Central University of Punjab, Bathinda

M.Sc. Program in Life Sciences
Specialization: Microbial Sciences

Session- 2019-21

Department of Microbiology

Programme Outcome

The students will be equipped with the knowledge of microbial molecular and cellular processes and their applications. The laboratory training in addition to theory is to prepare them for careers in the industry, agriculture, and applied research where biological system is increasingly employed. Basics and current updates in different areas of Microbiology are included to train the students and also to sensitize them for research. The programme aims to increase the skilled scientific manpower with an understanding of research ethics and vast knowledge of microorganisms.

SEMESTER – I

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Total
XXX LBC.504*	Choose from value based courses/ MOOCs Ethics for Science*	Elective Foundation	1	-	-	1
LBC.506	Biochemistry	Core	3	-	-	3
LMS.507	Microbiology	Core	3	-	-	3
LMS.508	Cell Biology	Core	3	-	-	3
LBC.509	Essentials of Genetics	Core	3	-	-	3
LBC.510	Life Sciences Practical-I	Core	-	-	10	5
LBC.512	Basics of Biochemistry	Interdisciplinary Course (IDC)/MOOC#	2	-	-	2
					Total Credits	**20**

*Value based course offered by the department

A course from UGC approved MOOC (4 Credits) can replace two IDC credits each in semester I and semester II which has to be approved by department MOOC coordinator.

SEMESTER – II

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Total
LMS.513	Research Methodology and Biostatistics	Compulsory Foundation	3	1	-	4
LMS.521	Immunology	Core	3	-	-	3
LBC.522	Molecular Biology	Core	3	-	-	3
LMS.524	Clinical Microbiology	Core	4	-	-	4
LMS.525	Microbial Physiology and Metabolism	Core	2	1	-	3
LMS.526	Microbiology Practical-I (Practical)	Core	-	-	6	3
LBC.527	Life Sciences Practical-II	Core	-	-	6	3
LMS.529	Basics of Microbiology	Interdisciplinary Course (IDC)/MOOC#	2	-	-	2
					Total Credits	**25**

A course from UGC approved MOOC (4 Credits) can replace two IDC credits each in semester I and semester II which has to be approved by department MOOC coordinator

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SEMESTER – III

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Total
LMS.551	Industrial Microbiology	Core	3	-	-	3
LMS.552	Food and Dairy Microbiology	Core	3	-	-	3
LMS.554	Microbiology Practical –II (Practical)	Core	-	-	10	5
LMS. 562	Environmental Microbiology	Core	2	1	-	3
LMS.560	Principles of Ecology, Evolution and Developmental Biology	Discipline Elective (opt any one)/MOOC#	3	1	-	4
LBC.561	Cell Culture Techniques	Discipline Elective (opt any one)	3	1	-	4
LMS.543	Seminar-I	Skill Based	1	-	-	1
LMS.599	Project	Skill Based	-	-	12	6
					Total Credits	**25**

A course from UGC approved MOOC (4 Credits) can be taken which has to be approved by department MOOC coordinator.

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SEMESTER – IV

Course Code	Course Title	Course Type	Credit Hours			
			L	T	P	Total
XXX LBC.504*	Choose from value based courses/ MOOCs Ethics for Science*	Elective Foundation	1	-	-	1
LMS.571	Microbial Biotechnology	Core	4	-	-	4
LBC.580	Genetic Engineering	Discipline Elective (opt any one)	3	1	-	4
LMS. 581	Clinical Diagnostics	Discipline Elective (opt any one)	3	1	-	4
LBC.573	Recent Advances in Life Sciences-I	Compulsory Foundation (Discipline Enrichment Courses)	-	2	-	2
LBC.574	Recent Advances in Life Sciences-II	Compulsory Foundation (Discipline Enrichment Courses)	-	2	-	2
LMS.544	Seminar-II	Skill Based	1	-	-	1
LMS.599	Project	Skill Based	-	-	12	6
					Total Credits	**20**

L: Lectures; T: Tutorial; P: Practical; Cr: Credits

*Value based course offered by the department

SEMESTER – I

Course Code: LBC.506
Course Title: Biochemistry
Total Hours: 48

L	T	P	Cr
3	-	-	3

Learning Outcomes: The course is designed to teach fundamental and basics of biochemistry and to prepare them for advanced courses in biochemistry. The students will be able to demonstrate an understanding of fundamental biochemical principles, such as the structure/function of biomolecules, metabolic pathways, and the regulation of biological/biochemical processes.

Unit I **12 Hours**

Principles of Biophysical Chemistry: pH, Water, Buffer, Reaction kinetics, Laws of Thermodynamics, Colligative properties, Structure of atoms, Molecules and chemical bonds. **Composition, Structure and Function of Bio-macromolecules:** Carbohydrates, Lipids, Proteins, and Nucleic acids. Primary, Secondary, Tertiary and Quaternary structures of proteins, Domains, Motifs and Folds, Stability of protein. **Techniques:** Chromatography: Thin layer chromatography (TLC), gel filtration, ion exchange and affinity chromatography, GC, HPLC and LC-MS Spectrometry: Circular Dichroism, Nuclear Magnetic Resonance and atomic absorption spectroscopy.

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Unit II **12 Hours**

Enzymology: Enzyme classification, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics, Michaelis-Menten equation and Lineweaver Burk plots, Enzyme regulation, Isozymes and Clinically important enzymes.

Unit III **12 Hours**

Carbohydrate and Lipid Metabolism: Carbohydrate metabolism: Glycolysis, Kreb's Cycle, Electron transport chain, Pentose phosphate pathway, Gluconeogenesis, Glycogen metabolism; Lipid Metabolism: Fatty acid catabolism, Lipid biosynthesis.

Unit IV **12 Hours**

Amino Acid and Nucleic Acid Metabolism: Amino acid biosynthesis and catabolic pathways; Nucleotide synthesis and degradation pathways.

Suggested Readings:

1. Berg, J.M., Tymoczko, J.L., Gatto, Jr., G.J., and Stryer, L. (2015). *Biochemistry,* 8th Edition, W.H. Freeman.

2. Nelson, D. and Cox, M.M. (2017). *Lehninger Principles of Biochemistry,* 7th Edition, W.H. Freeman.
3. Garrett, RH, Grisham, CM. (2012). *Biochemistry*, 5th Edition, Cengage Learning.
4. McKee, T and McKee, JR. (2015). *Biochemistry: The Molecular Basis of Life,* 6th Edition, Oxford University Press

Modes of transaction
-Lecture
-Problem solving
-Panel discussion
-Tutorial

Course Code: LMS.507
Course Title: Microbiology
Total Hours: 48

L	T	P	Cr
3	-	-	3

Learning Outcomes: Students will learn the basics of microbes, microbial growth, their application in day to day life and beneficial versus harmful micro-organisms. At the end of the course the student will acquire a broad understanding of different group of microorganisms important in health, disease and industry. Students will also be able to comprehend the microbiological principles that can optimize, enhance or inhibit the microbial growth in different settings viz industrial microbiology, medical microbiology.

Unit I **12 Hours**

Microbial Systematics: 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.

Introduction to Microbiology: Scope and history of Microbiology, Cell structure, different components, function and their significance for bacteria and archaea. Algae, and viruses.

Unit II **12 Hours**

Growth, Nutrition & Control: Phases in bacterial growth, Growth Curve, Calculation of G-time, Physical and environmental requirements of growth, Microbial nutrient requirements – macro-nutrients, micro-elements – growth factors - sources of nutrients – nutritional classification of bacteria - Phototroph, Chemotroph, Autotroph (lithotroph), Heterotroph (organotroph), Photoautotroph, Photoheterotroph, Chemoautotroph, Chemoheterotroph - Nutritional patterns of pathogens – Saprophytes – Auxotroph.

Unit III **12 Hours**

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. **General Virology**: Morphology, viral genome – types and structures; nomenclature and classification of virus (Animal, plant, bacterial viruses). Life cycle and replication of animal viruses, Introduction to some emerging viral diseases.

Unit IV **12 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: 48

L	T	P	Cr
3	-	-	3

Learning Outcomes: Students will understand the structure and basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles and their related functions. Students will be able to

apply the basic core of scientific and quantitative knowledge to enhance understanding of cell structure and function at the molecular level.

Unit I **12 Hours**

Introduction to the Cell: Evolution of the cell, From molecules to first cell, From prokaryotes to 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: 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 **12 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 secretary 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, Noncollagen 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. 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., Lews, J., Raff, M., Roberts, K. and Watson, J.D. (2010). *Molecular Biology of the Cell*. Garland publishers, Oxford.
2. Celis, J.E. (2006). *Cell biology: A laboratory handbook*, Vol 1, 2, 3. Academic Press, UK.

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3. Gupta, P.K. (2008). *Cytology, Genetics and Evolution*. Rastogi publications, Meerut, India.
4. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley &Sons. Inc. New Delhi, India.
5. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
6. Lodish H, Berk A, Kaiser CA, Krieger A, Scott MP, et al. (2012). *Molecular Cell Biology*, W. H. Freeman; USA

Modes of transaction

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

Course Code: LBC.509
Course Title: Essentials of Genetics
Total Hours: 48

L	T	P	Cr
3	-	-	3

Learning Outcomes: Students will learn the basic principles of inheritance at the molecular, cellular and organismal levels. The students will know the various concepts of hereditary information and how they work in living organisms and to apply them to real life situations.

Unit I **12 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 (Coiling in Snails).

Unit II **12 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 verses 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

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L	T	P	Cr
-	-	10	5

Course Code: LBC.510
Course Title: Life Sciences Practical-I (Practical)
Total Hours: 150

Learning Outcomes: The students will demonstrate the ability to perform experiments pertaining to biochemistry, microbiology, cell biology & genetics. They will also gain an understanding of the principles of the experiments and will be able to apply them to real world problems.

Part A. Biochemistry

1. Introduction to Good Laboratory Practices
2. Preparation of solutions, buffers, pH setting etc.
2. Quantitative estimation of proteins, sugars, total lipids and amino acids.
3. Isolation of protein from biological sample
4. Enzyme activity assays: invertase, amylase, alkaline phosphatase
5. 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. Temporary staining for epithelial cells and blood cells.
2. Cell count using haemocytometer
3. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip).
4. Study of polyploidy in onion root tip by colchicine treatment.

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5. Study of structure of cell organelles through electron micrographs
6. To demonstrate the presence of mitochondria and other cell organelles using vital stains
7. Depicting nature of cellular membranes: Osmosis, Hypertonicity, Hypotonicity, Isotonicity
8. Preparation of cell culture media

Part D. Genetics

1. Learning Blood group typing with its genetic basis.
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 added/modified from time to time depending on available faculties/facilities.

Modes of transaction

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

Tools used

PPT, Video, Google Drive

Course Code: LBC.512
Course Title: Basics of Biochemistry (IDC)
Total Hours: 30

L	T	P	Cr
2	-	-	2

Learning Outcomes: This is an interdisciplinary course to acquaint the students of different streams with a very basic knowledge and understanding of biomolecules, their structure, composition and function. The students from different backgrounds will develop a basic understanding of various biochemical processes in living systems.

Unit I **7 Hours**

Principles of Biophysical Chemistry: pH, Buffer, Reaction kinetics, Thermodynamics. **Composition, Structure and Function of Biomolecules:** Carbohydrates, Lipids, Proteins: Primary, Secondary, Tertiary and Quaternary structures, Nucleic acids and Vitamins.

Unit II **8 Hours**

Carbohydrate and Protein Metabolism: Carbohydrate metabolism; Glycolysis, Kreb's Cycle, Hexose monophosphate shunt pathway, Glycogenolysis, Glycogenesis. Protein metabolism, Urea Cycle.

Unit III **8 Hours**

Fatty acid and Nucleic Acid Metabolism: Fatty acid catabolism and synthesis; Degradation and synthesis of nucleotides.

Unit IV **7 Hours**

Enzymology: Classification of enzymes, Principles of catalysis, Mechanism of enzyme catalysis, Effect of pH and temperature on enzyme activity, Application of enzymes in day to day life. Isozymes.

Suggested Readings:

1. Satyanarayana, U. (2013) *Biochemistry*, Publisher: Elsevier; Fourth edition ISBN-9788131236017.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry.* W.H. Freeman & Company. USA.
3. Nelson, D. and Cox, M.M. (2008). *Lehninger Principles of Biochemistry*. BI publications Pvt. Ltd. Chennai, India.
4. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc. New Delhi, India.

Modes of transaction

-Lecture
-Inquiry training
-Team teaching

Tools used

PPT, Video, Google Drive

Course Code: LBC.504
Course Title: Ethics for Science
Total Hours: 16

L	T	P	Cr
1	-	-	1

Learning Outcomes: To ensure that the student knows the aspects of ethics in research which will help them to understand the set of conduct norms applied in science. The course will cover the ethics involved in human, animals and plants research and misconduct, fraud and plagiarism. The students from inter-

disciplenary background will learn about the basic good practices to be followed in research and overall as a student.

Unit I **3 Hours**

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

Unit II **4 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 **5 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 **4 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.

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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.
   Ethical guidelines for biomedical research on human participants, ICMR,

Modes of transaction
-Lecture
-Demonstration
-Self-learning
-Group discussion

SEMESTER II

Course Code: LMS.530
Course Title: Research Methodology and Biostatistics
Total Hours: 60

L	T	P	Cr
3	1	-	4

Learning Outcomes: To ensure that the student understands various aspects of research methods, ethics, technical and scientific writings and literature search. This course will also help the students to understand the complex outcome of their results using biostatistical approaches in testing hypothesis, designing experiments, analyzing experimental data and interpreting the results.

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.

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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, x^2 test. Standard errors of regression coefficients and types of correlation coefficient. Computer application of statistical softwares, Microsoft Excel as statistical tool, Formating 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: 48

Learning Outcomes: At the end of the course students will be able to describe fundamental concepts in immunology using correct scientific terminologies. They will be able to interpret and apply their knowledge in health and disease from an immunological perspective.

Course Contents

Unit I **12 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 **12 Hours**

Functions of Acquired Immunity: Types and characterstics of Lymphocytes, 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 microbes, immunity to tumors, AIDS, hepatitis and human immune-deficiencies and allergies. Recent advances in vaccine development for diseases like AIDS, 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.

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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

IQAC

Course Code: LBC.522
Course Title: Molecular Biology
Total Hours: 48

L	T	P	Cr
3	-	-	3

Learning Outcomes. The students will master basic and advanced concepts related to molecular processes in a cell and how they are related to biochemical processes in microbes and higher organisms. In addition, they will understand the applications of molecular biology to societal needs with reference to medicine, industry and agriculture.

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. **Molecular Techniques and Bioinformatics:** Gel electrophoresis, Southern, Northern, Western, hybridization, DNA fingerprinting, cloning, PCR, real-time PCR, DNA sequencing including NGS, microarrays, chromatin immunoprecipitation, metabolomics, proteomics, biological databases and searches, analysis of genomic and proteomic data, DNA-protein interactions, protein-protein interactions, protein sequencing, emerging techniques.

Unit II **12 Hours**

DNA Replication and Repair: Prokaryotic and eukaryotic DNA replication, Mechanism of DNA replication, Enzymes and accessory proteins involved in DNA replication, Replication errors, DNA damage and repair, gene editing.

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 **12 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 **12 Hours**

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, coexpression; Recent trends.

IQAC

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.

Modes of transaction

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

Tools used PPT, Video, Google Drive

Course Code: LMS.524
Course Title: Clinical Microbiology
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes: The students will understand about the basic concept of epidemiology, various cellular processes during disease development and the relevance of microbes and various diseases caused by bacteria, fungi, protozoa and viruses. The student will gain in-depth knowledge the microbial pathogenesis, bacteriology, mycology, parasitology and virology. This will further help the students to comprehend clinical diagnostics and treatment of the different diseases caused by these microbes.

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.

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: *Microsporum; 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**

Recognition and Pathogenesis of Viral Infection: Contributions of various host defense mechanisms in viral infections; Details on important viruses namely Herpesvirus, Poliovirus, Influenza virus, Adeno Virus, Poxviruses, Hepatitis Viruses, Coronaviruses, Retroviruses and Flaviviruses.

IQAC

Oncogenic viruses: oncogenic viruses, viral transformation by activation of cellular signal transduction pathways, viral transformation via cell cycle control pathways. **Viral Chemotherapy:** Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors: mechanism of action and drug resistance, viruses as therapeutic agents.

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. Walsh, G. (1998) Biopharmaceuticals: Biochemistry and Biotechnology, John Wiley & Sons, New York.
4. Benjamin, E. (1996), Immunology-A short course
5. Kindt, T.J., Osborne, B.A. and Goldsby, R.A. (2012). Kuby Immunology 7th Edition W.H. Freeman, USA
6. Madigan,M.T., Martinko, J.M., Bender, K., and Buckley, D. (2011) Brock Biology of Microorganisms, 13th Ed., Pearson Education, USA.

Modes of transaction:

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

IQAC

L	T	P	Cr
2	1	-	3

Course Code: LMS.525
Course Title: Microbial Physiology and Metabolism
Total Hours: 46

Learning Outcomes: In this course, the students will learn about the metabolic diversity exhibited by microorganisms, their thermodynamics and regulatory networks that support their survival and growth**.** In this advanced level courses, students will be able to grasp basic mechanisms of energy-yielding and consuming processes, 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 **12 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 some 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 hydrogeno-monas 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: 90

L	T	P	Cr
-	-	6	3

Learning Outcomes: In this course the students will observe and perform experiments related to clinical microbiology and virology which will enhance

their laboratory skills, and scientific knowledge. On completion of this course, students will be able to prepare and distinguish between various types of microbial media, culturing methods and can detect 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, Lowensten-Jension 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 titre of a virus sample using Plaque assay.
18. Production of a purified virus stock and its quantitation.

IQAC

- Practical may be added/modified from time to time depending on available faculties/facilities.

Modes of transaction

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

Course Code: LBC.527
Course Title: Life Sciences Practical-II (Practical)
Total Hours: 90

L	T	P	Cr
-	-	6	3

Learning Outcomes: Students will be able to understand and carry out basic molecular biology, cell culture and immunological techniques and correlate them with their fundamental concepts in the subject. Students will be able to assess the use of molecular biology, cell culture and immunological techniques in health and disease. At the end of the course, students will gain a broad appreciation of the techniques and their application to study bacterial and mammalian cells, cellular DNA, RNA, proteins along with different aspects of immune processes.

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 added/modified from time to time 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

Course Code: LMS. 529
Course Title: Basics in Microbiology (IDC)
Total Hours: 31

L	T	P	Cr
2	-	-	2

Learning Outcomes: Basics in microbiology course is designed as an interdisciplinary course to acquaint the students of different streams with a very basic knowledge and understanding of microbes, pathogens and their control. The course will impart a basic foundation of microbiology to the students from different backgrounds. At the end of the course the student will acquire a broad understanding of different group of microorganisms important in health, diseases and industry.

Unit I **8 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

SEMESTER – III

L	T	P	Cr

Course Code: LMS.551

3		-	3

Course Title: Industrial Microbiology
Total Hours: 45

Learning Outcomes: The students will study the use of microorganisms for the value added products through fermentation processes. They will learn various upstream and downstream processes in the large scale production of several primary and secondary metabolites of microbial origin and will be able to apply this knowledge in research and industry.

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.

IQAC

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

Modes of transaction:
-Lecture
-Demonstration
-Lecture cum demonstration
-Inquiry training
-Group discussion

IQAC

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

L	T	P	Cr
3	-	-	3

Learning Outcomes: In this course, the students will learn and understand the microbiology of foods and dairy products. They will also get acquainted with the food spoilage and preservation methods, and understand the industrial aspect of dairy microbiology. The student will acquire the knowledge about pathogenic and spoilage microorganisms associated with different foods and their commercial importance.

Unit I **12 Hours**

Food Borne Microbes: Importance and significance of microorganisms in food. Food borne diseases- Bacterial food borne diseases- (Staphylococcal intoxification, Botulism, Salmonellosis, Shigellosis, EPEC Diarrhoea, Clostridium

Perfringens gastroenteritis, Bacillus cereus gastroenteritis; Food-borne fungi- Mycotoxins- Aflatoxicosis, Mycotoxicosis, Ergotism.

Unit II **12 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. Probiotic bacteria in foods.

Unit III **11 Hours**

Fermented and Dairy Food Products: Microorganisms involved in food fermentations. Microbiology of Milk. Sources of Milk contamination and their control Microbiology of raw and pasteurized milk, Starter cultures for fermented dairy products (*Streptococcus thermophillus*, *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), ISI (Indian Standard Institute).

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.

IQAC

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
2	1	-	3

Learning Outcomes: Student will be able to know how microbes interact in the environment. Students will also learn and understand the composition of industrial waste water and xenobiotics, and their treatment using microorganisms. Further they can 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; Trickling 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. N.S. Subba Rao. (1995). *Bio-fertilizers in Agriculture and Forestry*.

IQAC

Modes of transaction:

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

Course Code: LMS.554
Course Title: Microbiology Practical –II (Practical)
Total Hours: 150

L	T	P	Cr
-	-	10	5

Learning Outcomes: The students will learn and perform experiments pertaining to the theory papers of industrial and environmental microbiology and food and dairy microbiology. The students will be able to 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. Std 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.

IQAC

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 added/modified from time to time depending on available faculties/facilities.

Modes of transaction

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

Course Code: LMS.560
Course Title: Principles of Ecology, Evolution and Developmental Biology
Total Hours: 60

L	T	P	Cr
3	1	-	4

Learning Outcomes: In this course the students will learn the about the origin of life and development of plants and animals, with a particular emphasis on the molecular genetic basis for developmental events. The course will focus on developmental phenomena studied in several of the most prominently utilized model organisms.

Unit I **15 Hours**

Principles of Ecology

Biotic and abiotic interactions, concept of habitat and niche, characteristics of a population, life history strategies, concept of metapopulation, species interactions, levels of species diversity and its measurement, ecological succession, Indian ecosystems, altruism and evolution-group selection, kin selection, reciprocal altruism, use of space and territoriality; mating systems, parental investment and reproductive success; parental care, habitat selection.

Unit II **12 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 III **18 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*). 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 **15 Hours**

Morphogenesis and organogenesis in animals and plants: : Cell aggregation and differentiation in *Dictyostelium*, axes and pattern formation in *Drosophila,* Organogenesis: vulva formation, eye lens induction, limb development and regeneration in vertebrates; Metamorphosis. Shoot, root and leaf development; floral meristems and development in plant.. Cell-Cell Communication and Signaling. Apoptosis, Caspases, Importance of programmed cell death (PCD) in animal/plant development. Medical implications of developmental biology: genetic errors/ teratogenesis/ stem cell therapy.

Suggested Readings:

1. 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.
2. Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
3. Futuyma, D.J. (2009). *Evolution*. Sinauer Associates Inc. USA.
4. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
5. Hall, B.K. and Hallgrimsson, B. (2007). *Strickberger's Evolution.* Jones and Bartlett Publishers, India.
6. Lewin, R. (2004). *Human Evolution - An Illustrated Introduction*. Wiley-Blackwell, USA.
7. Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.

8. Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.
9. Green, D. R. & Reed J. C. (2010). *Apoptosis: Physiology and Pathology*. Cambridge press, UK.
10. 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.
11. 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: LBC.561
Course Title: Cell Culture Techniques
Total Hours: 60

L	T	P	Cr
3	1	-	4

Learning Outcomes: At the end of the course the student will have the background of animal tissue culture essential for understanding their applications in other fields and planning projects in the field of biotechnology encompassing cell culture based system. Students will be able to design and execute cell culture based experiments in a research setting as well as industrial setting with a thorough clarity in the basic principles.

Unit I **12 Hours**

Introduction to animal cell cultivation: 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**

Studying 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, Flowcytometry, 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, Fourth Edition: Genomics to Personalized Healthcare. Academic Press

Modes of transaction

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

Course Code: LMS.543
Course Title: Seminar I
Total Hours: 15

L	T	P	Cr
1	-	-	1

Learning Outcomes: The course is designed so that the students understand and read the recent scientific articles and give presentation on a recent topic on microbiology. Students will augment their understanding about current research topics and recent advances of biochemistry. The course will further improve the scientific writing, communication and presentation skills of the students.

Evaluation Criterion: The student selects an advanced topic in Microbiology and related fields; they prepare a presentation of approximately 20 minutes based on recent literature available and recent advances on that topic and will also prepare a report. 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
-	-	12	6

Learning Outcome: The project would ensure that the student learns the nuances of the scientific writing. Herein the student will have to write her/ his synopsis including an extensive review of literature. Upon completion of this course the students will be able to use various search engines and websites to identify the area of their research interest. Students will also be able to formulate their hypothesis and work plan with simultaneous identification of scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology.

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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:

1. Attendance and punctuality
2. Regular discussion with supervisor
3. Extensive review of literature
4. Interest in the field
5. Management of time and resources
6. Synopsis presentation

Transactional Mode:

-Problem solving
-Experimentation
-Problem solving
-Seminars
-Self Learning

SEMESTER – IV

Course Code: LMS.571
Course Title: Microbial Biotechnology
Total Hours: 60

L	T	P	Cr
4	-	-	4

Learning Outcomes: This course focuses on the application and use of micro-organisms in the production of secondary metabolites and enzymes, human and livestock health, nanotechnology and removable energy. This course will provide a strong understanding of applied microbiology and its applications and will help the students to explore work opportunities in Biotechnology Companies and Industries as well.

Unit I
13 Hours

Antimicrobials, Organic acids and enzymes: Microbial production of penicillin, Tetracycline and peptide antibiotics; Acetic acid; Lactic acid; Gluconic acid, vaccines. 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; diseases of mushrooms therapeutic value of an edible mushroom. Genetically modified foods and their importance. Immobilization of cells/enzymes. Synthesis of commercial products using microbial systems: Biopolymers–xanthan gum and PHA's (Bioplastics).

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**.**

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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.

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.

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

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Course Code: LBC.580
Course Title: Genetic Engineering
Total Hours: 60

L	T	P	Cr
3	1	-	4

Learning Outcomes: The course will acquaint the students to versatile tools and techniques employed in genetic engineering. A sound knowledge on methodological repertoire allows students to innovatively apply these in basic and applied fields of biological research. At the end of the course, the student will acquire conceptual understanding of the application of basic molecular biology in manipulating and modifying genetic material, cells and organisms. They will have thorough understanding of the techniques and applications of genetic engineering from academic and industrial perspectives. The students will be capable of applying the acquired knowledge in a setting of Medical Biotechnology, Industrial Biotechnology, and Agricultural Biotechnology.

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 Selection, genomic and cDNA library construction & DNA-sequencing techniques, Site-directed mutagenesis.

Unit II **15 Hours**

Gene Cloning and Expression in Microbial and Eukaryotic Systems: Cloning in *E. coli*, in Gram-positive bacteria, in Streptomycetes, in *Saccharomyces Cerevisiae* and *Pichia pastoris*, in Insect Cells, in Mammalian Cells expression system, Fusion proteins, Transcriptional & Translational Fusions, Adding Tags and Signals.

Unit III **15 Hours**

Applications of Recombinant DNA Technology: Vaccines (subunit-, peptide-, attenuated-, DNA- and vector-based), Metabolic Engineering and Protein Engineering: Enzymes, Antibiotics, Therapies for Genetic Diseases, Bioremediation.

Unit IV **15 Hours**

Genetic Manipulation and functional assessment: 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.

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: LBC.581
Course Title: Clinical Diagnostics
Total Hours: 60

L	T	P	Cr
3	1	-	4

Learning Outcomes: The objective this course is to introduce the students to diverse methods of clinically diagnosing human diseases which will further help them to use these techniques various applied fields of biological research.

Unit I **12 Hours**

Introduction to Clinical Diagnostics: Philosophy and general approach to clinical specimens, Sample collection (Blood, urine, spinal fluid, synovial fluid, amniotic fluid) - method of collection, preservation, transport and processing of samples. Diagnosis – disease altered state, prognosis, direct and indirect, concept of antigen and antibody. Principles of validation of diagnostic assays for infectious diseases, Validation and quality control of polymerase chain reaction methods used for the diagnosis of infectious diseases.

Unit II **18 Hours**

Protein based Clinical Diagnostics: Antigen – Antibody Interaction, Lattice Theory, Precipitin Curve, Simple Immunodiffusion (Radial Immunodiffusion – Qualitative, Quantitative); Double Diffusion (Mechanism of Reaction of Identity, Partial Identity, and Non-Identity); Rocket Electrophoresis, Immunoelectrophoresis; Western Blot, Immunofluorescence, Radioimmunossay; ELISA – types and assay development; Agglutination – Antibody titer, Prozone Phenomenon, Direct and Indirect Agglutination, ABO Blood typing, Agglutination Inhibition; Advantages and limitation with respect to clinical diagnosis and research usage. Microparticle based antigen - Antibody interaction techniques. Monoclonal antibody – production, applications, novel approaches in detection, Humanized monoclonal antibodies.

Unit III **15 Hours**

DNA based Clinical Diagnostics: Nucleic acid extraction from clinical samples, quantization, digestion, hybridization, Amplification by PCR (Inverse PCR, Multiplex PCR, Nested PCR, Alu-PCR, Hot-start, *In situ* PCR, Long-PCR, PCR-ELISA, iPCR, applications and limitations) DNA fingerprinting and polymorphism studies (SNP, RAPD, RFLP, VNTR, Mutation detection etc). Emphasis on interpretation of results and quality control.

High-throughput Technologies and Pathological Diagnostics: Microarray (protein, DNA), Real-Time PCR, Reporter assays. Biosensors – types, applications, examples (glucose etc), telemedicine.Fluorescence based techniques (FISH analysis, Flow cytometry, Fluorescent Microscopy) Mass spectrometry, Histopathology, Immunohistochemistry and Real-Time PCR. Microbiological Diagnosis and Hematology. Enzyme and hormone based diagnostic techniques

Unit IV **15 Hours**

Case Studies: Diagnosis of Infectious Diseases – some specific examples.Diagnosis of bacterial infection caused by *Coliforms, Salmonella, Shigella, Vibrio, and Mycobacterium tuberculosis.* Diagnosis of fungal infections. Dermetophytoses, Candidiosis and Aspergillosis. Diagnosis of DNA and RNA viruses. Pox viruses, Adenoviruses, Rhabdo Viruses, Hepatitis Viruses and Retroviruses.Diagnosis of Protozoan diseases: Amoebiosis, Malaria, Trypnosomiosis, Leishmaniasis, Filariasis and Schistosomiasis.Medical Genetics: Organization of human genome, Human Genome Project, Identifying human disease genes. Genetic Counselling. Genetic disorders: Sickle cell anaemia, Duchenne muscular Dystrophy, Retinoblastoma, Cystic Fibrosis and Sex –linked inherited disorders. Neonatal and Prenatal disease diagnostics.

Suggested Readings:

1. Burtis, Carl A, Ashwood, Edward R, Bruns, David E., "*Tietz textbook of Clinical Chemistry & Molecular Diagnostics*" USA: Saunders, 2006.
2. World Organization for Animal Health: "*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals"* Volumes I & II, 6th Edition, 2010.
3. Rao, Juluri R, Fleming, Colin C., Moore, John E., "*Molecular Diagnostics: current technology and Applications"*, Horizon Bioscience, U. K., 2006.
4. Goldsby, Richard A., Kuby, Janis, "*Immunology*", New York: WH Freeman and Company, 2003.
5. Mahon, Connie R. ; Lehman, Donald C. ; Manuselis, George "*Textbook of Diagnostic Microbiology*". USA: Saunders, 2007.

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
- Case study
-Case analysis

Course Code: LBC.573
Course Title: Recent Advances in Life Sciences-I
Total Hours: 30

L	T	P	Cr
-	2	-	2

Learning Outcomes: The course deals with the specific content for the national level tests conducted by UGC, CSIR and other agencies. The course is divided into two parts and in Part-I the students will be practicing and revising the topics related to cell biology, genetics, biochemistry and microbiology. The students will be given exercises, mock tests and practice test from the previous year's examinations. Students will be prepared and trained for national level competitive examinations. After completion of this course students will be able to manage the time to attempt the questions and would be able to understand the technical difficulties.

Unit I **7 Hours**

Cell Biology: Molecules and their Interaction Relevant to Biology, Cellular Organization, Cell Communication, cell Signaling and Cell Cycle.

Unit II **8 Hours**

Biochemistry: Structure and functions of carbohydrates, lipids, amino acids, proteins, nucleic acids and vitamins. Bioenergetics and thermodynamics. Metabolism of carbohydrates, lipids, amino acids and nucleotides.

Unit III **8 Hours**

Genetics: Nucleic acids: types and Functions. Genetic code, Mendelian and non-Mendelian inheritance. Genetic mapping. Recombination. Microbial Genetics.

Unit IV **7 Hours**

Microbiology: Scope and history of Microbiology, classification of Bacteria, Fungi, Protozoa, Algae, and viruses. Microbial growth. Ecology and applied microbiology.

- The topics covered will be revised from time to time as per the revised NET syllabus.

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
-Panel discussion
-Inquiry training
-Group discussion
-Brain storming

Course Code: LBC.574
Course Title: Recent Advances in Life Sciences-II
Total Hours: 30

L	T	P	Cr
-	2	-	2

Learning Outcomes: The course deals with the specific content for the national level tests conducted by UGC, CSIR and other agencies. The course is divided into two parts and in Part-II the students will be practicing and revising the topics related to molecular biology, immunology, animal physiology, developmental biology and plant physiology. The students will be given exercises, mock tests and practice test from the previous year's examinations. Students will be prepared and trained for national level competitive examinations. After completion of this course students will be able to manage the time to attempt the questions and would be able to understand the technical difficulties.

Unit I **7 Hours**

Evolution and Developmental Biology: Lamarckism, Darwinism, Concepts of variation. Molecular divergence and phylogeny. Gametogenesis, Fertilization and Cell Death, Molecular Genetic Basis for Developmental Events and Basic Concepts of Development.

Unit II **8 Hours**

Animal Physiology: Muscle Physiology: Types of muscles, Properties; Cardiovascular system, Nutrition and digestive system. Excretory System, Nervous system and Endocrine system. Comparative physiology.
Immunology: Molecular Mechanisms of Antibody Diversity and Cellular Immunity. Hybridoma technology and vaccine development associated challenges for chronic and infectious diseases.

Unit III **7 Hours**

Plant Physiology: Photosynthesis, Respiration and Photorespiration: Light harvesting complexes, Mechanisms of electron transport, Photoprotective mechanisms. Photo-respiratory pathways. Phytohormones. Stress Physiology: Mechanisms of resistance to biotic stress and tolerance to abiotic stress.

Unit IV **8 Hours**

Molecular Biology and Techniques in Biology: DNA replication and repair. Transcription and translation. Gene regulation. Molecular techniques. Concepts of bioinformatics. Genomics, proteomics and metabolomics.

- The topics covered will be revised from time to time as per the revised NET syllabus.

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Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
-Panel discussion
-Inquiry training
-Group discussion

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

L	T	P	Cr
1	-	-	1

Learning Outcomes: The course is designed so that the students understand and read the recent scientific articles and give presentation on a recent topic of microbiology. Students will augment their understanding about current research topics and recent advances of microbiology. The course will further improve the scientific writing, communication and presentation skills of the students.

Evaluation Criterion: The students select an advanced topic in microbial sciences and related fields; they prepare a presentation of approximately 20 minutes based on recent literature available and recent advances on that topic. The students will prepare a report. Students are evaluated based on presentation and written report.

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Course Code: LMS.599
Course Title: Project
Total Hours: 180

L	T	P	Cr
-	-	12	6

Learning Outcomes: The project would ensure that the student learns the nuances of the scientific writing. Herein the student will carry out the experiments to achieve the objectives as mentioned in the synopsis. The data collected as a result of experiments must be meticulously analyzed in light of established scientific knowledge to arrive at cogent conclusions. The student can also write a review for the project work. Upon completion of the project the students will be able to critically analyze, interpret and present the data in light of established scientific knowledge to arrive at cogent conclusions. The student will also be able to 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:

1. Attendance and punctuality
2. Regular discussion with supervisor
3. Extensive review of literature
4. Interest in the field
5. Management of time and resources
6. Final presentation

Modes of transaction

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

Course Code: LBC.504
Course Title: Ethics for Science
Total Hours: 16

L	T	P	Cr
1	-	-	1

Learning Outcomes: To ensure that the student knows the aspects of ethics in research which will help them to understand the set of conduct norms applied in science. The course will cover the ethics involved in human, animals and plants research and misconduct, fraud and plagiarism. The students from inter-disciplenary background will learn about the basic good practices to be followed in research and overall as a student.

Unit I **3 Hours**

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

Unit II **4 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 **5 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 **4 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.

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Modes of transaction

-Lectures
-Self-Learning
-Tutorial