Centre for Biochemistry and Microbial Sciences

School of Basic and Applied Sciences
Central University of Punjab, Bathinda

M.Sc. Program in Life Sciences

Specialization: Microbial Sciences

2017-18

Centre for Biochemistry and Microbial Sciences

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Central University of Punjab, Bathinda

Vision Statement

The focus of the centre is to combat the diverse problems related to human, animal and plant health due to microorganisms and to prevent and treat diseases. Further, the centre envisions to utilize the microbes for sustainable solutions to several global issues. The curriculum for M.Sc. Life Sciences program with specialization in Microbial Sciences is designed to train the students in the diverse branches of Microbiology, particularly covering the contemporary global issues. The centre will also promote R&D activities in the emerging areas of microbiology. The centre is involved in the community service and awareness programs related to medical microbiology and biochemistry.

Mission of the Programme

The mission of the programme is to provide excellence in teaching, research and training the students in the various fields of microbiology. The areas of research in the centre include infectious diseases, cancer pathogenesis, vaccine development, nutrition, cardiovascular disease and microbe-mediated plant growth promotion with a focus on translational research.

Goals

- To teach/train students in the diverse fields of microbiology and produce nationally competitive students.
- To perform research in Microbiology for the betterment of society.
- To deliver expert microbiological diagnostic services to the public.

Centre for Biochemistry and Microbial Sciences

School of Basic and Applied Sciences
Central University of Punjab, Bathinda

M.Sc. Program in Life Sciences (Specialization: Microbial Sciences)
(Academic Session 2017-18)

Semester – I

Course Code	Course Title	L (hr)	T (hr)	P (hr)	Cr
	Foundation Courses				
LBM.501	Research Methodology & Biostatistics	2	1		3
	Core Courses				
LBM.503	Biochemistry	2	1		3
LBM.504	Microbiology	2	1		3
LBM.505	Cell Biology	2	1		3
LBM.506	Essentials of Genetics	2	1		3
LBM.502	Life Sciences Practical I			10	5
	Elective Courses (opt any one)				
LMS.550	Microbial Systematics	2			2
	Opt any course from Life Sciences				
	Interdisciplinary Course (ID)				
LBM.401	Basics of Biochemistry	2			2
	Semester–I: Total Credits				**24**

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

Examination Pattern

A: Continuous Assessment: Based on Objective Type Tests (10%), Term Paper (10%) and Assignment(s) (5%)

B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

D: End-Term Exam (Final): Based on Objective Type Tests (25%)

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Foundation Courses

LBM.501: Research Methodology and Biostatistics

Learning Objective: 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	Syllabus	Lectures
1.	**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.	10
2.	**Good Laboratory Practices:** 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.	8
3.	**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.	12
4.	**Inferential Statistics:** 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.	14

Suggested Reading:

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

Core Courses

LBM.503: Biochemistry

Learning Objective: The course is designed to teach fundamental and basics of biochemistry and to prepare them for advanced courses in biochemistry.

Unit	Syllabus	Lectures
1.	**Principles of Biophysical Chemistry:** pH, Buffer, Reaction kinetics, Thermodynamics, Colligative properties, Structure of atoms, Molecules and chemical bonds. Stabilizing interactions: Van der Waals, Electrostatic, Hydrogen bonding & Hydrophobic interactions.	10
2.	**Composition, Structure and Function of Biomolecules:** Carbohydrates, Lipids, Proteins, Nucleic acids and Vitamins. Secondary, Tertiary and Quaternary structures, Domains, Motif and Folds. Stability of protein. A-, B-, Z-DNA, tRNA, micro-RNA, and Nucleic acid structures.	12
3.	**Enzymology:** Classification, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics, Enzyme regulation, Isozymes and Clinically important enzymes.	10
4.	**Bioenergetics and Metabolism**: Thermodynamics, Carbohydrates, Lipids, Amino Acids and Nucleotides.	16

Suggested Reading:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry.* W.H. Freeman & Company. USA.
2. Haynie, D.T. (2007). *Biological thermodynamics*. Cambridge University. UK.
3. Mathews, C.K., Van Holde, K.E. and Ahern, K.G. (2000). *Biochemistry*. Oxford University Press Inc. New York.
4. Nelson, D. and Cox, M.M. (2008). *Lehninger Principles of Biochemistry*. BI publications Pvt. Ltd. Chennai, India.

Additional reading:

5. Ochiai, E. (2008). *Bioinorganic chemistry: A survey.* Academic Press. Elsevier, India.
6. Raven, P.H., Johnson, G.B. and Mason, K.A. (2007). *Biology*. Mcgraw-Hill. USA.
7. Shukla AN (2009). *Elements of enzymology.* Discovery Publishing. New Delhi, India.
8. Voet, D. and Voet, J.G. (2008). *Principles of biochemistry*. CBS Publishers & Distributors. New Delhi, India.

LBM.504: Microbiology

Learning Objective: Students will learn the basics of microbes, microbial growth, their application in day to day life and beneficial versus harmful micro-organisms.

Unit	Syllabus	Lectures
1.	**Introduction to Microbiology:** Scope and history of Microbiology, Cell structure, function and classification of Bacteria, Fungi, Protozoa, Algae, and viruses.	12
2.	**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	14
3.	**Cultivation and Control of Microbes:** Types of growth media (natural, synthetic, complex, enriched, selective- definition with example), pure culture methods (streak plate, spread plate, pour plate, stab culture, slant culture). Control of microbes- Sterilization, disinfection, antiseptic, tyndallization, pasteurization: Physical- dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, Chemical methods- antimicrobial drugs, Antibiotic assays, and Drug resistance in bacteria.	12
4.	**Applied Microbiology:** Food, Dairy and Agricultural Microbiology, Industrial Microbiology. Major bacterial diseases of animals and plants, Airborne, Food-borne, Soil-borne, Nosocomial and Sexually Transmitted/Contagious Diseases, Bacterial and Viral pathogenesis, Major viral diseases of plants and animals.	14

Suggested Reading:

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

Additional Reading:

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

LBM.505: Cell Biology

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

Unit	Syllabus	Lectures

1.	**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.	12
2.	**Structural Organization and Function of Intracellular Organelles**: The lysosomes, Ribosomes, The peroxisomes, The golgi apparatus, The endoplasmic reticulum, Mitochondria and chloroplast, Structure of mitochondria and chloroplast, Oxidation of glucose and fatty acids, Electron transport oxidative phosphorylation, Chloroplast and photosynthesis. **Protein Secretion and Sorting:** Organelle biogenesis and protein secretion, synthesis and targeting, of mitochondria, chloroplast, peroxisomal proteins, translational modification in the ER. Intracellular traffic, vesicular traffic in the secretary pathway, protein sorting in the Golgi bodies, traffic in the endocytic pathway, exocytosis.	14
3.	**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.	14
4.	**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.	14

Suggested Reading:

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.
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

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LBM.506: Essentials of Genetics

Learning Objective: Students will learn the basic principles of inheritance at the molecular, cellular and organismal levels.

Unit	Syllabus	Lectures
1.	**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.	14
2.	**Gene Mapping Methods:** Linkage maps; homothallism, heterothallism and tetrad analysis in yeast, 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	14
3.	**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; Mutations and Hardy Weinberg equilibrium. Molecular basis of spontaneous and induced mutations. Transposons – Types of transposons and their properties.	12
4.	**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	14

Suggested Reading:

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.

LBM.502: Life Sciences Practical-I

Pertaining to theory courses: **Biochemistry, Microbiology, Cell Biology & Genetics**

1. Instrumental methods for Life Sciences-Microscopy, centrifugation, chromatography.
2. Preparation of solutions, buffers, pH setting etc.
3. Quantitative estimation of proteins, sugars, total lipids and amino acids.
4. Isolation of protein from human blood.
5. Principle and application of electrophoresis (Native, and SDS-PAGE), and staining.
6. Enzyme activity assays: invertase, amylase, alkaline phosphatase
7. Quantitative estimation of phenolic compounds.
8. Isolation of pure culture techniques.
9. Staining methods: Simple staining, Negative Staining, Gram Staining, Acid-Fast stain.
10. Microbial growth studies.
11. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip).
12. Study of structure of cell organelles through electron micrographs (demonstration).
13. To demonstrate the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B.
14. Study of polyploidy in onion root tip by colchicine treatment.
15. Identification of inactivated X chromosome as Barr body and drumstick.
16. Blood group typing using haemagglutination tests.
17. To test PTC tasting ability in a random sample and calculate gene frequencies for the taster and non–taster alleles.
18. Studies of a Model organism: Identification of normal and mutant flies (*Drosophila melanogaster*) & Preparation of *Drosophila* polytene chromosomes.
19. Induction of mutations by physical/chemical mutagens, screening and isolation of mutants, Replica plating technique.

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

Elective Courses

LMS.550: Microbial Systematics

Learning Objective: This course is designed to understand the basic taxonomy, diversity and classification of micro-organisms.

Unit	Syllabus	Lecture
1.	**Microbial Systematics:** Definition, Nomenclatural rules, classification and identification. Major characteristics used in taxonomy – morphological, physiological and metabolic, genetic and molecular taxonomy. **Archaea:** Systematics, and occurrence, diversity, characteristic features, significance and potential applications of different groups of archaebacteria.	8
2.	**Bacteria:** Conventional and molecular systematics, and general discussion on the occurrence, diversity, characteristic features, significance and potential applications of various groups of bacteria according to Bergey's Manual of Systematic Bacteriology. **Fungal Systematics and Diversity:** General features of fungi- cell structure; growth, environmental conditions for growth; nutrition and life cycle patterns,	10

	parasexuality and heterothallism. General features of fungi, classification cell structure; growth; nutrition and life cycle patterns, parasexuality and heterothallism. Endophytic fungi as latent pathogens and biocontrol agents.	
3.	**General Virology**: Discovery of viruses, morphology, viral genome – types and structures; nomenclature and classification of virus (Animal, plant, bacterial viruses). Structural organization of bacteriophages and their life cycle. Animal and Plant Viruses: Life cycle and replication of animal viruses, Structure of plant viruses like TMV, viriods; Brief outline of cyanophages and mycophages.	10
4.	**Algae:** Distribution; classification and nutrition; 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.	8

Suggested Reading:

1. Balows, A., Trüper, H. G., Dworkin, M., Harder, W., Schleifer, K. H. (1992) *The Prokaryotes. A Handbook on the Biology of Bacteria: ecophysiology, isolation, identification, applications*. Volumes I-IV Springer-Verlag, New York.
2. Logan, A., Niall A. Logan (1994) *Bacterial Systematics*, Wiley-blackwell.
3. R.M. Atlas *(1985) Principles of Microbiology* , Mosby publishers, St. Louis;
4. Madigan and John M. Martinko, Paul V. Dunlap, David P. Clark (2008) *Brock Biology of Microorganisms* (12th edition) BenjaminCummings Publishing Company
5. Gerard J Tortora, Berdell R Funke, Christine L Case (2008) *Microbiology: An Introduction* Benjamin Cummings Publishing Company.
6. Elizabeth Moore (1996) *Fundamentals of the Fungi*, Fourth edition, Benjamin Cummings; Landecker.
7. Mahendra Rai IK (2007) *Mycotechnology: Present status and future prospects*. International Publishing House Pvt. Ltd.
8. Carlos A. Rosa and Gabor Peter. (2006) *The Yeast Handbook: Biodiversity and Ecophysiology of yeasts.* Springer Verlag Berlin Heidelberg.
9. Laura Barsanti and Paolo Gualtieri (2006) *Algae: Anatomy, Biochemistry and Biotechnology*. Taylor and Francis Group, LLC.
10. Mark F. Wiser (2011). *Protozoa and Human Disease,* Garland Science Taylor and Francis.

Interdisciplinary Course

LBM.401: Basics of Biochemistry

Learning Objective: 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.

Unit	Syllabus	Lectures
1.	**Principles of biophysical chemistry:** pH, Buffer, Reaction kinetics, Thermodynamics.	4
2.	**Composition, structure and function of Biomolecules:** Carbohydrates, Lipids, Proteins: Primary, Secondary, Tertiary and Quaternary structures, Nucleic acids: A-, B-, Z-DNA, tRNA, and micro-RNA. Vitamins.	8

3.	**Primary Metabolic pathways:** Carbohydrate metabolism; Glycolysis, Kreb's Cycle, Respiration, Hexose monophosphate shunt pathway, Glycogenolysis, Glycogenesis. Protein metabolism; Amino acid synthesis, Urea Cycle. Lipid peroxidation, Fermentation, fatty acid metabolism, nucleic acid metabolism	14
4.	**Enzymology:** Classification of enzymes, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics, Enzyme regulation, Isozymes.	6

Suggested Reading:

1. Satyanarayana, U. (2013) *Biochemistry*, Publisher: Elsevier; Fourth Edition.
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.

Additional Reading:

1. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. John Wiley & Sons. Inc. New Delhi, India.

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Semester – II

Course Code	Course Title	L (hr)	T (hr)	P (hr)	Cr
	Core Courses				
LBM.507	Immunology	2	1		3
LBM.508	Molecular Biology	2	1		3
LMS.509	Microbial Physiology and Metabolism	2	1		3
LMS.511	Clinical Microbiology	2	1		3
LMS.512	Microbiology Practical-I			6	3
LBM.513	Life Sciences Practical –II			6	3
	Elective Courses (opt any one)				
LBM.514	Techniques in Life Sciences	2			2
	Opt any course from Life Sciences				
	Seminar				
LBM.596	Seminar	1			1
	Interdisciplinary Course (ID)				
LMS.451	Basics of Microbiology	2			2
	Total Credits				**23**

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

Examination Pattern

A: Continuous Assessment: Based on Objective Type Tests (10%), Term Paper (10%) and Assignment(s) (5%)

B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

D: End-Term Exam (Final): Based on Objective Type Tests (25%)

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Core Courses

LBM.507: Immunology

Learning Objective: The objective of this course is to instill awareness on basics of immune system where students will learn the components of immunity and various immune responses that work together to protect the host.

Unit	Syllabus	Lectures
1.	**Immune System:** Overview of immune system; cells and organs of immune systems; innate and acquired immunity, Recognition of self and non-self, Humoral immunity-immunoglobulins, basic structure, classes and subclasses, structural and functional relationships, nature of antigen, antigen-antibody reaction, estimation of affinity constants. **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. Lymphocytes, cytokines, interferons, interleukins, antigen recognition-membrane receptors for antigens	14
2.	**Complement System and Major Histocompatibility System:** Complement components, their structure and functions and mechanisms of complement activation by classical, alternative and lectin pathway. 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, & tumor immunology.	14
3.	**Hypersensitivity:** Types, features and mechanisms of immediate and delayed hypersensitivity reactions, immunity to microbes, immunity to tumors, AIDS and immune-deficiencies, hybridoma technology and vaccine, natural, synthetic and genetic, development of vaccine for diseases like AIDS, cancer and malaria.	12
4.	**Monoclonal Antibodies and Diagnostic Immunology:** Production, characterization and applications in diagnosis, therapy and basic research, immunotoxins, concept of making immunotoxins. Methods for immunoglobulin determination-quantitative and qualitative antigen and antibody reactions, agglutination-precipitation, immunoflourescence and immunoblotting and assessment of human allergic diseases.	14

Suggested Reading:

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*. Wiley-Blackwell, USA.

Additional reading:

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.

LBM.508: Molecular Biology

Learning Objective: This course is designed for understanding the molecular processes of DNA replication, transcription, translation, and basic mechanisms of cellular signal transduction and regulation of gene expression.

Unit	Syllabus	Lectures
1.	**Structure and Conformation of Nucleic Acids:** Structure of DNA, Denaturation and Renaturation, Conformation of nucleic acids (A, B, Z), Organelle DNA: mitochondria and chloroplast DNA **Genome organization:** Chromosome Structure, Chromatin and its regulation, nucleosome and its assembly, nucleolus, repetitive DNA, transposons & retrotransposons **Molecular Techniques and Bioinformatics:** Gel electrophoresis, cloning, PCR, real-time PCR, DNA sequencing including NGS, microarrays, biological databases and searches, analysis of genomic and proteomic data, DNA-protein interactions, protein-protein interactions, protein sequencing	14
2.	**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, genome editing. **Recombination:** Site-specific, homologous, transposition and non-homologous end joining (NHEJ).	14
3.	**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, Operon Concept	14
4.	**Translation:** Genetic code, prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co-and post- translational modifications **Gene Regulation:** Prokaryotic – lac, trp, gal and ara operons, lambda gene regulation during lysogeny and lytic cycle; Eukaryotic – yeast, higher eukaryotes, epigenetic regulation.	14

Suggested Reading:

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.

LMS.509: Microbial Physiology and Metabolism

Learning Objective: Microbial Physiology is the study of structure, function, energy metabolism, growth and regulatory mechanisms of microorganisms. 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.

Unit	Syllabus	Lecture

1	**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.	12
2	**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.	14
3	**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.	14
4	**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.	14

Suggested Reading:

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

LMS.511: Clinical Microbiology

Learning Objective: The students will understand about the disease causing microbes, various cellular processes during disease development and the relevance of microbes in vaccine development.

Unit	Syllabus	Lecture
1	**Introduction:** Important developments in medical microbiology, Concept of epidemic, endemic and pandemic, acute, chronic, morbidity, mortality, prevalence, incidence, Normal microflora of human body and their advantage, Opportunistic infections, sources of infection for man, gnotobiotic study, vehicles or reservoirs of infection; exogenous infection i) patients, ii) carriers (healthy, convalescent, contact, paradoxical and	16

	chronic), iii) infected animals (zoonosis), iv) soil endogenous infection, v) water borne infections; Mode of spread of infection : i) respiratory, ii) skin, iii) wound & burn infection, iv) veneral infection, v) alimentary tract infection, vi) Arthropods borne infection, vii) laboratory borne infection & nosocomial infection. Infections of nervous system, General concepts for clinical specimen collection and biosafety levels.	
2	**Molecular Basis of Microbial Pathogenesis:** Molecular Koch's postulates, Process of infection-Types, stages of infection, 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, aggressins and toxins.	12
3	**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*	12
4	**Antibacterial agents:** Mode of action of antibiotics and chemotherapeutic drugs. Antibiograms. Antibiotic sensitivity assays- disc method; replica plating technique; Ames test; Antibiotic resistance in bacteria-various factors that contribute to the development of resistance, MDR Biofilms. **Vaccinology:** Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines. Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies.	12

Suggested Reading

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, J*ohn 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

LMS.512: Microbiology Practical –I

Pertaining to Theory Papers: **Microbial Physiology and Metabolism, and Clinical Microbiology**

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. Isolation of Photosynthetic bacteria
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.
7. Isolation and cultivation of autotrophic microbes
8. Culturing methods of microbes – slant and stab cultures, tube culture, flask cultures, shake flask cultures
9. Anaerobic culturing methods – anaerobic jar and its use, pyrogallol method, thioglycollate media culturing, anaerobic glove box and its application.
10. Microbial growth experiments – Viable count of growing cultures and generation time determination
11. Determination of microbial growth by turbidometric methods, Study of bacterial growth curve, Factors effecting the microbial growth,
12. Methods for studying microbial respiration
13. Preparation of different types of culture media/observation. Blood Agar, Chocolate Agar, 28. Mannitol salt agar, Blair Parker medium, MacConkey agar, Lowensten-Jension medium, Wilson Blair Bismuth sulphite medium, Biochemical media.
14. Tests for disinfectants (Phenol coefficient/RWC)
15. Study of normal micro-biota of mouth; isolation, identification and preservation of microorganisms
16. Study of normal micro-biota of skin; isolation identification and preservation of microorganisms
17. Identification and Biochemical tests of respiratory tract bacterial pathogen using avirulent strain of MTCC Culture of *Streptococci/ Klebsiella pneumoniae*.
18. Identification and Biochemical tests of gastrointestinal bacterial infection using avirulent strain of MTCC Culture of *Salmonella / Shigella* spp.
19. Laboratory examination and identification and biochemical tests of pus specimens using avirulent strain of MTCC Culture for *Staphylococcus aureus*, *Streptococcus pyogenes* and *Pseudomonas aeruginosa*.
20. 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.
21. Determination of MIC values for antimicrobial chemicals
22. Identification of pathogenic bacteria (any three of *E. coli*, *Salmonella*, *Pseudomonas*, *Staphylococcus*, *Bacillus*) based on cultural, morphological and biochemical characteristics.
23. Biochemical, enzymatic and serological tests (Coagulase, Catalase, WIDAL, VDRL tests).
24. PCR based diagnosis.

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

LBM.513: Life Sciences Practical-II

Pertaining to theory courses: **Immunology and Molecular Biology**

1. Isolation of mononuclear cells from peripheral blood and viability test by dye exclusion method.
2. Separation of serum from blood.
3. Double immunodiffusion test using specific antibody and antigen.
4. Dot Immuno blot assay (DIBA).
5. ELISA.
6. To perform immunoelectrophoresis.
7. Polyacrylamide gel electrophoresis and Western blotting.
8. Growth and maintenance of cell line(s).
9. Trypsinization method for recovery of cells from monolayer.
10. Demonstration of Flow Cytometry.
11. Cytotoxic assay method for a given cell line and testing by trypan blue dye exclusion

method.
12. To perform Total Leukocyte Count of the given blood sample.
13. To perform Differential Leukocyte Count of the given blood sample.
14. Isolation of genomic DNA from human blood and plants.
15. Digestion of DNA using restriction enzymes (RE) and agarose gel electrophoresis.
16. Ligation and *E.coli* transformation using chemical transformation, plating, colony selection, plasmid DNA isolation, RE digestion and agarose gel electrophoresis.
17. Construction of restriction map by single and double digestion, Designing DNA probe, Southern blot hybridization (demonstration only).
18. Amplification of known DNA sequences by Polymerase Chain Reaction (PCR).
19. RNA isolation from human cell lines or plants.
20. cDNA synthesis and RT-PCR.
21. Real-time PCR and DNA sequencing (demonstration only).
22. NCBI BLAST, Primer design, Multiple Sequence Alignment and Phylogenetic analysis of molecular data using MEGA
23. Determination of genes mapped within a specific chromosomal locus using GeneLoc integration resource, Gene orthologue prediction using Ensembl.

- Practical may be added/modified from time to time.

Elective Courses

LBM.514: Techniques in Life Sciences

Unit	Syllabus	Lectures
1.	**Good Laboratory Practices**: Sterilization techniques, Spectrometry: Colorimetry, mass, UV, IR, NMR and atomic absorption spectrophotometery, Centrifugation: Principle and applications, Ultracentrifugation. Chromatography: Principle, procedure and applications of thin layer chromatography (TLC), gel filtration and ion exchange, affinity chromatography, GC, GLC, HPLC and FPLC.	10
2.	**Microscopy:** Light microscopy, phase contrast microscopy, fluorescent microscopy, scanning electron microscopy (SEM/FESEM), transmission electron microscopy (TEM), micrometry and photomicrography, Histochemistry, Scanning-probe microscopy, Atomic force microscopy, CLSM.	6
3.	**Nucleic Acids:** Isolation, purification and analysis of nucleic acids. Electrophoresis: Principle of gel electrophoresis, polyacrylamide gel electrophoresis (PAGE and SDS-PAGE), agarose gel electrophoresis, pulse field gel electrophoresis (PFGE) and 2-Dimensional gel electrophoresis. Polymerase chain reaction (PCR): Principle, types and applications, PCR based markers: RAPDs, SSRs, SNPs, ISSRs, and SCARs etc. Blotting techniques: Southern, Northern, Western, Dot blotting and hybridization, DNA fingerprinting.	10
4.	**Immunology Techniques:** Flow cytometry, Hybridoma technology/Production of antibodies, Histochemical and	10

	Immunotechniques, Immunochemical Techniques, Developing Monoclonal and Polyclonal antibodies, Immunocytochemistry, Radioimmunoassay (RIA), Enzyme Linked Immunosorbent Assay (ELISA). **Mutation Analyses Techniques:** Restriction mapping, SSCP analyses, DNA sequencing-manual and automated methods. **Cell and tissue culture techniques:** Plants and animals.	

Suggested Reading:

1. Brown, T.A. (2010). *Gene cloning and DNA analysis: An Introduction*. 6th Edition, Wiley-Blackwell Publisher, New York.

2. Goldsby, R.A., Kindt, T.J. and Osborne, B.A. (2008). *Kuby Immunology.* 6th Edition, W. H. Freeman & Company, San Francisco.

3. Gupta, P.K. (2005). *Elements of biotechnology*. Rastogi Publications, Meerut.

4. Gupta, S. (2005). *Research methodology and statistical techniques*, Deep & Deep Publications (P) Ltd. New Delhi.

5. Kothari, C.R. (2008.) *Research methodology(s)*. New Age International (P) Ltd., New Delhi

6. Lewin, B. (2010). *Genes X*, CBS Publishers & Distributors. New Delhi.

7. Mangal, S.K. (2007). *DNA Markers In Plant Improvement*. Daya Publishing House, New Delhi.

8. Nelson, D. and Cox, M.M. (2009). *Lehninger Principles of Biochemistry*. W.H. Freeman and Company, New York.

9. Primrose. S.B. and Twyman, R. (2006). *Principles of Gene Manipulation and Genomics.* Blackwell Publishing Professional, U.K.

10. Sambrook, J. (2006). *The Condensed Protocols from Molecular Cloning: A Laboratory Manual.* Cshl Press. New York.

11. Sambrook, J. and Russell, D.W. (2000). *Molecular Cloning: A Laboratory Manual* (3 Vol-set). 3rd Edition, CSHL Press, New York.

12. Sawhney, S.K. and Singh, R. (2005). *Introductory Practical Biochemistry*. Narosa Publishing House, New Delhi.

13. Slater, A., Scott, N.W. and Fowler, M.R. (2008). *Plant Biotechnology: The Genetic Manipulation of Plants*. Oxford University Press, USA.

14. Wilson, K. and Walker, J. (2006). *Principles and Techniques of Biochemistry and Molecular biology*. 6th Edition, Cambridge University Press India Pvt. Ltd., New Delhi.

Interdisciplinary Course (ID)

LBM.451: Basics in Microbiology

Learning Objective: 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.

Unit	Syllabus	Lecture
1	**Historical Background and Scope of Microbiology**: Impact of microbes on human affairs. Salient features of different groups of microorganisms such as bacteria, fungi, protozoa and algae including their morphological	8

	features, mode of reproduction and cell cycle. Benificial applications of microbes.	
2	**Microbial Growth, Nutrition and Classification:** The definition of 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. Basic principles and techniques used in bacterial classification. Phylogenetic and numerical taxonomy. General characteristics, structure and classification of plant animal and bacterial viruses.	12
3	**Pathogens.** A brief account of bacteria of medical importance e.g. *Mycobacteria, Salmonella, Shigella, Haemophilus, Staphylococcus* and *Streptococcus.* Lytic and lysogenic cycle in bacteriophages. A Brief account of Retroviruses, Viroids, Prions and emerging viruses such as HIV, Avian and swine flu viruses. Brief account medically important fungi. . Brief account of medically important protozoans like *Plasmodium, Trypanosoma, Leishmania, Entamoeba* etc.	12
4	**Control of Microorganism:** Control of Microorganism by physical and chemical agents. Antiseptics and disinfectants. Narrow and broad spectrum antibiotics. Antifungal antibiotics, Mode of action of antimicrobial agents. Antibiotic resistance mechanisms. Pre and probiotics.	8

Suggested Reading

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.

LBM.596: Seminar

Learning Objective: To read the recent scientific articles and give presentation on a recent topic of biochemistry to further improve student scientific writing and presentation skills.

The students select an advanced topic in biochemistry and related fields; they prepare a presentation of approximately 20 minutes based on recent literature available and recent advances on that topic. The students prepare a report of 15-20 pages.

Evaluation Criterion: Students are evaluated for total of 100 marks, out of which 50 marks are for the Literature survey/background information, Organization of content, Presentation and Discussion. The remaining 50 marks are for the report submitted by the student.

Centre for Biochemistry and Microbial Sciences

School of Basic and Applied Sciences
Central University of Punjab, Bathinda

Semester – III

Course Code	Course Title	L (hr)	T (hr)	P (hr)	Cr
	Core Courses				
LMS.515	Industrial and Environmental Microbiology	3	1		4
LMS.516	Food and Dairy Microbiology	2			2
LMS.517	Bacteriology and Virology	3	1		4
LMS.518	Microbiology Practical –II			6	3
	Elective Courses (opt any one)				
LBM.551	Genetic Engineering	2			2
	Opt any course from Life Sciences				
	Research				
LMS.599	Research Project (Part – I)			16	8
	Total Credits				**23**

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

Examination Pattern

A: Continuous Assessment: Based on Objective Type Tests (10%), Term Paper (10%) and Assignment(s) (5%)

B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

D: End-Term Exam (Final): Based on Objective Type Tests (25%)

Core Courses

LMS.515: Industrial and Environmental Microbiology

Learning Objective: The students will study the use of microorganisms for the value added products through fermentation processes. Further, they will learn and understand the composition of industrial waste water and xenobiotics, and their treatment using microorganisms.

Unit	Syllabus	Lectures
1	**Introduction:** Scope and historical development; Isolation, screening, genetic improvement and maintenance of industrially important microorganisms, Industrially important microorganisms, Screening techniques - Detection and assay of fermentation products - Strain improvements - Mutations, protoplast fusion and rDNA techniques for strain development. Types of fermentation systems; Bioreactor designs and operations.	8
2	**Microbes in Industry:** Production of fermented beverages, single cell protein; Recombinant DNA technology based products; Biotransformation. Overproduction of metabolites; Metabolic pathway engineering of microbes for production of novel products for industry; Downstream processing; Immobilization of cells/enzymes. Synthesis of commercial products using microbial systems: Biopolymers-xanthan gum and PHA's (Bioplastics), Microbial enzymes-lipases and alkaline proteases. Genetically modified microbes in agriculture and the environment. Isolation of industrially important microorganisms, their maintenance and improvement. Production of primary and secondary metabolites. e.g. alcohol, organic acids, organic solvents, amino acids, enzymes, antibiotics and their recovery.	12
3	**Production of Biotechnological Products and their Significance:** Commercial production of microbial products. Production Bacitracin, Streptomycin, Riboflavin, B-carotene, Gibberellins, glutamic acid and surfactants. Commercially useful non-microbial products produced through microbes - insulin, interferons. Production of SCP - *Spirulina* and yeast. Industrial biotechnology for pollution control, treatment of industrial and other wastes; Production of ecofriendly chemicals, e. g. biopesticides, bioinsecticides, biofertilizers, biofuels etc. Production of biofertilizers. Immobilization of cells and enzymes. Thermostable enzymes: Taq & Pfu. Biosensors and Biochips. Microbes as sources of nanoparticles, microbial producers of nanoparticles, advantages of microbial nanoparticles, applications, social and ethical implications.	14
4	**Microbiology of Waste-water:** Occurrence and distribution of microbes in water, Role of organic pollution of water, techniques for measurement of microorganisms in aquatic ecosystems, Algal bloom, Concepts of 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. **Microbial Toxicology and Degradation of Xenobiotics:** General chemistry of pollutants viz., particulate matter, poly-aromatic hydrocarbonds, organosulfur,	20

	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 Concepts of xenobiotics, bio-concentration and bio-magnification, Bio-transformation and biodegradation of xenobiotics like organophosphates and organohalides compounds, plastic, paints.	

Suggested Reading

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. Baker, K.H. And Herson D.S. (1994). *Bioremediation*. MacGraw Hill Inc. N.Y.
7. Ec Eldowney, S. Hardman D.J. and Waite S. (1993). Pollution: Ecology and Biotreatment Longman Scientific Technical.
8. R. K. Trivedy (1998) *Advances in Waste Water Treatment Technologies*. Volumes II and I. Global Science Publication.
9. Lawrence, P., Wacekett, C. and Douglas Hershberger. (2000) *Biocatalysis and Biodegradation: Microbial transformation of organic compounds.* ASM Publications.
10. Christon J. Hurst (2001). *A Manual of Environmental Microbiology*. 2nd Edition. ASM Publications.
11. N.S. Subba Rao. (1995). *Bio-fertilizers in Agriculture and Forestry*.

LMS.516: Food and Dairy Microbiology

Learning Objective: 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.

Unit	Syllabus	Lectures
1.	**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.	8
2.	**Microbial growth in food: I**ntrinsic, 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.	8

3.	**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.	10
4.	**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), ction Agency), HACCP (Hazard Analysis and critical control points), ISI (Indian Standard Institute).	8

Suggested Reading:

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 edition.
6. Doyle, M. P. and Beuchat, L. R., 2007, Food Microbiology- Fundamentals and
7. Frontiers, ASM Press.
8. Elmer H. Marth, James Steele, (2001). Applied Dairy Microbiology, Second Edition, CRC press.

LMS.517: Bacteriology and Virology

Learning Objective: This course will introduce the students to the wide world of bacterial pathogens related to human health and viruses that affect humans, animals, insects, bacteria, fungi, and plants in community, agricultural, and natural environments. It will also acquaint the students about various aspects of viruses with particular emphasis on disease prevention, treatment and pathogenicity with their practical use in gene therapy.

Unit	Syllabus	Lectures
1	**Biology of Pathogenic Bacteria:** Morphological characteristics, pathogenesis and laboratory diagnosis including rapid methods of following pathogenic bacteria; *Staphylococcus, Streptococcus, Enterococcus, Escherechia coli, Neisseria, Klebsiella, Proteus, Salmonella, Shigella, Virbrio, Campylobacter, Pseudomonas, Acinetobacter, Yersinia, Francisella, Pasteurella, Treponema, Mycoplasma, Klebsiella, Haemophilus, Bordetella, Bacillus, Clostridium, Corynebacterium, Mycobacterium, Actinomyces, Nocardia, Bacteroides, Fusobacterium, Listeria, Legionella. Mycoplasma, Rickettsiae, Chlamydiae, Spirochetes.*	14
2	**Classification, Morphology and Biology of Viruses:** Virus evolution and classification, properties of viruses, virus structure, Chemical composition -	14

	proteins, nucleic acids, and enzymes and virus replication. **Replication Patterns of Specific Viruses**: Replicative strategies employed by animal DNA viruses. Replicative strategies employed by animal RNA viruses. Identification of virus prototypes associated with different virus replication schemes; Details on important viruses namely Herpesvirus, Poliovirus, Influenza virus, VSV, SV40 and Adeno Virus, Poxviruses, Hepatitis Viruses, coronaviruses, Retroviruses. Oncogenesis: oncogenic viruses, viral transformation by activation of cellular signal transduction pathways, viral transformation via cell cycle control pathways. **Subviral pathogens:** HDV, Prions, Viroids.	
3	**Recognition and Pathogenesis of Viral Infection:** Study of different pathogen recognition receptor related to viruses, Mechanism of host cell damage- Host cell 'shut off', apoptosis, necrosis, and alteration of signaling pathways. Stages of infection, Patterns of some viral diseases- epidemiology, transmission, infection, symptoms, risk, emerging viruses. **Anti-viral strategies-prevention and Control of Viral Diseases:** Host specific and nonspecific defense mechanisms involved in resistance to and recovery from virus infections. Role of interferon and NF-kB in viral infections. Contributions of various host defense mechanisms in viral infections; **Viral Chemotherapy and Vaccines:** Nucleoside analogs, reverse transcriptase inhibitors, protease inhibitors: mechanism of action and drug resistance, History of vaccines especially smallpox and polio, subunit vaccines and DNA vaccines. **Modern Approaches of Virus Control:** Antisense RNA, siRNA, ribozymes, viruses as therapeutic agents, viruses for gene delivery, viruses to destroy other viruses.	14
4	**Diagnostic Virology:** Visualization and enumeration of virus particles, Detection of viruses: physical, biological, immunological and molecular methods. Serological methods – haemaglutinin and HAI, complement fixation, immunofluorescence methods, ELISA and RIA: Physical, chemical and molecular methods- protein, radioactive tracers, electron microscopy, PCR based assays, flow cytometry and immunohistochemistry. Infectivity assays for phages and plant viruses. Characterization of viral product expressed in the infected cells. Isolation and purification of viruses. **Microbial Viruses:** Diversity, classification, characteristics and applications of bacteriophages, and general account on algal, fungal and protozoan viruses.	12

Suggested Reading:

1. S.J. Flint, L.W. Enquist, V.R. Racaniello, and A.M. Salka. (2004) *Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses,* 2nd edition, ASM Press, Washington, DC.
2. Nigel Dimmock, Andrew Easton and Keith Leppard (2005) *Introduction to Modern Virology*, 5th edition, Blackwell Publishing.
3. Edward K. Wanger, Martinez Hewiett, David Bloom, David Camerini. (2007) *Basic Virology* by 3rd edition, Blackwell Publishing.
4. Alan J. Cann (2001) *Principles of Molecular Virology*, 3rd edition, Elsevier Academic Press.
5. Roger Hull (2002) *Plant Virology*, 4th edition, Academic Press.
6. Atlas, R.M. (1994) *Principles of Microbiology*, McMillan, New York

7. Madigan,M.T., Martinko, J.M., Bender, K., and Buckley, D. (2011) *Brock Biology of Microorganisms,* 13th Ed., Pearson Education, USA
8. C. George Ray, John C. Sherris, Kenneth J. Ryan. (2003). *Sherris Medical Microbiology: An introduction to Infectious Diseases*, Hardcover: 992 pages, Publisher: McGraw-Hill Professional.
9. Willey, J.M., Sherwood, L., and Woolverton, C. (2013) *Prescott's Microbiology* 9th Revised Edition, McGraw Hill Higher Education, New York.

LMS.518: Microbiology Practical –II

Pertaining to Theory Papers: **Industrial and Environmental Microbiology and Food and Dairy Microbiology**

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

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

LBM.551: Genetic Engineering

Learning Objective: The aim of this core-course is to 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

Unit	Syllabus	Lectures
1.	**Tools of Genetic Engineering:** Restriction enzymes, Enzymes in genetic engineering, recombinant cloning vectors & their biology (Plasmid, Phage and yeast-based), transformation and selection, genomic and cDNA library construction & DNA-sequencing techniques	8
2.	**Recombinant Expression Systems & Mutagenesis:** prokaryotic (Fusion proteins, surface display, removal of selectable marker genes, secretion into periplasm & medium) & eukaryotic (*Saccharomyces cerevisiae*, *Pichia pastoris*, Baculovirus-insect, Mammalian cell expression system), oligonucleotide-directed and site-directed mutagenesis	10
3.	**Biotechnology of Microbial Systems:** Vaccines (subunit-, peptide-, attenuated-, DNA- and vector-based), Enzymes, Antibiotics, Bioremediation, Gene therapy	8
4.	**Biotechnology of Eukaryotic Systems:** Engineering of plants (Ti-based system, Chloroplast engineering, Insect resistance, Salt & Drought stress & Oxidative stress), Transgenic animals (Transgenic mice, Transgenic livestock, Transgenic poultry), Regulation of recombinant DNA technology, Concerns about safety of consuming genetically modified foods, concerns about the impact of genetically modified organisms on the environment.	10

Suggested Reading:

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.

LMS.599: Research Project (Part – I)

Course Objective: The objective of research project part I would be to 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 with simultaneous identification of scientifically sound (and achievable) objectives backed by a comprehensive and detailed methodology.

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, and 5. Management of time and resources 6. Synopsis presentation

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Semester – IV

Course Code	Course Title	L (hr)	T (hr)	P (hr)	Cr
	Core Courses				
LMS.519	Microbial Biotechnology and its Applications	3	1		4
	Research				
LMS.599	Research Project (Part –II)			32	16
	Total Credits				**20**

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

Examination Pattern

A: Continuous Assessment: Based on Objective Type Tests (10%), Term Paper (10%) and Assignment(s) (5%)

B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25%)

D: End-Term Exam (Final): Based on Objective Type Tests (25%)

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LMS.519: Microbial Biotechnology and its Applications

Learning Objective: This course focuses on the application and use of micro-organisms in the pharmaceutical industry, human and livestock health, nanotechnology and removable energy.

Unit	Syllabus	Lectures
1	**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.	12
2	**Significance of Fungi in Human and Livestock Health:** Symbiotic fungi, toxigenic fungi and mycotoxins, pathogenic fungi; Significance of yeasts and fungi in agricultural production – symbiotic fungi, fungi in improving plant productivity, toxigenic fungi and mycotoxins, plant pathogenic fungi, fungi in biocontrol; Significance of fungi in biotechnology and industrial production; Fungal metabolites and their economic significance – mycotoxins, medicinal uses of fungi (antibiotics), food additives, alcohol, vinegar, enzymes, biopesticides. Fungi as food – mushrooms, Mushroom poisoning.	15
3	**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.	15
4	**Microbial Nanotechnology** –Microbial synthesis of Nanoparticles. Synthesis of nanodrugs – metal nanoparticles and drug delivery vechicles – 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.	12

Suggested Reading:

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). *Bionanotechnology: Global Prospects*. CRC Press.

LMS.599: Research Project (Part – II)

Course Objective: The objective would be to ensure that the student learns the nuances of the scientific research and 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 analysed in light of established scientific knowledge to arrive at cogent conclusions.

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