley, J.P. and Klein, D.A. (2005). *Microbiology*. McGraw-Hill Science, USA.
6. *Experiments In Microbiology, Plant Pathology and Biotechnology*. 4th Edition (2010). New Age Intl. Publishers Ltd. - New Delhi
7. Strelkauskas, A., Strelkauskas, J. and Moszyk-Strelkauskas, D. (2009). *Microbiology: A Clinical Approach*. Garland Science, New York, USA.
8. Tortora, G.J., Funke, B.R. and Case, C.L. (2009). *Microbiology: An Introduction*. Benjamin Cummings, USA

Modes of transaction

- Lecture
- Problem solving
- Panel discussion
- Group discussion

Course Code: LMS. 508
Course Title: Cell Biology
Total Hours: 45

L	T	P	Cr
3	0	0	3

Learning Outcomes:

Students will be able to:

- Demonstrate the structure and basic components of prokaryotic and eukaryotic cells.
- Describe the cell organelles and their related functions.
- Apply the basic core of scientific and quantitative knowledge to enhance understanding of cell structure and function at the molecular level.

Course Contents

Unit I

10 Hours

Introduction to the Cell: Evolution of the cell. Prokaryotes and eukaryotes, Prokaryotic and eukaryotic genomes and single cell to multicellular organisms. **Membrane Structure and Function:** Models of membrane structure, Membrane proteins, Membrane carbohydrates, Membrane transport of small molecules, Membrane transport of macromolecules and particles. Techniques in cell biology: Types of Microscopy (phase contrast, fluorescent, electron microscopy (SEM/TEM), Scanning-probe, Atomic force and, Confocal microscopy. Centrifugation: Principle and applications and types (Differential, Density Gradient, Iso-density centrifugation).

Unit II

11 Hours

Structural Organization and Function of Intracellular Organelles: Structure and function of nucleus, Ribosomes, lysosomes, peroxisomes, Golgi apparatus, endoplasmic reticulum, mitochondria and chloroplast. Oxidation of glucose and fatty acids, Electron transport oxidative phosphorylation, and photosynthesis. **Protein Secretion and Sorting:** Organelle biogenesis and protein secretion, synthesis and targeting. Intracellular traffic, vesicular traffic in the secretory pathway, protein sorting in the Golgi bodies, traffic in the endocytic pathway, exocytosis.

Unit III

12 Hours

The Cytoskeleton: The nature of cytoskeleton, Intermediate filaments, Microtubules, Actin filaments, Cilia and centrioles, Organization of the cytoskeleton. **Cell communication and cell signaling:** Cell adhesions, Cell junctions and the extra cellular matrix, Cell-cell adhesion and communication, Cell matrix adhesion, Collagen the fibrous protein of the matrix, Non-collagen component of the extra cellular matrix.

Unit IV

12 Hours

Cell Growth and Division: Overview of the cell cycle and its control, The molecular mechanisms for regulating mitotic and meiotic events, Amitosis, Cell cycle control, Checkpoints in cell cycle regulation and dysregulation. Cell to cell signaling, Overview of the extra cellular signaling, Identification of cell surface receptors, G-protein coupled receptors and their effectors, Second messengers, Enzyme-linked cell surface receptors, Interaction and regulation of signaling pathways.

Suggested Readings:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell*. Garland publishers, Oxford.
2. Alberts B, Hopkin K, Johnson AD *et al.* (2019) *Essential Cell Biology*, 5th Ed., W W Norton & Company.
3. Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Vol 1, 2, 3. Academic Press, UK.
4. Gupta, P.K. (2008). *Cytology, Genetics and Evolution*. Rastogi publications, Meerut, India.
5. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc. New Delhi, India.
6. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
7. Lodish, H, Birk, A, et al. (2016) *Molecular Cell Biology*. 8th ed. WH Freeman.

Modes of transaction

- Lecture
- Problem solving
- Group discussion
- Self-learning

Course Code: LMS.509

Course Title: Molecular Genetics

Total Hours: 45

L	T	P	Cr
3	0	0	3

Learning Outcomes:

Students will be able to:

- Illustrate the basic principles of inheritance at the molecular, cellular and organism levels.
- Elaborate the concepts of hereditary information and how they work in living organisms and to apply them to real life situations.

Course Contents

Unit I

10 Hours

Mendelian Principles: Dominance, segregation, independent assortment, Allele, multiple alleles, pseudoallele, complementation tests **Extensions of Mendelian Principles:** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters. **Extra-Chromosomal Inheritance:** Chloroplast and Mitochondrial inheritance; Cytoplasmic inheritance.

Unit II

11 Hours

Gene Mapping Methods: Molecular markers: RAPD, RFLP, SSR, SNP, ISSR, and SCAR; Linkage maps, tetrad analysis in *Neurospora*, mapping with molecular markers, development of mapping population in plants. **Human Genetics:** Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders. **Quantitative Genetics:** Polygenic inheritance, heritability and its measurements, QTL mapping.

Unit III

12 Hours

Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal versus somatic mutants, insertional mutagenesis, applications in reverse and forward Genetics; Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications; Hardy Weinberg equilibrium. Molecular basis of spontaneous and induced mutations. **Recombination:** Site-specific, homologous, DNA transposition, retrotransposition and non-homologous end joining (NHEJ).

Unit IV

12 Hours

Microbial Genetics: Microbes as tools for genetic studies. Organization of genetic material in bacteria; and viruses, Gene transfer mechanisms, F plasmid; Lambda phage: structure, genetic makeup and life cycle (lytic and lysogeny); Natural transformation and competence; Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Bacterial Conjugation- Properties of the F plasmid, F⁺ x F⁻ mating, F' x F⁻ conjugation. Transduction- Generalized and specialized transduction, virus life cycle and replication.

Suggested Readings:

1. Snusted, D.P., Simmons, M. J. (2012). *Principles of Genetics*. 6th Edition, John Wiley & Sons, New York.
2. Raven P, Johnson GB, Mason KA, Losos JB, Singer SS (2014). *Biology*, 10th Edition, McGraw-Hill, USA.
3. Griffiths AJF, Wessler SR, Carroll SB, Doebley J (2015). *An introduction to Genetic Analysis*. 11th Edition W.H. Freeman publication, USA.

4. Larry Snyder, Larry Snyder, Joseph E. Peters, Tina M. Henkin, Wendy Champness (2013) *Molecular Genetics of Bacteria*, 4th edition; ASM Press.
5. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2014). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.

Modes of transaction

- Lecture
- Problem Solving
- Self-Learning
- Inquiry training
- Co-operative learning

Tools used

PPT, Videos, Google Drive

Course Code: LMS.525

Course Title: Microbial Physiology and Metabolism

Total Hours: 45

L	T	P	Cr
3	0	0	3

Learning Outcomes:

The students will be able to:

- Illustrate the metabolic diversity exhibited by microorganisms, their thermodynamics and regulatory networks that support their survival and growth.
- Grasp basic mechanisms of energy-yielding and consuming processes
- Compile the knowledge about microbial transport system, and mechanism of bacterial sporulation in broad spectrum of micro-organism.

Course Contents

Unit I

10 Hours

Bacterial Photosynthesis: Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria. Carbon dioxide fixation pathways..

Unit II

11 Hours

Bacterial Respiration: Bacterial aerobic respiration, components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain. Electron transport chain in heterotrophic and chemolithotrophic bacteria.
Bacterial Anaerobic Respiration: Introduction. Nitrate, carbonate and sulfate as

electron acceptors. Electron transport chains in some anaerobic bacteria. Catalase, super oxide dismutase, mechanism of oxygen toxicity.

Unit III

12 Hours

Bacterial Permeation: Structure and organization of membrane (Glyco-conjugants and proteins in membrane systems), fluid mosaic model of membrane. Methods to study diffusion of solutes in bacteria, passive diffusion, facilitated diffusion, different mechanisms of active diffusion. Proton Motive Force, PTS, role of permeases in transport, different permeases in *E. coli*. Transport of amino acids and inorganic ions in microorganisms and their mechanisms.

Unit IV

12 Hours

Bacterial Sporulation: Sporulating bacteria, molecular architecture of spores, induction and stages of sporulation, Influence of different factors on sporulation. Cytological and macromolecular changes during sporulation. Heat resistance and sporulation. **Bacterial Chemolithotrophy:** Physiological groups of chemolithotrophs, ammonia oxidation by members of Genus Nitroso group, nitrite oxidation by Nitro group of genera. Oxidation of molecular hydrogen by hydrogenomonas species. Ferrous and sulfur/sulfide oxidation by *Thiobacillus* species.

Suggested Readings:

1. Caldwell D.R. (1995) *Microbial Physiology and Metabolism*. Brown Publishers.
2. Moat A.G. and Foster J. W. (2002) *Microbial Physiology*, Wiley.
3. Brun. Y.V. and Shimkets L.J. (2000) *Prokaryotic Development*. ASM Press.
4. Rose AH *Advances in Microbial Physiology*. Vol. 36, Academic Press New York.
5. Gunsalus IC, Stanier R. (1960) *The Bacteria*, Academic Press.
6. White, D. (2011) *The Physiology and Biochemistry of Prokaryotes*, 4th Edition, Oxford University Press

Modes of transaction

- Lecture
- Problem solving
- Panel discussion
- Tutorial

Course Code: LMS.526

Course Title: Microbiology Practical -I

Total Hours: 150

L	T	P	Cr
0	0	10	5

Learning Outcomes:

The students will be able to:

- Design the experiments pertaining to biochemistry, microbiology, cell biology & genetics.
- Demonstrate the concepts of enzyme activity, microbial identification, cell based experiments and genetic processes.

Course Contents

Part A. Biochemistry

1. Introduction to Good Laboratory Practices
2. Preparation of solutions, buffers, pH setting etc.
3. Quantitative estimation of proteins, sugars, total lipids and amino acids.
4. Isolation of protein from biological sample
5. Enzyme activity assays: invertase, amylase, alkaline phosphatase
6. Quantitative estimation of phenolic compounds.

Part B. Microbiology

1. Use of Microscope and working in a biosafety cabinet; Preparation of growth media: Liquid and Solid media
2. Microbiological techniques for isolation of pure cultures: Streak Plate, Spread Plate and Pour Plate techniques
3. Staining of bacterial cultures: Simple staining, Negative Staining, Gram Staining, Acid-Fast stain.
4. Glucose uptake by *E. coli* / *Saccharomyces cerevisiae* (Active and Passive diffusion)
5. Effect of UV, gamma radiations, pH, disinfectants, chemicals and heavy metal ions on micro-organisms.
6. Preparation of microbiological media. Autotrophic media, minimal media, basic media, enriched media, enrichment media, differential media. Microbial growth studies.
7. Isolation of bacterial cultures from different sources (soil, air, water) and determination of CFU.
8. Testing of Antibiotic sensitivity/resistance
9. Use of selective and/or differential media for isolation and identification of specific bacterial cultures.
10. Biochemical tests to characterize bacterial cultures: Catalase test, Oxidase test, Methylene blue test

Part C. Cell Biology

1. Demonstration and using Microscope, pH meter, weighing balance and centrifuge.
2. Study of different types of prokaryotic and eukaryotic cells.
3. Temporary staining for epithelial cells and blood cells.
4. Using haemocytometer
5. Cell counting using various stains.
6. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip).
7. Study of polyploidy in onion root tip by colchicine treatment.
8. Study of structure of cell organelles through electron micrographs
9. To demonstrate the presence of mitochondria and other cell organelles using vital stains
10. Depicting nature of cellular membranes: Osmosis, Hypertonicity, Hypotonicity, Isotonicity

Part D. Genetics

1. Learning the genetic basis of blood group typing.
 2. Identification of inactivated X chromosome as Barr body and drumstick
 3. To demonstrate and understand the principle of Hardy-Weinberg equilibrium. Calculation of genotypic and allelic frequencies for a specific trait in a random sample.
 4. Techniques for screening and isolation of bacterial cultures with specific phenotypic/genotypic characteristics.
 5. Differentiating genetic variants (species/strains) using RFLP.
 6. Studying *Drosophila melanogaster* as a Model organism: Identification of normal and mutant flies (*Drosophila melanogaster*), Demonstration of *Drosophila* polytene chromosomes
- Practical may be modified depending on available faculties/facilities.

Modes of transaction

- Lecture cum demonstration
- Problem Solving
- Self-Learning
- Inquiry training
- Team teaching
- Experimentation

Evaluation Criteria for Practical Courses: Students are evaluated for a total of 100 marks with following distribution:
Continuous assessment- 60 Marks: Maintaining the lab records/notebooks, attendance during day to day practical.
Final Practical Examination- 40 Marks: Minor Experiment, Major Experiment (to be performed) and viva-voce.

Suggested Readings:

1. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory.*
2. *Laboratory protocols in Applied Life Sciences* (2014). Taylor & Francis Group, LLC
3. *Laboratory Exercises in Microbiology*, 10th Edition by John Harley
4. Benson, *Microbiological Applications Lab Manual*, Eighth Edition
5. James G. Cappuccino & Natalie Sherman (2014) *Microbiology: A Laboratory Manual*, 10th Edition 2014
6. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology.*
7. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell.* Garland publishers, Oxford.
8. Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Academic Press, UK.
9. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments.* John Wiley & Sons. Inc., New Delhi, India.
10. Sawhney, S.K. and Randhir, S. (2005). *Introductory Practical Biochemistry.* Alpha Science International Ltd. New Delhi, India.

Course Code: LMS. 529

Course Title: Basics in Microbiology (IDC)

Total Hours: 30

L	T	P	Cr
2	0	0	2

Learning Outcomes:

The students from different streams with a very basic knowledge and understanding of microbes, pathogens and their control will able to:

- Impart a basic foundation of microbiology to the students from different backgrounds.
- Acquire a broad understanding of different group of microorganisms important in health, diseases and industry.

Course Contents

Unit I

7 Hours

Introduction to Microbiology: Scope and history of Microbiology, Classification of Bacteria, Fungi, Protozoa, Algae, and viruses. **Basic principles and techniques used in bacterial classification.** Phylogenetic and numerical taxonomy. General characteristics, structure and classification of plant animal and bacterial viruses.

Unit II

8 Hours

Microbial Growth, and Nutrition: Microbial growth. Bacterial generation time. Monoauxic, Diauxic and synchronized growth curves. Factors affecting microbial growth. Principles of microbial nutrition- Chemoautotrophs, chemo-heterotrophs,

photoautotrophs and photo-heterotrophs. Types of growth media, pure culture methods. Culture maintenance and preservation

Unit III

8 Hours

Pathogens: Medically important bacteria. Retroviruses, Viroids, Prions and emerging viruses such as HIV, Avian and swine flu viruses. Medically important fungi and protozoans. **Beneficial applications of microbes:** Human Microflora, Pre and Probiotics, Industrially important microbes.

Unit IV

7 Hours

Control of Microorganism: Control of Microorganism by physical and chemical agents. Narrow and broad spectrum antibiotics, Mode of action of Antimicrobial agents. Antibiotic resistance mechanisms.

Suggested Readings

1. Madigan, M.T., Martinko, J.M., Bender, K., and Buckley, D. (2011) *Brock Biology of Microorganisms*, 13th Ed., Pearson Education, USA
2. Tauro, P., Kapoor, K.K. and Yadav, K.S. (1996). *Introduction to Microbiology*, New Age Pub., New Delhi
3. Pelczar, M.J. et al. (2001), *Microbiology- Concepts and Applications*, International Ed. McGraw Hill Publication, New York
4. Black, J.G. (2012), *Microbiology: Principles and Explorations*, 8 Sons, USA.
5. Willey, J.M., Sherwood, L., and Woolverton, C. (2013) *Prescott's Microbiology* 9th Revised Edition, McGraw Hill Higher Education, New York
6. Pommerville, J.C. (2009) *Alcamo's Fundamentals of Microbiology*, Jones and Bartlett Publishers.
7. Tortora, G.J., Funke, B.R., Case, C.L. (2012) *Microbiology -An Introduction*, Pearson education Pvt. Ltd. Singapore.

Modes of transaction

- Lecture
- Brain storming
- Problem solving

Tools used

PPT, Video, Google Drive

Semester II

Course Code: LMS.513

Course Title: Research Methodology and Biostatistics

Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning Outcomes: Student will be able to:

- Illustrate various aspects of research methods, ethics, technical and scientific writings and literature search.
- Demonstrate the outcome of results using biostatistical approaches in testing hypothesis, designing experiments, analyzing experimental data and interpreting the results.

Course Contents

Unit I

15 Hours

General Principles of Research: Meaning and importance of research, critical thinking, formulating hypothesis and development of research plan, review of literature, interpretation of results and discussion. Scientific writing: writing synopsis, research manuscript and dissertation. Literature search and survey, e-Library, web-based literature search engines. Research presentation and poster preparation.

Unit II

15 Hours

Bioethics and Biosafety: Good Laboratory Practices, Sterilization techniques, Cell and tissue culture techniques: Plants and animals. Biosafety for human health and environment. Biosafety issues for using cloned genes in medicine, agriculture, industry, and ecoprotection. Genetic pollution, Risk and safety assessment from genetically engineered organisms. Ethical theories, Ethical considerations during research, Ethical issues related to animal testing and human project. Intellectual property rights (IPRs), Patents copyrights and Fair use, plagiarism and open access publishing.

Unit III

15 Hours

Overview of Biostatistics: Differences between parametric and non-parametric statistics, Univariant and multivariant analysis. Frequency distribution. Mean, Median, Mode, Probability Distribution, Standard deviation, Variation, Standard error, significance testing and levels of significance, Hypothesis testing. Measures of central tendency and dispersal, Histograms, Probability distributions (Binomial, Poisson and Normal), Sampling distribution, Kurtosis and Skewness.

Unit IV

15 Hours

Statistical Tools: Student's t-test, Paired t-test, Mann-Whitney U-test, Wilcoxon signed-rank, One-way and two-way analysis of variance (ANOVA), Critical difference (CD), Least Significant Difference (LSD), Kruskal-Wallis one-way ANOVA

by ranks, Friedman two-way ANOVA by ranks, χ^2 test. Standard errors of regression coefficients and types of correlation coefficient. Computer application of statistical software, Microsoft Excel as statistical tool, Formatting of excel spreadsheet cells, formula based calculation in excel sheets.

Suggested Readings:

1. Gupta, S. (2005). *Research Methodology and Statistical Techniques*. Deep & Deep Publications (p) Ltd. New Delhi.
2. Kothari, C.R. (2008). *Research Methodology (s)*. New Age International (p) Limited. New Delhi.
3. Fleming, D. O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.
4. Rockman, H. B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.
5. Shannon, T. A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.
6. Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases*. Oxford University Press, UK.
7. WHO (2005). *Laboratory Biosafety Manual*. World Health Organization.
8. Norman, G. and Streiner, D. (2008). *Biostatistics: The Bare Essentials*, Decker Inc. USA, 3rd edition.
9. Myra L. Samuels, Jeff Witmer, Andrew Schaffner (2003). *Statistics for the Life Sciences*. Prentice Hall publishers, 4th edition
10. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*. W.H. Freeman publishers. 3rd edition.
11. Emden, H.V. (2008). *Statistics for Terrified Biologists*. Blackwell publishers.

Modes of transaction

- Lecture
- Demonstration
- Lecture cum demonstration
- Inquiry training
- Panel discussion
- Problem solving
- Self-learning

Course Code: LMS.521
Course Title: Immunology
Total Hours: 45

L	T	P	Cr
3	0	0	3

Learning Outcomes:

After the completion of the course students will be able to:

- Describe the fundamental concepts in immunology using correct scientific terminologies.
- Interpret the concept of specificity in immunology and discrimination of self from non-self in host
- Apply the knowledge in health and disease from an immunological perspective.

Course Contents

Unit I

11 Hours

Immune System: Overview of immune system; cells and organs of immune systems; innate and recognition of self and non-self. Nature of antigen. Components of acquired immunity. Humoral immunity and cell mediated immunity. Immunoglobulins, basic structure, classes and subclasses, structural and functional relationships. Molecular Mechanisms of Antibody Diversity and Cellular Immunity: Organization of genes coding for constant and variable regions of heavy chains and light chains, antibody diversity & class switching.

Complement System: Complement components, their structure and functions and mechanisms of complement activation by classical, alternative and lectin pathway.

Unit II

10 Hours

Functions of Acquired Immunity: Cells of acquired immunity, Th1 and Th2 responses, cytokines, chemokines, interferons, interleukins, antigen recognition-membrane receptors for antigens. Structure and functions of Major Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA) system, polymorphism, distribution variation and function. Association of MHC with disease and superantigen, recognition of antigens by T and B-cells, antigen processing, role of MHC molecules in antigen presentation and co-stimulatory signals.

Unit III

12 Hours

Immunity and Human Diseases: Types of hypersensitivity, features and mechanisms of immediate and delayed hypersensitivity reactions, immunity to bacterial, fungal, viral and protozoan diseases, immunity to tumors, and allergies. Recent advances in vaccine development for diseases like AIDS, hepatitis, cancer and malaria. Vaccine technology- Role and properties of

adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines.

Unit IV

12 Hours

Monoclonal Antibodies and Diagnostic Immunology: Immunotoxins production, characterization and applications in diagnosis, therapy and basic research. Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies. Methods for immunoglobulin determination-quantitative and qualitative antigen and antibody reactions, agglutination-precipitation, immunocytochemistry, radioimmunoassay (RIA), Enzyme Linked Immunosorbent Assay (ELISA), immunofluorescence, immunoblotting and Flow cytometry.

Suggested Readings:

1. Kindt, T. J., Osborne, B.A. and Goldsby, R.A. (2007). *Kuby Immunology* 7th Edition. W.H. Freeman, USA.
2. Abbas. (2008). *Cellular and Molecular immunology*. CBS Publishers & Distributors, India.
3. Charles, A. and Janeway, J.R. (1994). *Immunobiology: The immune system in health and disease*. Blackwell Publishing, USA.
4. Delves, P.J., Roitt, I.M. and Seamus, J.M. (2006). *Roitt's Essential Immunology (Series-Essentials)*. Blackwell Publishers, USA.
5. Elgert K.D. (2009). *Immunology: Understanding the immune system*.
6. Paul, W.E. (1993). *Fundamental Immunology*. Raven Press, SD, USA.
7. Sawhney, S.K. and Randhir, S. (2005). *Introductory practical biochemistry*. Alpha Science International Ltd. New Delhi, India.
8. Tizard (2008). *Immunology: An Introduction*. Cengage Learning, Thompson, USA.

Modes of transaction

- Lecture
- Inquiry training
- Panel discussion
- Problem solving
- Self-learning

Course Code: LMS.522
Course Title: Molecular Biology
Total Hours: 45

L	T	P	Cr
3	0	0	3

Learning Outcomes.

The students will be able to:

- Describe the molecular structure of DNA, RNA and their replication, damage and repair.
- Explain the basic and advanced concepts related to molecular processes in a cell and how they are related to biochemical processes in microbes and higher organisms.
- Propose the applications of molecular biology to societal needs with reference to medicine, industry and agriculture.

Course Contents

Unit I

12 Hours

Structure and Conformation of Nucleic Acids: Structure of DNA, Denaturation and Renaturation, Conformation of nucleic acids (A, B, Z), Organelle DNA. **Genome organization:** Chromosome Structure, Chromatin and its regulation, nucleosome and its assembly, repetitive DNA, interrupted genes, gene shuffling. **DNA replication:** Arrangement of replicons in a genome, various modes of replication, continuous, discontinuous synthesis, various replication enzymes, replication fork and priming, leading and lagging strand, elongation, termination, specific features of replication in prokaryotes and eukaryotes, action of topoisomerases, telomere maintenance and chromatin assembly, single stranded DNA replication, relationship between DNA replication and cell cycle, and DNA copy number maintenance. Molecular biology techniques.

Unit II

12 Hours

Recombination and Repair of DNA: DNA repair and recombination, DNA mismatch repair, Double Strand Break repair, recombination as a molecular biology tool, CRISPR-Cas systems for editing, regulating and targeting genomes.

Transcription and mRNA Processing: Types of RNA, Prokaryotic & eukaryotic transcription, general and specific transcription factors, Regulatory elements and mechanisms of transcription regulation, Transcriptional and posttranscriptional gene silencing: Initiation, Elongation & Termination of transcription, Capping, Polyadenylation, Splicing, editing, mRNA stability, RNA interference and microarray analysis, RNA editing

Unit III

10 Hours

Translation: Genetic code, prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co-and post- translational modifications, mode of action of antibiotics.

Unit IV**11Hours**

Gene Regulation: Prokaryotic – lac, trp, gal and ara operons, lambda gene regulation during lysogeny and lytic cycle; Eukaryotic – yeast, higher eukaryotes, hormonal regulation of genes, epigenetic regulation; Gene network analysis, co-expression.

Suggested Readings:

1. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2014). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.
2. Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. (2014). *Lewin's Genes XI*. Jones & Bartlett Learning, USA.
3. Green, M.R., Sambrook, J. (2012). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
4. Lodish, H, Birk, A, et al. (2016) *Molecular Cell Biology*. 8th ed. WH Freeman.

Modes of transaction

- Lecture
- Problem Solving
- Self-Learning
- Inquiry training
- Co-operative learning
- Team teaching

Tools used

- PPT, Video, Google Drive
- Group discussion

Course Code: LMS.528**Course Title: Medical Microbiology****Total Hours: 60**

L	T	P	Cr
4	0	0	4

Learning Outcomes:

The students will be able to:

- Outline the concept of epidemiology and various cellular processes during disease development.
- Classify the relevance of microbes and diseases caused by bacteria, fungi, protozoa and viruses.
- Comprehend the clinical diagnostics and treatment of the different diseases caused by these microbes.

Course Contents

Unit I

15 Hours

Epidemiology: Concept of epidemic, endemic and pandemic, acute, chronic, morbidity, mortality, prevalence, incidence, Normal microflora of human body and their advantage. **Molecular Basis of Microbial Pathogenesis** Establishment of pathogenic microorganisms: Entry, spread and tissue damage. Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Biofilms and quorum sensing, modulation of apoptotic processes and toxins. Bioluminescence (*Vibrio fischeri*, *Vibrio harveyi*), virulence (*Pseudomonas aeruginosa*, *Staphylococcus*), competence and sporulation (*Bacillus subtilis*) and antibiotic resistance in bacteria. Quorum quenching: impact and mechanism and modulation of apoptotic processes.

Unit II

15 Hours

Introduction and Biology of Pathogenic Bacteria: Important developments in medical microbiology, Morphological characteristics, pathogenesis and laboratory diagnosis including rapid methods of following pathogenic bacteria; *Staphylococcus*, *Streptococcus*, *Enterococcus*, *Escherichia coli*, *Neisseria*, *Klebsiella*, *Salmonella*, *Shigella*, *Vibrio*, *Campylobacter*, *Pseudomonas*, *Acinetobacter*, *Yersinia*, *Treponema*, *Haemophilus*, *Bordetella*, *Bacillus*, *Clostridium*, *Corynebacterium*, *Mycobacterium*, *Actinomyces*, *Nocardia*, *Fusobacterium*, *Listeria*, *Rickettsiae*, *Chlamydiae*, *Spirochetes*.

Unit III

15 Hours

Pathogenic Fungi: Morphological characteristics, pathogenesis and laboratory diagnosis of following pathogenic fungi: *Microsporium*; *Trichophyton*; *Histoplasma capsulatum*; *Blastomyces dermatitidis*; *Candida albicans*; *Cryptococcus neoformans*; *Pneumocystis carinii*, *Aspergillus spp.*

Protozoal Pathogens: General description, biological properties and diseases caused by Protozoa- *Plasmodium spp*, *Giardia intestinalis*, *Trypanosoma spp*, *Leishmania spp*, *Entamoeba histolytica*.

Unit IV

15 Hours

Mechanism of Antibiotic and Resistance: Mode of action of antibiotics and chemotherapeutic drugs: inhibitors of cell wall synthesis, Protein Synthesis, Nucleic Acid Synthesis and Metabolism, Antibiotic sensitivity assays, Antibiograms. Antibiotic resistance in bacteria-various molecular factors that contribute to the development of resistance, Monoclonal antibodies as therapeutic agents to resistance bacteria. Nosocomial Infection and its treatment.

Suggested Readings:

1. Atlas, R.M. (1994) Principles of Microbiology, McMillan, New York
2. Tortora, G.J., Funke, B.R., Case, C.L. (2004) Microbiology -An Introduction, Pearson education Pvt. Ltd. Singapore.

3. Madigan, M.T., Martinko, J.M., Bender, K., and Buckley, D. (2011) *Brock Biology of Microorganisms*, 13th Ed., Pearson Education, USA.
4. Jawetz, Melnick, & Adelberg (2016) *Medical Microbiology* by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. Lange Publication.
5. Locht C and Simonet M, Caister (2012) *Bacterial Pathogenesis: Molecular and Cellular Mechanisms* by Academic Press.
6. Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. (2016) *Molecular Microbiology: Diagnostic Principles and Practice*. American Society for Microbiology Press.
7. Nelson KE and Williams CM (2019) *Infectious Disease Epidemiology: Theory and Practice*. Jones and Bartlett.
8. Mahon, Connie R. Lehman, Donald C. Manuselis, George (2007) *Textbook of Diagnostic Microbiology*. USA: Saunders.
9. World Organization for Animal Health: “*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*” Volumes I & II, 6th Edition, 2010.
10. Rao, Juluri R, Fleming, Colin C., Moore, John E., (2006) *Molecular Diagnostics: current technology and Applications*. Horizon Bioscience, U. K.

Course Code: LMS.523

Course Title: Virology

Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning outcomes:

After the course the student will be able to:

- Describe the structure, function, life cycle and pathogenicity of the most important and emerging viral pathogens of clinical importance
- Explain the general principles to prevent and treat viral infections.
- Describe the methodological principles and problems relating to diagnostics, vaccines and surveillance of infectious agents and their spreading.
- Critically evaluate the advantages and disadvantages different types of antiviral drugs and antiviral strategies.
- Independently search, compile, evaluate and critically interpret relevant scientific literature and information, based on a given issue, and critically analyse methods, and interpret results.

Unit I

15 Hours

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, Viral genomic organization, structure and replication. Bacteriophages and their replication. Virus related agents: Prion and viroids

Unit II**15 Hours**

Viral Infection and Pathogenesis: Determinants of tissue tropism, penetration and uncoating, biosynthesis of genetic material, maturation, release, and transmission of infection, host defense, innate immune response and adaptive immune response. **Emerging Viral Diseases:** Herpesvirus, Influenza virus, Hepatitis Viruses, Coronaviruses, Retroviruses and Flaviviruses.

Unit III**15 Hours**

Oncogenic viruses: oncogenic DNA and RNA viruses, viral transformation by activation of cellular signal transduction pathways, viral transformation via cell cycle control pathways. Viruses as therapeutic agents.

Unit IV**15 Hours**

Viral Chemotherapy and Vaccine: Fusion or entry inhibitors, Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors: mechanism of action and drug resistance. Recent advances in development of antiviral vaccine. **Diagnosis and methods in virology:** Protein detection, nucleic acid detection, hemagglutination. Cultivation of viruses: Tissue culture and animal models. Quantification of viruses: Plaque assay and end point dilution assay. Purification of viruses. Plaque isolation.

Suggested Readings:

1. *Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses* by S.J. Flint, L.W. Enquist, V.R. Racaniello, A.M. Skalka. 4th edition. ASM Press. 2015.
2. Dimmock N., Easton A., Leppard K (2016) *Introduction to Modern Virology*. Blackwell Publishing.
3. Wanger, K. Hewlett M., Bloom D., Camerini D. (2007). *Basic Virology* Blackwell Publishing.
4. Cann AJ (2015) *Principles of Molecular Virology*. Elsevier Academic Press.

Modes of transaction:

- Lecture
- Demonstration
- Lecture cum demonstration
- Inquiry training

Course Code: LMS.527

Course Title: Microbiology Practical-II

Total Hours: 90

L	T	P	Cr
0	0	6	3

Learning Outcomes:

The students will be able to:

- Plan experiments related to clinical microbiology and virology which will enhance their laboratory skills, and scientific knowledge.
- Distinguish between various types of microbial media, culturing methods,
- Inspect and isolate the microbes from the day to day sources.

Course Contents

1. Preparation of Media: Nutrient broth, Nutrient agar, plates, slants, soft agar; Pure culture technique: Streak plate, spread plate and pour plate methods.
2. Staining methods: Simple staining, Negative Staining, Gram Staining, Acid-Fast stain.
3. Culturing methods of microbes – slant and stab cultures, tube culture, flask cultures, shake flask cultures
4. Methods for studying microbial respiration
5. Preparation of different types of culture media/observation. Blood Agar, Chocolate Agar, Mannitol salt agar, Blair Parker medium, MacConkey agar, Lowenstein-Jensen medium, Wilson Blair Bismuth sulphite medium, Biochemical media.
6. Tests for disinfectants (Phenol coefficient/RWC)
7. Study of normal micro-biota of mouth; isolation, identification and preservation of microorganisms
8. Study of normal micro-biota of skin; isolation identification and preservation of microorganisms
9. Identification and Biochemical tests of respiratory tract bacterial pathogen using avirulent strain of MTCC Culture of *Streptococci/ Klebsiella pneumoniae*.
10. Identification and Biochemical tests of gastrointestinal bacterial infection using avirulent strain of MTCC Culture of *Salmonella / Shigella* spp.
11. Laboratory examination and identification and biochemical tests of pus specimens using avirulent strain of MTCC Culture for *Staphylococcus aureus*, *Streptococcus pyogenes* and *Pseudomonas aeruginosa*.
12. Laboratory examination of sputum: Collection of sputum. Microbiological examination of sputum for pus cells and predominant bacteria. Ziehl-Neelsen staining to detect the presence of Mycobacterium using avirulent strain of MTCC Culture.
13. Determination of MIC values for antimicrobial chemicals
14. Identification of pathogenic bacteria (any three of *E. coli*, *Salmonella*, *Pseudomonas*, *Staphylococcus*, *Bacillus*) based on cultural, morphological and biochemical characteristics.

15. Biochemical, enzymatic and serological tests (Coagulase, Catalase, WIDAL, VDRL tests).
16. PCR based diagnosis.
17. Estimation of infectivity titer of a virus sample using Plaque assay.
18. Production of a purified virus stock and its quantitation.

Practical may be modified depending on available faculties/facilities.

Modes of transaction

- Lecture cum demonstration
- Problem Solving
- Self-Learning
- Inquiry training
- Experimentation

Evaluation Criteria for Practical Courses: Students are evaluated for a total of 100 marks with following distribution:

Continuous assessment- 60 Marks: Maintaining the lab records/notebooks, continuous assessment, attendance during day to day practical.

Final Practical Examination- 40 Marks: Minor Experiment, Major Experiment (to be performed) and viva-voce.

Suggested Readings:

1. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory.*
2. *Laboratory protocols in Applied Life Sciences* (2014). Taylor & Francis Group, LLC
3. *Laboratory Exercises in Microbiology*, 10th Edition by John Harley
4. Benson, *Microbiological Applications Lab Manual*, Eighth Edition
5. James G. Cappuccino & Natalie Sherman (2014) *Microbiology: A Laboratory Manual*, 10th Edition 2014
6. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology.*
7. Alberts, B. Bray, D. Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell.* Garland publishers, Oxford.
8. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual.* Cold Spring Harbor Laboratory Press, New York.
9. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology.* CRC Press, Taylor and Francis Group, UK.

Course Code: LMS.528

Course Title: Microbiology Practical -III

Total Hours: 90

L	T	P	Cr
0	0	6	3

Learning Outcomes:

The students will be able to:

- Outline the basic molecular biology, cell culture and immunological techniques and correlate them with their fundamental concepts in the subject
- Assess the use of molecular biology, cell culture and immunological techniques in health and diseases,
- Elaborate the molecular biology techniques and their application to study bacterial and mammalian cells, cellular DNA, RNA, proteins along with different aspects of immune processes.

Course Contents

Part A. Immunology

1. To perform Total Leukocyte Count of the given blood sample.
2. To perform Differential Leukocyte Count of the given blood sample.
3. Separation of serum from blood.
4. Double immunodiffusion test using specific antibody and antigen.
5. To perform immunoelectrophoresis using specific antibody and antigen.
6. Dot Immuno blot assay (DIBA).
7. ELISA
8. Polyacrylamide gel electrophoresis and Western blotting.
9. Isolation of mononuclear cells from peripheral blood and viability test by dye exclusion method.
10. Growth and maintenance of cell lines.
11. Trypsinization method for recovery of cells from monolayer.
12. Cytotoxic assay method for a given cell line and testing by trypan blue dye exclusion method.
13. Demonstration of Flow Cytometry.
14. Immunohistochemistry: H & E staining, Fluorescent staining, Fluorescent Microscopy, Confocal Microscopy

Part B. Molecular Biology

1. Isolation of genomic DNA
2. DNA amplification by Polymerase Chain Reaction (PCR).
3. Ligation and E.coli transformation using chemical transformation, plating, colony selection,
4. Isolation of plasmid DNA, restriction enzyme digestion and agarose gel electrophoresis.
5. Construction of restriction map by single and double digestion, Designing DNA probe,
6. Southern blot hybridization (demonstration only).

7. RNA isolation from biological samples.
8. cDNA synthesis and real time PCR (qPCR).
9. DNA sequencing (demonstration only).
10. NCBI BLAST search and Primer design.
11. Multiple Sequence Alignment and Phylogenetic analysis using MEGA
12. Determination of genes mapped within a specific chromosomal locus using GeneLoc integration resource and gene orthologue prediction using Ensembl.
13. Protein-protein interactions using STRING; Introduction to KEGG and Metacyc databases

Practical may be modified depending on available faculties/facilities.

Modes of transaction

- Lecture cum demonstration
- Problem Solving
- Self-Learning
- Inquiry training
- Experimentation
- Team teaching

Tools used

PPT, Video, Google Drive

Software tools

BLAST, MEGA

Evaluation Criteria for Practical Courses: Students are evaluated for a total of 100 marks with following distribution:

Continuous assessment- 60 Marks: Maintaining the lab records/notebooks, attendance during day to day practical.

Final Practical Examination- 40 Marks: Minor Experiment, Major Experiment (to be performed) and viva-voce.

Suggested Readings:

1. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory*.
2. *Laboratory protocols in Applied Life Sciences* (2014). Taylor & Francis Group, LLC
3. *Laboratory Exercises in Microbiology*, 10th Edition by John Harley
4. Benson, *Microbiological Applications Lab Manual*, Eighth Edition
5. James G. Cappuccino & Natalie Sherman (2014) *Microbiology: A Laboratory Manual*, 10th Edition 2014
6. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology*.

7. Alberts, B. Bray, D. Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell*. Garland publishers, Oxford.
8. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.
9. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK

Course Code: LMS. 530

Course Title: Introduction to Immune system

Total Hours: 30

L	T	P	Cr
2	0	0	2

Learning Outcomes:

The students will be able to:

- Instill awareness on very basics of immune system
- Identify the components of the human immune response that work together to protect the host.

Unit I

7 Hours

Elements of Immune system: Cells, Organs, and microenvironments of the immune system. Innate and adaptive immunity, cellular and humoral immunity, inflammatory and regulatory networks and small biochemical mediators (cytokines).

Unit II

8 Hours

Function of immune system: Discriminate between self and non-self. A functional immune system confers a state of health through effective elimination of infectious agents (bacteria, viruses, fungi, and parasites) and through control of malignancies by protective immune surveillance.

Unit III

7 Hours

Immunodeficiency and dysfunction as the basis of disease: Immune Deficiency and Immune dysfunction. Allergies, Types of hypersensitivity reactions. Immunity to microbes, tumors and AIDS.

Unit IV

8 Hours

Immunological Processes and Therapeutics: Hybridoma technology and vaccine, natural, synthetic and genetic, development of vaccine. Methods for immunoglobulin determination-quantitative and qualitative antigen and antibody reactions, agglutination-precipitation, immunofluorescence ELISA and Flowcytometry.

Suggested Readings:

1. Abbas. (2010). *Cellular and Molecular Immunology*. CBS Publishers & Distributors, India.
2. Charles, A. and Janeway, J. R. (1994). *Immunobiology: The Immune system in health and disease*. Blackwell Publishing, USA.
3. Delves, P. J., Roitt, I. M. and Seamus, J. M. (2011). *Roitt's essential immunology (Series– Essentials)*. Blackwell Publishers, USA.
4. Elgert, K. D. (2009). *Immunology: Understanding the immune system*. Wiley-Blackwell, USA.
5. Kindt, T. J., Osborne, B. A. and Goldsby, R. A. (2007). *Kuby Immunology* 7th Edition. W. H. Freeman, USA.
6. Sawhney, S. K. and Randhir, S. (2005). *Introductory practical biochemistry*. Alpha Science International Ltd. New Delhi, India.
7. Tizard. (2009). *Immunology: An Introduction*. Cengage Learning, Thompson, USA

Modes of transaction

- Lecture
- Problem Solving
- Inquiry training
- Team teaching

Semester – III**Course Code: LMS.551****Course Title: Industrial Microbiology****Total Hours: 45**

L	T	P	Cr
3	0	0	3

Learning Outcomes:

The students will be able to:

- Summarize the use of microorganisms for the value added products through fermentation and other large scale processes.
- Apply the upstream and downstream processes in the large scale production of several primary and secondary metabolites of microbial origin
- Apply the knowledge of basic industrial microbiology in actual research and industry.

Course Contents

Unit I

12 Hours

Introduction: Scope and historical development; Sources of industrially important microbes, strain development, types of fermentation and fermenters, process optimization, and recent developments in fermentation technology. Types of fermentation systems; Bioreactor designs and operations.

Downstream processing of microbial products: Filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane processes, drying (lyophilization and spray drying), and crystallization. Types of fermentation systems; Bioreactor designs and operations.

Unit II

12 Hours

Microbes in Industry: 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. Production of vitamins: Vitamin B12 (Cyanocobalamine) production; Riboflavin (vitamin B2) production.

Unit III

10 Hours

Secondary Metabolites in Microbes: Organic Metabolites-Ethanol, Acetone; Citric acid, Acetic acid, Lactic acid, Gluconic acid, Itaconic acid, Amino acids; Enzymes- Amylases, Glucose Isomerase, L Asparaginase, Proteases, Renin, Penicillin acylases, Lactases, Pectinases, Lipases; Vitamins- Vitamin B12, Riboflavin, B carotene; Antibiotics: beta-Lactam antibiotics; Amino acid and peptide antibiotics; Carbohydrate antibiotics; Tetracycline and antracyclines; Nucleoside antibiotics; Aromatic antibiotics.

Unit IV

11 Hours

Metabolic Engineering of Plants & Micro-organisms: Introduction to metabolic engineering: Concept and importance of metabolic engineering, basic enzyme kinetics, metabolite regulation of metabolic pathways, basic metabolic control analysis (MCA), metabolic fluxes and basic flux balance analysis (FBA), Applications of MCA and FBA for the improvement of microbial strains and plant cells fermentation processes.

Suggested Readings :

1. Cruger W and Cruger A. (2004). *Biotechnology - A Textbook of Industrial Microbiology*. Panima.
2. Kun LY. (2006). *Microbial Biotechnology*. World Scientific.
3. Marwaha, S.S. and Arora, J.K. (2000), *Food Processing: Biotechnological Applications*, Asia Tech Publishers Inc., New Delhi.
4. Lee, B.H. (1996), *Fundamental of Food Biotechnology*, VCH Publishers.
5. Joshi, V.K. and Pandey, A. (1999), *Biotechnology: Food Fermentation* Vol. 1 & 2, Education Publisher and Distributor, New Delhi.
6. Stephanopoulos. (1998). *Metabolic Engineering: Principles & Methodologies*, Published by cbspd
7. Sang Yup Lee, E. Terry Papoutsakis. (1999). *Metabolic Engineering*, CRC Press.
8. Allan Whitaker, Peter F. Stanbury, and Stephen J. Hall (2014) *Principles of Fermentation Technology*.
9. Gary Higton, Michael J. Waites, Neil L. Morgan, John S. Rockey (2001) *Industrial Microbiology: An Introduction*.

Modes of transaction :

- Lecture
- Demonstration
- Lecture cum demonstration
- Inquiry training
- Group discussion

Course Code: LMS.552**Course Title: Food and Dairy Microbiology****Total Hours: 45**

L	T	P	Cr
3	0	0	3

Learning Outcomes:

The students will be able to:

- Identify the microbiology of food and dairy products
- Explain the food spoilage and preservation methods.
- Propose the industrial aspect of dairy microbiology.
- Provide solution for pathogenic and spoilage microorganisms associated with different foods and their commercial importance.

Course Contents**Unit I****11 Hours**

Microbiology of Food: Microbial habitat of specific food materials, adaptations and changes in microbiome of vegetables, fruits, milk, fermented and non-fermented milk products, fresh meats, poultry and non-dairy fermented foods. Microbial spoilage of foods: Types and causes of spoilage of cereals and cereals

products, spoilage of vegetables and fruits, spoilage of meat and meat products, spoilage of fish and other sea foods, spoilage of eggs and other poultry products, spoilage of milk and milk products.

Unit II

13 Hours

Microbial Growth in Food: Intrinsic, extrinsic and implicit factors, Microbial interactions, Inorganic, organic and antibiotic additives. Physical and chemical factors influencing the destruction of microorganisms including thermal death time, Z, F and D values. **Modern Methods of Cell Culture:** synchronous and co-cell culture, continuous cell culture in liquid and solid media, Cell immobilization and applications, Pre and probiotics cultures and its benefits. Probiotic bacteria in foods. **Food Borne Diseases:** Importance and significance of microorganisms in food. Food borne diseases- Bacterial food borne diseases- (Staphylococcal intoxication, Botulism, Salmonellosis, Shigellosis, EPEC Diarrhoea, Clostridium Perfringens gastroenteritis, Bacillus cereus gastroenteritis; Food-borne fungi- Mycotoxins- Aflatoxicosis, Mycotoxicosis, Ergotism.

Unit III

11 Hours

Fermented and Dairy Food Products: Microorganisms involved in food fermentations. Starter cultures for fermented dairy products (*Streptococcus thermophilus*, *Lactobacillus bulgaricus*). Fermented milk products- Acidophilus and Bulgarian milk, yoghurt, cheese, Kefir, Koumiss; Fermented grains and vegetable products - Sauerkraut, Soy sauce, Tempeh, Miso, and Kimchi; Single cell protein, Role of microorganisms in beverages – tea and coffee fermentations. Vinegar Fermentation.

Unit IV

10 Hours

Food Preservation and Safety: Use of High and low temperature, Control of water activity, Use of Radiations in preservation, Modified atmosphere packaging, High pressure processing, chemical preservatives and naturally occurring antimicrobials; Bacteriocins and their applications. Microbial testing of food, Microbiological quality standards of food and regulatory bodies: FDA (Food and Drug Administration), HACCP (Hazard Analysis and critical control points), FSSAI (Food Safety and Standards Authority of India).

Suggested Readings:

1. Ray, B. and Bhunia, A. (2013). *Fundamental Food Microbiology*, 5th revised edition. CRC press Inc.
2. Frazier, W.C. and Westhoff, D.C. (2013). *Food Microbiology*. 5th Ed. Tata McGraw Hill.
3. Doyle, M.P. and Buchanan, R.L. (2012), *Food Microbiology*, ASM Press, Washington.
4. Jay, J.M., Loessner, M.J. and Golden, D.A. (2005) *Modern Food Microbiology*, 7th ed. Springer-Verlag New York

5. Richard K. Robinson, (2002). Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, Wiley-Blackwell; 3rd Edition.
6. Doyle, M. P. and Beuchat, L. R., 2007, Food Microbiology- Fundamentals and Frontiers, ASM Press.
7. Elmer H. Marth, James Steele, (2001). Applied Dairy Microbiology, Second Edition, CRC Press.

Modes of transaction:

- Lecture
- Demonstration
- Lecture cum demonstration
- Inquiry training
- Group discussion
- Self-learning
- Field visits

Course Code: LMS. 562

Course Title: Environmental Microbiology

Total Hours: 45

L	T	P	Cr
3	0	0	3

Learning Outcomes:

The students will be able to:

- Identify how microbes interact in the environment.
- Categorize the composition of industrial waste water and xenobiotics, and their treatment using microorganisms.
- Utilize this knowledge in small house hold set up or in large scale industrial remedial set ups.

Unit I

10 Hours

Environment and Ecosystem: Biotic and abiotic environment. Environmental segments. Composition and structure of environment. Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Food chains, food webs and trophic structures. Ecological pyramids.

Unit II

12 Hours

Microbiology of Waste-water: Concepts C-BOD, N-BOD and COD, Oxygen-sag curve. General characteristics of industrial waste-water coming from sugar industries, tanneries, paper-pulp and alcohol industries. Disinfection of drinking water with anti-microbial agents. Coliform test of potable water. Primary treatment of wastewater, treatment of industrial effluent by aerobic treatment methods; Tricking filters, and Oxidation ponds. Methods of anaerobic treatment of sludge. Bioaccumulation of heavy metal ions from industrial

effluents. Removal of nitrogen and phosphorous and volatile organic matter from water. Water borne risk to human health.

Unit III

12 Hours

Microbial Toxicology: General chemistry of pollutants. Particulate matter, poly-aromatic hydrocarbons, organosulfur, organophosphorous, organohalides, organonitrogen, organometallic compounds. Fog and smog, acid rain Dose-response relationship, Determination of LD50, Effect of heavy metals, pesticides on the microbial population in air, water and soil. Ames test to determine the genotoxicity of toxicants. Mode of action of carcinogens, Microbial tolerance and resistance against heavy metals, antibiotics and pesticides.

Unit IV

11 Hours

Degradation of Xenobiotics: Concepts of xenobiotics, bio-concentration and bio-magnification, Bio-transformation and biodegradation of xenobiotics like organophosphates and organohalides compounds, plastic, paints. Genetically Modified Organisms released and its environmental impact assessment and ethical issues.

Suggested Readings:

1. Baker, K.H. And Herson D.S. (1994). *Bioremediation*. MacGraw Hill Inc. N.Y.
2. E Eldowney, S. Hardman D.J. and Waite S. (1993). *Pollution: Ecology and Biotreatment* Longman Scientific Technical.
3. R. K. Trivedy (1998) *Advances in Waste Water Treatment Technologies*. Volumes II and I. Global Science Publication.
4. Lawrence, P., Wacekett, C. and Douglas Hershberger. (2000) *Biocatalysis and Biodegradation: Microbial transformation of organic compounds*. ASM Publications.
5. Christon J. Hurst (2001). *A Manual of Environmental Microbiology*. 2nd Edition. ASM Publications.
6. Ian Pepper, Charles Gerba, Terry Gentry (2014) *Environmental Microbiology* 3rd Edition; Academic Press.
7. N.S. Subba Rao. (1995). *Bio-fertilizers in Agriculture and Forestry*.

Modes of transaction :

- Lecture
- Demonstration
- Lecture cum demonstration
- Inquiry training
- Group discussion
- Field visits

Course Code: LMS.561

Course Title: Genetic Engineering and Recombinant DNA Technology

L	T	P	Cr
4	0	0	4

Total Hours: 60

Learning Outcomes:

The students will be able to:

- Apply the versatile tools and techniques of genetic engineering in basic and applied fields of biological research.
- Identify the application of basic molecular biology in manipulating and modifying genetic material, cells and organisms.
- Utilize the acquired knowledge in a setting of Medical Biotechnology, Industrial Biotechnology, and Agricultural Biotechnology.

Course Contents

Unit I

15 Hours

Tools of Genetic Engineering: Restriction enzymes, Enzymes in genetic engineering, Cloning vectors, Expression vectors & their biology (Plasmid Vectors, Vectors based on Lambda Bacteriophage, Cosmids, M13 Vectors, Expression Vectors, Vectors for Cloning Large DNA Molecules), Transformation and transfection. Selection, genomic and cDNA library construction & DNA-sequencing techniques, Site-directed mutagenesis. **Cloning and Expression Systems:** Artificial chromosome vectors (YACs, BACs), Animal virus derived vectors. Cloning in *E. coli*, Gram-positive bacteria, Streptomyces, *Saccharomyces Cerevisiae*, *Pichia pastoris*, Insect Cells and Mammalian Cells. Expression system, Fusion proteins, Transcriptional & Translational Fusions, Adding Tags and Signals.

Unit II

15 Hours

Genetic Manipulation and Over expression of Recombinant Proteins: Basics of different types of PCR, Model organisms, Genetically modified plants and animals, Creating Transgenics, Knockouts, Knockdowns, RNAi technology, CRISPR technology. Generation of Transient and stable cell lines. Functional genomics: Forward and reverse Genetics. Overexpression and tagging of recombinant proteins in *E.coli*, driven by lac, T7 and Tet-regulatable promoters, Expression in *B. subtilis*. Overexpression systems in *S.cerevisiae*, *P.pastoris*, *S.pombe* and *K.lactis*. Baculovirus overexpression system. Mammalian cell overexpression system.

Unit III

15 Hours

Transcriptional Analysis of Gene Expression and Transcriptomics: Gene expression analysis by Northern Blotting, RT-PCR, EST analysis and the use of reporter genes. Enzymatic and bioluminescent reporters. Reporters used in protein localization and trafficking studies. Promoter analysis – deletion analysis and linker scanning analysis coupled to reporter assays, mapping transcriptional

start sites by S1 nuclease mapping, primer extension studies or 5' RACE. Transcriptome analysis by DD-PCR and EST analysis, DNA microarrays (cDNA arrays and oligo arrays), Serial Analysis of Gene Expression (SAGE), RNA-sequences.

Unit IV

15 Hours

Techniques and Applications of Recombinant DNA Technology: Analysis of protein-DNA and protein-protein interactions, protein engineering and proteome analysis: Gel retardation assay, DNA footprinting by DNase I and chemical methods, yeast one-hybrid assay, ChIP- chip, ChIP-seq. Yeast two hybrid, three-hybrid, split hybrids and reverse hybrid. Co-immunoprecipitation, pull-down, far-western. Use of GFP and its variants in FRET analysis, use of BiFC. Phage display. Insertional and deletion mutagenesis. Site directed mutagenesis by conventional and PCR-based methods. Proteome analysis by 2D gel electrophoresis coupled to mass spectrometric analysis. Principles and used of MALDI-TOF and LC-MS platforms. PMF verses MS/MS. Protein arrays and their applications. Vaccines, Metabolic Engineering and Protein Engineering: Enzymes, Antibiotics, Therapies for Genetic Diseases, Bioremediation. Biosafety and Ethical considerations in rDNA and genetic engineering.

Suggested Readings:

1. Glick BJ, Pasternak JJ, Patten CL. (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA*. 4th edition, American Society for Microbiology
2. Kurnaz IA. (2015) *Techniques in Genetic Engineering*. 1st edition, CRC Press.
3. Primrose SB, Twyman R. (2006) *Principles of Gene Manipulation and Genomics*. 7th edition, Wiley-Blackwell.
4. Green MR, Sambrook J. (2012). *Molecular cloning: A laboratory manual*. 4th edition, Cold Spring Harbor Laboratory Press, New York.

Modes of transaction

- Lecture
- Problem Solving
- Self-Learning
- Inquiry training
- Team teaching

Course Code: LMS.563

Course Title: Introduction to Cell and Tissue Culture

Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning Outcomes:

The students will be able to:

- Outline the background of animal tissue culture.
- Execute this knowledge in other fields and planning projects in the fields of molecular biology and biotechnology.
- Design the cell culture based experiments in a research setting as well as industrial setting with a thorough clarity in the basic principles.

Course Contents

Unit I

12 Hours

Introduction to Animal Cell culture: Basics terms and definitions, historical background, Importance of animal cell culture technology, laboratory facilities-design, equipments and safety parameters, waste disposal in a cell culture set-up. Aseptic techniques for animal cell cultivation.

Unit II

18 Hours

Cell Culture Technology: Basic requirement for growing animal cells - Cell culture reagents, media preparation and their types. Maintenance of cell culture: Culturing, sub-culturing, passaging, cell metabolism during culture, Cell culture types: primary and continuous culture, *in vitro* transformation of animal cells, anchorage-dependence, monolayer and suspension culture, normal cells and transformed cells. Scaling up- techniques for cells in suspension and in monolayer. Cell line preservation and authentication. Contamination check and prevention: bacterial, yeast, fungal, mycoplasma, viral testing

Unit III

15 Hours

Study of Biological system using Cell Culture Techniques: Functional assays based on cell culture: Cell morphology, Quantitation, Growth pattern, DNA content and cell cycle, Cytotoxicity assays, Study of Cell Death: senescence, apoptosis and necrosis, Cell proliferation, Cell viability measurements, Karyotype analysis, FISH. Immunolabeling of cells to study molecular expression pattern- Microscopy, Flow-cytometry, Cytospin, Immunohistochemistry, Transfection, Transient, stable cell line generation and Gene Silencing.

Unit IV

15 Hours

Cell and Tissue culture- Trends and Breakthroughs: Hybridoma technology for monoclonal antibody production, production of genetically-engineered cells and their applications, use of cell cultures in the production of biologicals, Insect Cell Culture and its application., Types of stem cells, current stem cell therapies, stem cells in heart, brain and spinal cord regeneration and regenerative medicine

Regenerative Medicine: Tissue engineering, Three-dimensional culture, multicellular tumour spheroids (MCTS)-mono and co-cultures, re-aggregate organ cultures, drug testing *in-vitro*. Nanotechnology.

Suggested Readings:

1. Michael Butler, *Animal Cell Culture and Technology*. BIOS Scientific Publishers
2. John R.W. Masters, *Animal Cell Culture-A Practical Approach*. Oxford University Press
3. R. Ian Freshney, *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications*.
4. Trent, R. J. (2010). *Molecular Medicine, Genomics to Personalized Healthcare*. Academic Press

Modes of transaction

- Lecture
- Self-Learning
- Group discussion
- Team teaching
- Experimentation

Course Code: LMS.529

Course Title: Microbiology Practical –IV

Total Hours: 150

L	T	P	Cr
0	0	10	5

Learning Outcomes:

The students will be able to:

- Conduct experiments pertaining to the theory papers of industrial and environmental microbiology and food and dairy microbiology.
- Apply these observations and scientific ideas in the real life microbiology associated tribulations.

Course Contents

1. Microbiological examination of fresh and canned foods, mushrooms, spoiled foods and fruits, milk and milk products
2. Microbiological quality testing of milk (MBRT test)
3. Isolation of toxin producing organisms and estimation of their toxins in different foods
4. Extraction of Mycotoxins from contaminated food.
5. Isolation of bacterial and fungal probiotics
6. Development of probiotics *in vitro*.
7. To study various food preservation methods.

8. Standard method for bacteriological water analysis: Presumptive, confirmatory and completed test.
9. Microbial growth studies.
10. Isolation of industrially important microorganisms for microbial processes (citric / lactic/ alpha amylase) and improvement of strain for increasing yield by mutation.
11. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
12. Extraction of Citric acid/Lactic acid by salt precipitation.
13. Monitoring of dissolved oxygen during aerobic fermentation
14. Biomass production (Baker's yeast and *Spirulina*).
15. Production of beverages (alcohol and wine).
16. Estimation of the fermentation products by titration Method
17. Isolation of food poisoning bacteria from contaminated foods, Dairy products
18. Production of fermented milk by *Lactobacillus acidophilus*.
19. Physical analysis of sewage/industrial effluent by measuring total solids, total dissolved solids and total suspended solids.
20. Determination of indices of pollution by measuring BOD/COD of different effluents.
21. Bacterial reduction of nitrate from ground waters
22. Isolation and purification of degradative plasmid of microbes growing in polluted environment.
23. Recovery of toxic metal ions of an industrial effluent by immobilized cells.
24. Utilization of microbial consortium for the treatment of solid waste [Municipal Solid Waste].
25. Biotransformation of toxic chromium (+ 6) into non-toxic (+ 3) by *Pseudomonas* species.
26. Tests for the microbial degradation products of aromatic hydrocarbons /aromatic compounds.
27. Reduction of distillery spent wash (or any other industrial effluent) BOD by bacterial cultures.
28. Microbial dye decolorization/adsorption.

Practical may be modified depending on available faculties/facilities.

Modes of transaction

- Lecture cum demonstration
- Problem Solving
- Self-Learning
- Inquiry training
- Experimentation

Evaluation Criteria for Practical Courses: Students are evaluated for a total of 100 marks with following distribution:

Continuous assessment- 60 Marks: Maintaining the lab records/notebooks, attendance during day to day practical.

Final Practical Examination- 40 Marks: Minor Experiment, Major Experiment (to be performed) and viva-voce.

Suggested Readings:

1. Michael J. Leboffe (2011) *A Photographic Atlas for the Microbiology laboratory.*
2. *Laboratory protocols in Applied Life Sciences* (2014). Taylor & Francis Group, LLC
3. *Laboratory Exercises in Microbiology*, 10th Edition by John Harley
4. Benson, *Microbiological Applications Lab Manual*, Eighth Edition
5. James G. Cappuccino & Natalie Sherman (2014) *Microbiology: A Laboratory Manual*, 10th Edition 2014
6. Aneja KR (2014) *Laboratory Manual of Microbiology and Biotechnology.*
7. Alberts, B. Bray, D. Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell.* Garland publishers, Oxford.
8. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual.* Cold Spring Harbor Laboratory Press, New York.
9. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology.* CRC Press, Taylor and Francis Group, UK.

Course Code: LMS.543

Course Title: Seminar I

Total Hours: 15

L	T	P	Cr
0	0	0	1

Learning Outcomes:

The students will be able to:

- Present the recent scientific articles on microbiology and associated fields.
- Augment their understanding about current research topics and recent advances of microbiology
- Justify the scientific writing, communication and presentation skills.

Evaluation Criterion: The student selects an advanced topic in Microbiology and related fields based on recent literature available and recent advances on the topic.

Continuous Assessment: 50 Marks: Attendance and interaction with teachers for the preparation of the seminar.

End Term Assessment: 50 Marks: Presentation of approximately 20 minutes and report to be submitted. Students are evaluated based on presentation and written report.

Modes of transaction

-Lecture

- Self-Learning
- Group discussion
- Team teaching

Course Code: LMS.599

Course Title: Project

Total Hours: 180

L	T	P	Cr
0	0	0	6

Learning Outcome:

The students will be able to:

- Organize extensive review of literature.
- Apply various search engines and websites to identify the area of their research interest.
- Formulate the hypothesis and work plan with scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology.

Evaluation Criteria

The evaluation will be on the basis of satisfactory and non-satisfactory where satisfactory will be based on the performance of the student as Excellent, Very good, Good, Average whereas student will be given non-satisfactory when their performance is below average.

The criteria for the performance will be:

Continuous Assessment: Based on attendance, punctuality and literature survey

End Term Assessment based on:

1. Extensive review of literature
2. Progress work
3. Presentation

Modes of transaction

- Self-Learning
- Group discussion
- Problem solving
- Seminars
- Experimentation

Course Code: LMS.504

Course Title: Ethics for Science (VAC)

Total Hours: 30

L	T	P	Cr
0	2	0	1

Learning Outcomes:

Students from inter-disciplinary background will be able to:

- Illustrate the basic good practices to be followed in research and overall as a student.
- Formulate Classify the principles ethics in research which will help them to understand the set of conduct norms applied in science.
- Interpret the ethical issues involved in human, animals and plants research.
- Judge the misconduct, fraud and plagiarism in research.

Unit I

6 Hours

Introduction and Basic Principles of Ethics: Ethical theories, Ethical considerations during research, Data Manipulations. Ethical review procedure and committees

Unit II

8 Hours

Ethics in Basic and Applied Sciences: Ethics in cloning, recombinant technology, Genetically Engineered Organisms and r-DNA based products. Animal Testing. Animal Rights, Perspectives and Methodology.

Unit III

8 Hours

Principles of Ethics in Clinical and Medical Sciences: Code of Ethics in Medical/clinical laboratories. Healthcare rationing, Ethical Issues of Xeno-transplantation, Ethics involved in embryonic and adult stem cell research, Ethics in assisted reproductive technologies: animal and human cloning and *In-vitro* fertilization. Ethical issues in MTP and Euthanasia. Types of consents and Human Genome project.

Unit IV

8 Hours

Ethics in Research: Intellectual property rights (IPRs), Patents copyrights. Fair use and plagiarism. Collaboration in research: authorship, resources sharing and mentoring, publications, conflict of interest, collaboration between academia and industry. Scientific misconduct.

Suggested Readings:

1. Clarke, A (2012). *Genetic Counseling: Practice and Principles*. Taylor & Francis
2. Fleming, D.O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.

3. Mahop, M.T. (2010). *Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries*. Routledge.
4. Rockman, H.B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.
5. Shannon, T.A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.
6. Thompson J and Schaefer, B.D (2013). *Medical Genetics: An Integrated Approach*. McGraw Hill.
7. Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases*. Oxford University Press, UK.
8. WHO. (2005). *Laboratory Biosafety Manual*. World Health Organization.
9. Ethical guidelines for biomedical research on human participants, ICMR.

Modes of transaction

- Lecture
- Demonstration
- Self-learning
- Group discussion

Semester – IV

Course Code: LMS.571

Course Title: Microbial Biotechnology

Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning Outcomes:

The students will be able to:

- Describe various sources for the isolation of industrially relevant microbes.
- Apply the knowledge about micro-organisms in the production of secondary metabolites and enzymes, human and livestock health, nanotechnology and removable energy.
- Explore the work opportunities in biotechnology Companies and industries.

Course Contents

Unit I

13 Hours

Development of Microbial Products: Microbial production of penicillin, Tetracycline and peptide antibiotics; Acetic acid; Lactic acid; Gluconic acid, recombinant biomolecules and therapeutic proteins, vaccines production, DNA based vaccines, antibody production, therapeutic enzymes Microbial production and commercial applications of Amylases, Proteases, Lipases. Biotransformation of steroid and non-steroid compounds.

Unit II

16 Hours

Production of Microbial Products: Single cell protein: Use of Microorganisms; raw material used as substrate; condition for growth and production; nutritive

value and uses of SCP. Mushroom production: cultivation of different types of mushroom; edible mushroom; therapeutic value of an edible mushroom. Genetically modified foods and their importance. Synthesis of commercial products using microbial systems: Biopolymers-xanthan gum and PHA's (Bioplastics). **Renewable Bioenergy using Microorganisms:** Methanogenesis, Methane production by anaerobic digestion of waste organic materials. Bioethanol and Biobutanol production by using microorganisms. Biohydrogen Generation, Microbial Fuel. Biodiesel from algae.

Unit III

15 Hours

Beneficial Microbes: Biofertilizers- *Rhizobium*, *Azospirillum*, *Azotobacter*, *Gluconacetobacter*, *Azorhizobium*, phosphobacteria - *mycorrhizae* - Blue Green Algae and *Azolla*. Mass production of biofertilizers and composting, Nanobiofertilizers for sustainable development of agriculture. **Designer Microbes and Health:** Gut microbiota and diseases, approaches for engineering gut microbiota, therapeutic uses of gut microbiota, Bacteriophages in control of bacteria. Microbial biosensors and its applications.

Unit III

16 Hours

Microbial Nanotechnology: Microbial synthesis of Nanoparticles. Synthesis of nanodrugs – metal nanoparticles and drug delivery vehicles – Nanoshells – Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology. **Regulatory Approvals and Clinical Trials:** Good laboratory practice (GLP), Current Good Manufacturing Practice (CGMP), different phases of clinical trials, difference between biologics, biosimilar and bio-better, development of biosimilars and generic biomolecules, analysis of process economics.

Suggested Readings:

1. W. B. Hugo and A. D. Russell, (2011) *Pharmaceutical Microbiology*, 8th Edition. Blackwell Scientific Publications.
2. Frederick Kavanagh, (2014). *Analytical Microbiology* Volume II. Elsevier.
3. S. P. Vyas and V. K. Dixit, (2012) *Pharmaceutical Biotechnology*. CBS Publishers & Distributors, New Delhi.
4. Elisabeth Papazoglou and Aravind Parthasarathy (2007). *Bionanotechnology*. Morgan & Claypool Publishers.
5. Bernd Rehm (2006). *Microbial Bionanotechnology: Biological Self-assembly Systems and Biopolymer-based Nanostructures*. Horizon Scientific Press.
6. Willey, J.M., Sherwood, L., and Woolverton, C. (2013). *Prescott's Microbiology* 9th Revised Edition, McGraw Hill Higher Education, New York.
7. Mehrotra RS and KR Aneja (2015). *An Introduction to Mycology*, New Age Publishers
8. Steven L. Stephenson (2010) *The Kingdom Fungi: The Biology of Mushrooms, Molds and Lichens*.
9. Reisner DE, Bronzino JD. (2008). *Bio-nanotechnology: Global Prospects*. CRC Press.

Modes of transaction

- Lecture
- Problem Solving
- Self-Learning
- Inquiry training
- Field visit

Course Code: LMS.580**Course Title: Microbial Pathogenicity****Total Hours: 60**

L	T	P	Cr
4	0	0	4

Learning Outcomes:

The students will be able to:

- Describe virulence determinants – colonization, toxins, enzymes and invasiveness with varied examples from different pathogens.
- Illustrate facultative or obligate intracellular and describe molecular Koch's postulates and multiplicity of virulence factors and coordinated regulation of virulence genes.
- Categorise 1-IV secretion systems, importance of biofilms and quorum sensing
- Propose the concepts of antimicrobial, multidrug efflux pumps, extended spectrum β -lactamases, X-MDR Mycobacterial tuberculosis, methicillin-resistant *S.aureus* (MRSA)

Unit I**15 Hours**

Introduction and Techniques to Study Bacterial Pathogenesis: Host defence mechanisms such as Phagocytosis, opsonization and complement, Non-specific, innate and adaptive host defences. Genetic and Bioinformatics approaches, Proteomic approaches, Systems biology based approaches to Host pathogen Interaction. Human Microbiome and their role in therapeutics.

Unit II**15 Hours**

Molecular Microbial Pathogenicity: Molecular Koch's postulates, multiplicity of virulence determinants, coordinated regulation of virulence genes, and environmental regulation of virulence determinants by two component signal transduction systems, antigenic variation; type three secretion system (TTSS, T3SS), Role of biofilms and quorum sensing in microbial pathogenicity. Environmental changes and infectious diseases: Global warming-led increase in vector-borne and water-borne infectious diseases; Impact of increasing urbanization, international travel and trade on infectious diseases.

Unit III

15 Hours

Emerging and Re-emerging Pathogens: Illustrate emerging and re-emerging pathogens using *V. cholerae* 0139, X-MDR *M. tuberculosis*, *Helicobacter pylori*, *Enterohaemorrhagic E. coli* (EHEC), EBOLA, Bird/swine flu, AIDS, and opportunistic fungal pathogens. Mechanisms of emergence of new pathogens: horizontal gene transfer (HGT) and pathogenicity islands (PAI)

Unit IV

15 Hours

Molecular Microbial Epidemiology: Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing; Molecular typing: RAPD, rep (REP, ERIC, BOX)-PCR, IS based typing, PFGE, AFLP, MLST, VNTR and whole genome sequence; **Rapid diagnostic principles:** Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, Real-time PCR, Lateral flow assays, diagnostic sequencing and mutation detection, automated instruments for detection / diagnosis of infectious agents.

Suggested Readings:

1. Jawetz, Melnick, & Adelberg (2016) *Medical Microbiology* by Carroll KC, Hobdon JA, Miller S, Morse SA, Mietzner TA. Lange Publication.
2. Locht C and Simonet M, Caister (2012) *Bacterial Pathogenesis: Molecular and Cellular Mechanisms* by Academic Press.
3. Persing DH, Tenover FC, Hayden R, Leven M, Miller MB, Nolte FS, Tang YW, Belkum AAV. (2016) *Molecular Microbiology: Diagnostic Principles and Practice*. American Society for Microbiology Press.
4. Nelson KE and Williams CM (2019) *Infectious Disease Epidemiology: Theory and Practice*. Jones and Bartlett.
5. Mahon, Connie R. Lehman, Donald C. Manuselis, George (2007) *Textbook of Diagnostic Microbiology*. USA: Saunders.
6. World Organization for Animal Health: “*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*” Volumes I & II, 6th Edition, 2010.
7. Rao, Juluri R, Fleming, Colin C., Moore, John E., (2006) *Molecular Diagnostics: current technology and Applications*. Horizon Bioscience, U. K.

Modes of transaction :

- Lecture
- Demonstration
- Lecture cum demonstration
- Inquiry training
- Group discussion

Course Code: LMS.582

Course Title: Pharmaceutical Microbiology

Total Hours: 60

L	T	P	Cr
4	0	0	4

Learning Outcomes:

The students will be able to:

- Describe the diverse methods of pharmaceutical Microbiology to treat the microbial human diseases.
- Explain the general principles to prevent and treat human diseases.
- Apply these techniques in various applied fields of biological research.

Course Contents

Unit I

14 Hours

Micro-organisms in Pharmaceutical Industry: Antibiotics and synthetic antimicrobial agents. Aminoglycosides, β lactams, tetracyclines, ansamycins, macrolid antibiotics. Antifungal antibiotics, antitumor substances. Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents. Chemical disinfectants, antiseptics and preservatives.

Unit II

14 Hours

Mechanism of Action of Antibiotics: Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis). Molecular principles of drug targeting. Drug delivery system in gene therapy Bacterial resistance to antibiotics. Mode of action of bacterial killing by quinolinones. Bacterial resistance to quionolinones. Mode of action of non-antibiotic antimicrobial agents. Penetrating defenses – How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion).

Unit III

16 Hours

Microbes in Pharmaceutical Products: Microbial contamination and spoilage of pharmaceutical products (sterile injectibles, non injectibles, ophthalmic preparations and implants) and their sterilization. Manufacturing procedures and in process control of pharmaceuticals. Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase). Vaccines and adjuvant-Traditional vaccine preparations, attenuated, dead or inactivated bacteria, Attenuated and inactivated viral vaccines, Toxoids, antigen-based and other vaccine preparations. New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines. Vaccine clinical trials.

Unit IV

16 Hours

Regulatory Practices and Quality Assurance: Biosensors and applications in Pharmaceuticals. Financing R&D capital and market outlook. IP, BP, USP. Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective. Rational drug design.

Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers. Biosensors in pharmaceuticals. Application of microbial enzymes in pharmaceuticals. Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization) Chemical and biological indicators. Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory) Safety in microbiology laboratory.

Suggested Readings:

1. W.B.Hugo & A.D.Russell *Pharmaceutical Microbiology*. Blackwell Scientific Publications.
2. Frederick Kavanagh *Analytical Microbiology* Academic Press New York.
3. David C. Hooper, John S. Wolfson *Quinolone antimicrobial agents*. ASM Washington DC.
4. Murray S.Cooper *Quality control in the Pharmaceutical Industry*. Academic Press New York.
5. H.J.Rehm & G.Reed, *Biotechnology*. VCH Publications, Germany.
6. S.P.Vyas & V.K.Dixit *Pharmaceutical Biotechnology*. CBS Publishers & Distributors, New Delhi.
7. Sydney H.Willig, Murray M.Tuckerman, William S. Hitchings, Mercel Dekker *Good Manufacturing Practices for Pharmaceuticals* New York.
8. Gregory Gregoriadis *Drug Carriers in biology & Medicine*. Academic Press New York.

Modes of transaction

- Lecture
- Problem Solving
- Self-Learning

Course Code: LMS.573

Course Title: Evolution and Ecology

Total Hours: 30

L	T	P	Cr
2	0	0	2

Learning Outcomes:

The students will be able to:

- Illustrate the ecological processes and evolutionary theories.
- Identify their shortcomings while practicing and revising the topics related to ecology and evolution.
- Solve the exercises, mock tests and practice test from the previous year’s examinations.

- Manage the time to attempt the questions in various competitive examinations.
- Minimize the technical difficulties associated with competitive examinations.

Course Contents

Unit I

7 Hours

Principles of Ecology: Biotic and abiotic interactions, concept of habitat and niche, ecological succession, Indian ecosystems: forest, grassland and aquatic (fresh water, marine, eustarine). Types, mechanisms, changes involved in succession. Altruism and evolution-group selection, kin selection, reciprocal altruism, use of space and territoriality; mating systems and habitat selection.

Unit II

8 Hours

Population Ecology: Characteristics of a population, population growth curves, population regulation, life history strategies (r and K selection), concept of metapopulation – demes and dispersal, interdemetic extinctions, age structured populations. Types of interactions, interspecific competition.

Unit III

8 Hours

Origin of Life: Lamarckism, Darwinism, Concepts of variation, adaptation, struggle, Mendelism, Spontaneity of mutations, Theories of phyletic gradualism vs. punctuated equilibria, Modern evolutionary synthesis. Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane model, Origin of eukaryotic cells, Evolution of unicellular eukaryotes, Anaerobic metabolism, Photosynthesis and aerobic metabolism.

Unit IV

7 Hours

Paleontology and Molecular evolution: The evolutionary time scale, Eras, periods and epoch, Major events in the evolutionary time scale, Origins of unicellular and multicellular organisms, Stages in primate evolution including *Homo sapiens*. Concepts of neutral evolution, Molecular divergence and molecular clocks, Molecular tools in phylogeny, Classification and identification; Origin of new genes and proteins; Gene duplication and divergence.

Suggested Readings:

1. Odum, E. and Barrett, G.W. (2005). *Fundamentals of Ecology*. Brooks Cole, USA.
2. Prasanthrajan, M and Mahendran, P.P. (2008). *A Text Book on Ecology and Environmental Science*. Agrotech, India.
3. Sharma, P.D. (2005). *Ecology and Environment*. Rastogi Publications, Meerut, India.
4. Verma, P.S. Agarwal, V. K. (2000). *Environmental Biology: Principles of Ecology*. S. Chand, New Delhi, India.

5. Darwin, C.R. (1911). *On the origin of species by means of natural Selection, or preservation of favoured races in the struggle for life*. Hurst Publishers, UK.
6. Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
7. Futuyma, D.J. (2009). *Evolution*. Sinauer Associates Inc. USA.
8. Hall, B.K. and Hallgrimsson, B. (2007). *Strickberger's Evolution*. Jones and Bartlett Publishers, India.
9. Lewin, R. (2004). *Human Evolution - An Illustrated Introduction*. Wiley-Blackwell, USA.

Modes of transaction:

- Lecture
- Demonstration
- Lecture cum demonstration
- Problem solving
- Self-learning

Course Code: LMS.574

Course Title: Human Physiology and Developmental Biology

Total Hours: 30

L	T	P	Cr
2	0	0	2

Learning Outcomes:

The students will be able to:

- Illustrate the development of plants and animals, with particular emphasis on the molecular genetic basis for developmental events.
- Formulate the developmental phenomena and their relation with most prominently utilized model organisms.
- Identify their shortcomings while practicing and revising the topics related to human physiology.
- Solve the exercises, mock tests and practice test from the previous year's examinations.
- Manage the time to attempt the questions in various competitive examinations.
- Minimize the technical difficulties associated with competitive examinations.

Course Contents

Unit I

8 Hours

Human Physiology: Muscle Physiology: Types and properties of muscles; Cardiovascular system, Nutrition and digestive system. Excretory System, Nervous system and Endocrine system. Comparative physiology.

Unit II

6 Hours

Basic Concepts of Development: Totipotency, Commitment, Specification, Induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages, Stem cells, Genomic equivalence and cytoplasmic determinants. Model organisms in Developmental biology (*Drosophila*, *C. elegans*, *Xenopus*).

Unit III

8 Hours

Fertilization and Gametogenesis: 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 and establishment of symmetry in plants, Seed formation.

Unit IV

8 Hours

Morphogenesis and organogenesis in animals and plants: Cell aggregation and differentiation in *Dictyostelium*, axes and pattern formation in *Drosophila*, Organogenesis and Metamorphosis. Shoot, root and leaf development; floral meristems and development in plant. Cell-Cell Communication and Signaling during development. Apoptosis, Caspases, Importance of programmed cell death (PCD).

Suggested Readings:

1. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
2. Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.
3. Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.
4. Green, D. R. & Reed J. C. (2010). *Apoptosis: Physiology and Pathology*. Cambridge press, UK.
5. Sadler, T.W., Tosney, K., Chescheir, N.C., Imseis, H., Leland, J. and Sadler- Redmond, S., L. (2011). *Langman's Medical Embryology (Longmans Medical Embryology)*. Lippincott Williams and Wilkins.
6. Schaefer, B.D. (2013). *Medical Genetics: An integrated Approach*. McGraw Hill Education, New Delhi.

Modes of transaction:

- Lecture
- Demonstration
- Lecture cum demonstration
- Problem solving
- Self-learning

Course Code: LMS.544
Course Title: Seminar II:
Total Hours: 15

L	T	P	Cr
0	0	0	1

Learning Outcomes:

The students will be able to:

- Present the recent scientific articles on microbiology and associated fields.
- Augment their understanding about current research topics and recent advances of microbiology
- Justify the scientific writing, communication and presentation skills.

Evaluation Criterion: The student selects an advanced topic in Microbiology and related fields based on recent literature available and recent advances on the topic.

Continuous Assessment: 50 Marks: Attendance and interaction with teachers for the preparation of the seminar.

End Term Assessment: 50 Marks: Presentation of approximately 20 minutes and report to be submitted. Students are evaluated based on presentation and written report.

Modes of transaction

- Lecture
- Self-Learning
- Group discussion
- Team teaching

Course Code: LMS.504
Course Title: Project
Total Hours: 180

L	T	P	Cr
0	0	0	6

Learning Outcomes:

The students will be able to:

- Organize extensive review of literature.
- Apply various search engines and websites to identify the area of their research interest.

- Formulate the hypothesis and work plan with scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology.
- Compile the data obtained from experimental plan.
- Analyze the results in light of established scientific knowledge to arrive at cogent conclusions.
- Demonstrate their substantial research-based capabilities.

Evaluation Criteria

The evaluation will be on the basis of satisfactory and non-satisfactory where satisfactory will be based on the performance of the student as Excellent, Very good, Good, Average whereas student will be given non-satisfactory when their performance is below average.

The criteria for the performance will be:

Continuous Assessment: Based on attendance, punctuality and literature survey

End Term Assessment based on:

1. Extensive review of literature/Laboratory work
2. Compiled project report
3. Final presentation

Modes of transaction

- Self-Learning
- Group discussion
- Experimentation

Course Code: LMS.504

Course Title: Ethics for Science (VAC)

Total Hours: 30

L	T	P	Cr
0	2	0	1

Learning Outcomes:

Students from inter-disciplinary background will be able to:

- Illustrate the basic good practices to be followed in research and overall as a student.
- Formulate Classify the principles ethics in research which will help them to understand the set of conduct norms applied in science.
- Interpret the ethical issues involved in human, animals and plants research.
- Judge the misconduct, fraud and plagiarism in research.

Unit I

6 Hours

Introduction and Basic Principles of Ethics: Ethical theories, Ethical considerations during research, Data Manipulations. Ethical review procedure and committees

Unit II**8 Hours**

Ethics in Basic and Applied Sciences: Ethics in cloning, recombinant technology, Genetically Engineered Organisms and r-DNA based products. Animal Testing. Animal Rights, Perspectives and Methodology.

Unit III**8 Hours**

Principles of Ethics in Clinical and Medical Sciences: Code of Ethics in Medical/clinical laboratories. Healthcare rationing, Ethical Issues of Xenotransplantation, Ethics involved in embryonic and adult stem cell research, Ethics in assisted reproductive technologies: animal and human cloning and *In-vitro* fertilization. Ethical issues in MTP and Euthanasia. Types of consents and Human Genome project.

Unit IV**8 Hours**

Ethics in Research: Intellectual property rights (IPRs), Patents copyrights. Fair use and plagiarism. Collaboration in research: authorship, resources sharing and mentoring, publications, conflict of interest, collaboration between academia and industry. Scientific misconduct.

Suggested Readings:

1. Clarke, A (2012). *Genetic Counseling: Practice and Principles*. Taylor & Francis
2. Fleming, D.O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.
3. Mahop, M.T. (2010). *Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries*. Routledge.
4. Rockman, H.B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.
5. Shannon, T.A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.
6. Thompson J and Schaefer, B.D (2013). *Medical Genetics: An Integrated Approach*. McGraw Hill.
7. Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases*. Oxford University Press, UK.
8. WHO. (2005). *Laboratory Biosafety Manual*. World Health Organization.
9. Ethical guidelines for biomedical research on human participants, ICMR, 2006.

Modes of transaction

- Lectures
- Self-Learning
- Tutorial