Centre for Biochemistry and Microbial Sciences

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

M.Sc. Program in Life Sciences

Specialization: Biochemistry

2017-18

Centre for Biochemistry and Microbial Sciences

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Central University of Punjab, Bathinda

Vision Statement

The centre strives to synergize the study of biochemistry with health disparities research through innovation and collaboration and to provide the highest quality of translational biomedical research, education, and service. The curriculum for M.Sc. Life Sciences program with a specialization in biochemistry of the centre is designed to train the students in the diverse branches of biochemistry. The centre will also promote R&D activities in the emerging areas of biochemistry. The centre is involved in the community service and awareness programs related to medical biochemistry and microbiology.

Mission of the Programme

The programme is committed to provide outstanding teaching in the biochemical sciences and to conduct quality research of international repute. The mission of the centre is to train competent professional biochemists with the knowledge, skills and values required to address the need for high-level manpower in the country. The tranined students will further carry out creative, innovative and inventive research, and provide reliable services to the community.

Goals:

- Provide high-quality academic programmes in biochemistry.
- Provide graduates with a sound knowledge of the fundamental principles and practice of biochemistry.
- Recruit high quality students.
- Develop and maintain laboratories with state-of-the-art equipment.
- Conduct community service by offering special training programmes, awareness camps and community development.

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

M.Sc. Program in Life Sciences (Specialization: Biochemistry)

(Academic Session 2017-18)

Semester – I

Course Code	Course Title	L (hr)	T (hr)	P (hr)	Cr
	Foundation Courses				
LBM.501	Research Methodology and 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)				
LBC.550	Secondary Metabolites and Metabolic Engineering	2			2
	Opt any other Life Sciences Course				
	Inter-Disciplinary Course (ID)				
LBM.401	Basics of Biochemistry	2			2
	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, Water, 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.

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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:** Environmental microbiology, Microbial ecology, Aquatic 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, Principles of disease and epidemiology, Host-Microbe relationship, 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

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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

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, mapping by using somatic cell hybrids, 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.	16
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	12

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

LBC.550: Secondary Metabolites and Metabolic Engineering

Learning Objective: The course is designed to make the students understand principles of secondary metabolite synthesis in plants and microbes. The course will build knowledge about application of dynamic models to metabolism and analysis of metabolic pathway for its utilization in product formation.

Unit	Syllabus	Lectures
1.	**Secondary Metabolites in Plants:** Terpenoids-Mevalonate pathway and Methylerythritol phosphate pathway, Monoterpenes (C10), Sesquiterpenes (C15), Triterpenes (C30), Diterpenes (C20), Tetraterpenes (C40) and Polyterpenoids; Phenolics-shikimic acid pathway and Malonic acis Pathway, Simple Phenolics (*trans*-cinnamic acid, *p*-coumaric acid and their derivatives), Complex Phenolics (Lignin), Flavonoids, Tanins (Condensed tannin and Hydrolyzable tannins); Nitrogen containing compounds- Alkaloids (Cocaine, Nicotine, Morphine, Caffeine, pyrrolizidine alkaloids), Cyanogenic	10

	Glycosides; Glucosinolates.	
2.	**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.	8
3.	**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.	10
4.	**Tutorials & Case Studies**: Practical for the use of software tools for construction and simulation of small metabolic pathways, Case study using one genome scale metabolic model for the strain improvement for the production of organic metabolites- Ethanol, Acetone; Citric acid, Acetic acid, Lactic acid (Introduction only).	6

Suggested Reading:

1. Taiz, L. and Zeiger, E. (2010). *Plant Physiology*. Sinauer Associates Inc., USA.
2. Dey, P.M. and Harborne, J.B. (2000). *Plant Biochemistry*. Academic Press, UK.
3. Goodwin, T.W. and Mercer, E.I. (2003). *Introduction to Plant Biochemistry*. CBS Publishers & Distributors, New Delhi, India.
4. Crueger, W. and Crueger, A. (1990). *Biotechnology. A Textbook of Industrial Microbiology*. Sinauer Associates., USA.
5. Demain, A. and Solomon, N.A. (1950). *Biology of Industrial microorganisms*. Menlo Park, Calif.: Benjamin/Cummings Pub. Co., Advanced Book Program, CA.
6. David Fell (1997) Understanding the Control of Metabolism, Portland Press, London.
7. Segel, I.H. (1993) Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems. ISBN: 978-0-471-30309-1, 992 pages, Wiley Publication.
8. Stephanopoulos. (1998). Metabolic Engineering: Principles & Methodologies, Published by cbspd
9. Sang Yup Lee, E. Terry Papoutsakis. (1999). *Metabolic Engineering,* CRC Press
10. Orth, J.D., Thiele, I., and Palsson, B.Ø. *What is flux balance analysis?*. *Nature Biotechnology*, **28**: 245-248 (2010).
11. Edwards,J.S., Covert, M., and Palsson, B.Ø. Metabolic Modeling of Microbes: the Flux Balance Approach. Environmental Microbiology, **4(3)**: pp. 133-140 (2002).

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 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.

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
LBM.509	Animal Physiology	3	1		4
LBC.510	Enzymology and Enzyme Technology	2	1		3
LBC.511	Metabolism-I	2	1		3
LBC.512	Biochemistry Practical-I			2	1
LBM.513	Life Sciences Practical-II			6	3
	Elective Courses (opt any one)				
LBM.514	Techniques in Life Sciences	2			2
	Opt any other Life Sciences Course				
	Interdisciplinary Course (ID)				
LBM.451	Basics of Microbiology	2			2
	Seminar				
LBM.596	Seminar	1			1
	Total Credits				**25**

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, interrupted genes, gene shuffling **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.

LBM.509: Animal Physiology

Learning Objective: This course is designed to provide students with an understanding of the function and regulation of physiological systems which will include neural & hormonal homeostatic control mechanisms, as well as study of the musculoskeletal, circulatory, respiratory, digestive, urinary, immune, reproductive, and endocrine organ systems.

Unit	Syllabus	Lectures

1.	**Blood and Circulation:** Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis **Cardiovascular System:** Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above **Respiratory System:**- Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.	18
2.	**Digestive System:** Digestion, absorption, energy balance, BMR. **Excretory System:** Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance	18
3.	**Nervous System:** Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture **Sense organs:** Vision, hearing and tactile response	18
4.	**Endocrinology:** Endocrine glands, basic mechanism of hormone action, hormones and diseases Thermoregulation - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization **Musculoskeletal System:** Bones of the skeleton, muscles, cartilage, tendons, ligaments, joints, and other connective tissues	18

Suggested Reading:

1. Brody, T. (1998). *Nutritional Biochemistry*. Academic Press, USA.
2. Devlin, T.M. (2005). *Textbook of Biochemistry with clinical correlations*. John Wiley & Sons Inc. USA.
3. Guyton. (2007). *Textbook of medical physiology*. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
4. Hill, R.W, Wyse, G. A. and Anderson, M. (2008). *Animal physiology*. Sinauer Associates Inc. USA.
5. Murray, R.K. (2009). *Harper's illustrated biochemistry*. Jaypee Publishers, New Delhi, India.
6. Tyagi, P. (2009). *A textbook of Animal Physiology*.Dominant Publishers and distributors, New Delhi, India.

LBC.510: Enzymology and Enzyme Technology

Learning Objective: In this course, the students will learn about enzymes, their classification, structure, function and interaction.

Unit	Syllabus	Lectures
1.	**Historical Perspective, Enzyme Classification**: Recommendation and Systemic Nomenclature. **Enzyme Chemistry:** Subcellular Distribution of Enzymes. Isolation and Purification of Enzymes, Criteria for Enzyme homogeneity, General Properties, Enzyme Activity, Specific Activity and Turnover Number, Marker Enzymes.	10
2.	**Mechanism of Enzyme Action:** Enzyme-substrate complementarity, Stereochemistry of enzyme substrate action, acid base and covalent catalysis, factors associated with catalytic efficiency – orientation, distortion and strain,	14

	induced fit hypothesis. **Structure and Function of Selected Enzymes:** Chemical modification of active-site group, substrate /- driven mutagen etc. Chymotrypsin, Glyceraldehyde-3P-Dehydrogenase, Serine and Cysteine Proteases. **Multi Enzyme Complexes:** Occurrence, isolation & their properties: Mechanism of action and regulation of pyruvate dehydrogenase & fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.	
3.	**Enzyme Kinetics**: Enzyme-Substrate Interaction, ES Complex, Binding Site, Active Site. Specificity, Steady-State, Pre- Steady State and Equilibrium-State Kinetics, Michael- Menten Equation and its derivation, Graphical Methods for determination of K_m, V_{max}. Significance. **Factors Affecting of Enzyme-catalysed Reaction:** Enzyme, Substrate, pH, temperature. Collision and transitional state theories, Significance of Activation, Energy, Mechanism of bisubstrate and multisubstrate reaction, Methods for identifying mechanism.	14
4.	**Enzyme Inhibition and Activation:** Types of inhibition, and activation, Kinetics of competitive, non-competitive and uncompetitive inhibition, Determination of K_i, Suicide Inhibitors. **Enzyme Regulation:** Allosteric and Hysteric Enzymes, Proenzymes-Zymogens and activation. **Immobilized Enzymes:** Immobilization methods, Kinetics, Industrial applications.	10

Suggested Reading:

1. Palmer, T. (1995) *Understanding Enzymes*. Fourth edition, Prentice Hall.
2. Shukla, AN. (2009) *Elements of Enzymology*, Discovery Publishing house, New Delhi.
3. Price, NC, and Stevens, L. (1999) *Fundamentals of Enzymology*, Third edition, Oxford University Press.
4. Stein, RL. (2011) *Kinetics of Enzyme Action*, Wiley.
5. Bisswanger, H. (2008) *Enzyme Kinetics*, Wiley-VCH.
6. Marangoni, AG (2003) *Enzyme Kinetics*, Wiley.
7. Yon-Kahn, J and Herve, G. (2010) *Molecular and Cellular Enzymology*, Springer.

LBC.511: Metabolism-I

Learning Objective: The course will provide insights into bioenergetics, various components of cells essential for energy generation and their biosynthesis.

Unit	Syllabus	Lectures
1.	Bioenergetics – Concept of free energy, standard free energy, determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, biological standard state & standard free energy change in coupled reactions. Biological oxidation-reduction reactions, redox potentials, relation between standard reduction potentials & free energy change (derivations and numerical included). High energy phosphate compounds – introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates along with reasons for high ΔG. Energy change.	14
2.	Fundamentals of Biological Membranes - Membrane lipids and proteins, Membrane receptors, Transport of ion across plasma membrane, Transepithilial	10

	transport of solute and water, Electrical excitability and action potential.	
3.	Coenzymes and Cofactors – Role and mechanism of action of NAD+ /NADP+, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions with specific examples. Intermediary Metabolism – Approaches for studying metabolism.	10
4.	Carbohydrates – Glycolysis, various forms of fermentations in micro-organisms, citric acid cycle, its function in energy generation and biosynthesis of energy rich bond, pentose phosphate pathway and its regulation. Gluconeogenesis, glycogenesis and glycogenolysis, glyoxylate and gamma aminobutyrate shunt pathways, Cori cycle, anaplerotic reactions, Entner-Doudoroff pathway, glucuronate pathway. Metabolism of disaccharides. Hormonal regulation of carbohydrate metabolism. Energetics of metabolic cycle.	14

Suggested Reading:

1. Campbell, MK and Farrell, SO. (2002) Biochemistry, 4th ed. Brooks/Cole Pub Co.
2. Davidson, VL and Sittman, DB (1999) Biochemistry NMS, 4th ed. Lippincott. Willams and Wilkins.
3. Voet, D and Voet JG (2011) Biochemistry, 4th ed. Wiley
4. Kuchel, Philip W., et al. (1988) *Schaum's outline of theory and problems of biochemistry*. 2nd ed. McGraw-Hill.
5. Rodwell V, Bender D, Botham KM, Kennelly PJ and Weil PA (2015) Harper's Biochemistry. 30th ed. McGraw Hill.
6. Nelson DL and Cox MM (2004) Lehninger's Principles of Biochemistry, 4th ed. WH Freeman.
7. Berg JM, Tymoczko JL, Stryer L, Gregory J, Jr. Gatto (2010) Biochemistry, WH Freeman, 7th ed.
8. Lodish, H, Birk, A, et al. (2012) *Molecular Cell Biology*. 7th ed. WH Freeman.
9. Nelson DL and Cox MM (2012) Lehninger's Principles of Biochemistry, 6th ed. WH Freeman.
10. Filnean JB, Coleman R and Michell RH (1984) *Membranes and their cellular functions.* 3rd ed. Blackwell scientific publishers, Oxford.

LBC.512 Biochemistry Practical-I

1. Prepration of calibration curves.
2. Determination of protein by Biuret and Lowry's method.
3. Determination of protein by Bradford method.
4. Quantitaive estimation of glucose by glucose oxidase method
5. Estimation of fructose and glucose in honey
6. Isolation of casein from milk and its quantification
7. Isolation of gluten, glutelin and gliadin from wheat.
8. Enzyme assay for Salivary amylase
   i.Activity
   ii.Determination of optimum pH
   iii.Determination of optimum temperature
   iv.Determination of Km
   v.Determination of specific activity
9. Acid phosphatase activity in plant tissue

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

LBM.513: Life Sciences Practical-II

Pertaining to theory courses: **Immunology & 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 depending on available faculties/facilities.

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	6

	electron microscopy (TEM), micrometry and photomicrography, Histochemistry, Scanning-probe microscopy, Atomic force microscopy, CLSM.	
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 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.	10

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

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 features, mode of reproduction and cell cycle. Benificial applications of microbes.	8
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.

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Semester – III

Course Code	Course Title	L (hr)	T (hr)	P (hr)	Cr
	Core Courses				
LBC.514	Metabolism-II	2	1		3
LBC.515	Clinical Biochemistry	2	1		3
LBC.516	Biochemistry Practical-II			6	3
	Elective Courses (opt any one)				
LBM.551	Genetic Engineering	2			2
	Opt any other Life Sciences Course				
	Research				
LBC.599	Research Project (Part – 1)			16	8
	Total Credits				**19**

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

LBC.514: Metabolism-II

Learning Objective: This course is designed to cover the advanced aspects of biochemistry and biological molecules, including their biosynthesis and mechanisms by which they facilitate biochemical reactions.

Unit	Syllabus	Lectures
1.	**Lipids:** Introduction, hydrolysis of tri-acylglycerols, α-, β-, ω- oxidation of fatty acids. Oxidation of odd numbered fatty acids – fate of propionate, role of carnitine, degradation of complex lipids. Fatty acid biosynthesis, Acetyl CoA carboxylase, fatty acid synthase, ACP structure and function.	12
2.	Lipid biosynthesis, biosynthetic pathway for tri-acylglycerols, phosphoglycerides, sphingomyelin and prostaglandins. Metabolism of cholesterol and its regulation. Energetics of fatty acid cycle.	12
3.	**Amino Acids**: General reactions of amino acid metabolism - Transamination, decarboxylation, oxidative & non-oxidative deamination of amino acids. Special metabolism of methionine, histidine, phenylalanine, tyrosine, tryptophan, lysine, valine, leucine, isoleucine and polyamines. Urea cycle and its regulation.	12
4.	**Nucleic Acids:** Biosynthesis and degradation of purine and pyrimidine nucleotides and its regulation. Purine salvage pathway. Role of ribonucleotide reductase. Biosynthesis of deoxyribonucleotides and polynucleotides including inhibitors of nucleic acid biosynthesis. Porphyrins – Biosynthesis and degradation of porphyrins. Production of bile pigments.	12

Suggested Reading:

1. Campbell, MK and Farrell, SO. (2012) *Biochemistry*, 7th ed. Brooks/Cole Pub Co.
2. Davidson, VL and Sittman, DB (1999) *Biochemistry* NMS, 4th ed. Lippincott. Willams and Wilkins.
3. Voet, D and Voet JG (2011) *Biochemistry*, 4th ed. Wiley
4. Kuchel, Philip W., et al. (1988) *Schaum's outline of theory and problems of biochemistry*. 2nd ed. McGraw-Hill.
5. Rodwell V, Bender D, Botham KM, Kennelly PJ and Weil PA (2015) *Harper's Biochemistry*. 30th ed. McGraw Hill.
6. Nelson DL and Cox MM (2004) *Lehninger's Principles of Biochemistry*, 4th ed. WH Freeman.
7. Berg JM, Tymoczko JL, Stryer L, Gregory J, Jr. Gatto (2010) *Biochemistry*, WH Freeman, 7th ed.

LBC.515: Clinical Biochemistry

Learning Objective: In this course, the students will learn the general principles clinical biochemistry and understand the biochemical changes in metabolism that leads to diverse clinical diseases.

Unit	Syllabus	Lectures
1.	**Disorders of Carbohydrate Metabolism**: Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia. **Disorders of Lipids**: Plasma lipoproteins, cholesterol, triglycerides & phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia,	14

	Gaucher's disease, Tay-Sach's and Niemann-Pick disease, ketone bodies, Abetalipoproteinemia.	
2.	**Disorders of Liver and Kidney:** Jaundice, fatty liver, normal and abnormal functions of liver and kidney. Inulin and urea clearance. Electrolytes and acid-base balance-Regulation of electrolyte content of body fluids and maintenance of pH, reabsorption of electrolytes. .	14
3.	**Abnormalities in Nitrogen Metabolism:** Uremia, hyperuricemia, porphyria and factors affecting nitrogen balance. Blood Clotting, Disturbances in blood clotting mechanisms, Haemorrhagic disorders, Haemophilia, von Willebrand's disease, purpura, Rendu-Osler-Werber disease, thromboticthrombocytopenic purpura, disseminated intravascular coagulation, acquired prothrombin complex disorders, circulating anticoagulants. Cancer – Cellular differentiation, carcinogens and cancer therapy.	14
4.	**Inborn Errors of Metabolism**: Phenylketonuria, alkaptonuria, albinism, tyrosinosis, Maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, Histidinemia, Thalassemias and Haemophilias and Haematopoietic Malignancies. Muscular Dystrophy. **Diagnostic Enzymes:** Enzymes in health and diseases, Biochemical diagnosis of diseases by enzyme assays: SGOT, SGPT, CPK, cholinesterase, LDH.	14

Suggested Reading:

1. Gaw, A, Murphy MJ, Cowan RA, O'Reilly D, Stewart M, and Shepherd J (2004) *Clinical Biochemistry:* An Illustrated Colour Text (Paperback) 3rd Ed. Publisher: Churchill Livingstone.
2. Luxton, R (2008) *Clinical Biochemistry*. 2nd Ed. Scion Publishing Ltd.
3. Guyton, AC and Hall, JE (2010) *A text book of Medical Physiology*, 12th Ed. Publisher: Saunders.
4. Maheshwari, N (2008) *Clinical Biochemistry*. Publisher: JPB.
5. Gradwohl RBH (1970) C*linical Laboratory Methods and Diagnosis*: A *textbook on laboratory procedures and their interpretations,* Mosby publishers.
6. Henry, Bernard J et al. (2002), *Clinical diagnosis & Management by laboratory methods.* W.B. Saunders, New York
7. Gradwohls (2000) *Clinical Laboratory Methods and Diagnosis.* (ed) Sonnenwirth AC, and Jarret L, M.D.B.I. Publications, New Delhi
8. Coleman, W. B. and Tsongalis, G. J. (2009). *Molecular Pathology: The Molecular Basis of Human Disease.* Academic Press.
9. Nussbaum, R.L., McInnes, R. Mc., Willard, H.F. (2009). *Genetics in Medicine*. Elsevier Inc., Philadelphia. 10. Read A and Donnai D (2007). *New Clinical Genetics.* Scion Publishing Lmt., Oxfordshire, UK.
11. Patch, H. S. C. (2009). *Genetics for the Health Sciences*. Scion Publishing Ltd., UK.
12. Milunsky, A., Milunsky, J. (2009). *Genetic Disorders and the Fetus: Diagnosis, Prevention and Treatment*, 6th Edition. Wiley-Blackwell publishers

LBC.516: Biochemistry Practical-II

1. Estimation of cholesterol in biological tissue
2. Estimation of Ribonucleic acid
3. Estimation of Deoxyribonucleic acid
4. Estimation and Separation of serum/plasma Proteins in Blood
5. Estimation of blood/serum glucose
6. Estimation of Serum Total Cholesterol

7. Tests for Proteins, Glucose, Ketone Bodies, Bilirubin & Urobilinogen in Urine 8. Estimation of Urea in Blood (Serum) 9. Determination of Uric Acid in Serum 10. Estimation of Serum Bilirubin 11. Estimation of Serum Alkaline Phosphatase, ALT and AST 12. Oral Glucose Tolerance Test
• Practicals may be added/modified from time to time depending on available faculties/facilities.

Elective Courses

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.

LBC.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
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				
LBM.510	Plant Physiology	3	1		4
LBC.517	Nutritional Biochemistry	2			2
	Research				
LBC.599	Research Project (Part - II)			32	16
	Total Credits				**22**

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.510: Plant Physiology

Learning Objective: This course will provide insights into physiological processes in plants. Further, the students will understand various mechanisms used by plants to survive in abiotic and biotic stress conditions.

Unit	Syllabus	Lectures
1.	**Photosynthesis, Respiration and Photorespiration:** Light harvesting complexes, Mechanisms of electron transport, Photoprotective mechanisms, CO_2 fixation, C3, C4 and CAM pathways. Citric acid cycle. Plant mitochondrial electron transport and ATP synthesis, Alternate oxidase, Photo-respiratory pathway. **Nitrogen Metabolism:** Nitrate and ammonium assimilation, Amino acid biosynthesis.	18
2.	**Water Relations, Solute Transport and Photoassimilate Translocation:** Properties of water, Properties of solutions, Cell water potential, Soil -plant -atmosphere continuum. Uptake, transport and translocation of water, ions, Solutes and macromolecules from soil, Through cells, Across membranes, Through xylem and phloem, Transpiration, Mechanisms of loading and unloading of photoassimilates.	18
3.	**Phytohormones:** Biosynthesis, storage, breakdown and transport, physiological effects and mechanisms of action. **Sensory Photobiology:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, Photoperiodism and Biological clocks.	16
4.	**Stress Physiology:** Responses of plants to biotic (pathogens and insects) and abiotic (water, temperature and salt) stresses, Mechanisms of resistance to biotic stress and tolerance to abiotic stress. Biosynthesis of terpenes, Phenols and nitrogenous compounds and their roles. Programmed cell death: Apoptosis, Caspases, Importance and role of PCD in plant development.	20

Suggested Reading:

1. Buchanan, B.B. and Gruissem, W. (2010). *Biochemistry and molecular biology of plants.* IK International Pvt. Ltd. New Delhi, India.
2. Campbell, M.K. and Farrell, S.O. (2007). *Biochemistry.* Thomson Brooks/cole, USA.
3. Dey, P.M. and Harborne, J.B. (2000). *Plant biochemistry*. Academic Press, UK.
4. Goodwin, T.W. and Mercer, E.I. (2003). *Introduction to Plant Biochemistry*. CBS Publishers & Distributors, New Delhi, India.
5. Ross and Salisbury. (2009). *Plant Physiology.* Cengage Learning (Thompson), New Delhi, India.
7. Taiz, L. and Zeiger, E. (2010). *Plant physiology*. Sinauer Associates Inc., USA.

LBC.517: Nutritional Biochemistry

Learning Objective: This course aims to provide detailed knowledge regarding the biological basis of nutrition and the mechanisms by which diet and its components can influence health.

Unit	Syllabus	Lectures

1.	**Nutrition**: Basic concepts, scope and methodology; principal food components. Water as an essential nutrient. Vitamins: structure and function; Essential elements as food nutrients: classification and distribution; recommended allowances and their modifications under stress conditions; deficiency and excess of principal nutritional components.	10
2.	**Nutrition and Diet:** Formula diets and crash diets; balanced diets; dietary standards; food preservatives. Energy requirements: basal metabolic rate (BMR); factors affecting BMR and its measurement; resting metabolic rate; anthropometric measurements and obesity. Assessment of nutritional status and Recommended Daily allowances. Diseases associated with Digestive system: Maldigestion, malabsorption, celiac disease, creatorrhoea, diarrhea, ulcers and steatorrhoea.	10
3.	**Introduction to Nutraceuticals:** Historical perspective, classification, scope & future prospects. Sources of Nutraceuticals. **Properties, Structure and Functions of Various Nutraceuticals**: Glucosamine, Octacosanol, Lycopene, Carnitine, Melatonin and Ornithine alpha ketoglutarate. Use of proanthocyanidins, grape products, flaxseed oil as Nutraceuticals.	8
4.	**Applied Aspects of the Nutraceutical Science:** Relation of Nutraceutical Science with other Sciences: Medicine, Human physiology, genetics, food technology, chemistry and nutrition. Nutraceuticals bridging the gap between food and drug, Nutraceutical remedies for common disorders like Arthritis, Bronchitis,circulatory problems, hypoglycemia, Nephrological disorders, Liver disorders, Osteoporosis,Psoriasis and Ulcers etc. Nutraceutical rich supplements e.g. Beepollen, Caffeine, Green tea, Lecithin, Mushroom extract, Chlorophyll, Kelp and *Spirulina*. Types of inhibitors present in various foods and their inactivation. Probiotics and Prebiotics as nutraceuticals. Recent advances in techniques & feeding of substrates.	8

Suggested Reading:

1. Tom B, (1998) *Nutritional Biochemistry*, 2nd ed, Academic Press, London.
2. Steven HW, Steven J, et al. (2002). *Health promotion and disease prevention in clinical practice*, 2nd ed. J.B.Lippin Cott & Co.
3. Ramesh, C.G. (2010). *Nutraceuticals: Efficacy, Safety and Toxicity,* Academic Press Inc.
4. Debasis B., Harry G.P, and Anand S. (2015). *Nutraceuticals and Functional Foods in Human Health and Disease Preventio.* CRC Press.

LBC.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