

Centre for Biochemistry and Microbial Sciences

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

Ph.D. Program in Biochemistry and Microbial Sciences

Sr. No	Course Code	Course Title	L	P	Cr
1	LSS.701	Research Methodology and Computer Applications	4	-	4
2	LBM.702	Advanced Biochemistry	4	-	4
3	LBM.703	Advanced Microbiology	4	-	4
		Opt any two courses from the following courses			
4	LAS.702	DNA Damage & Repair in Human Health	4	-	4
5	LAS.703	Advances in Molecular Cell Biology	4	-	4
6	LPS.703	Advanced Genomics	4	-	4
7	LPS.704	Advances in Stress Biology	4	-	4
8	LPS.705	Advanced Molecular Systematics	4	-	4
		Total Sem-1			20

L: Lectures; P: Practical; Cr: Credits

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Semester I

LSS.701: Research Methodology and Computer Applications

Part	Syllabus	Lectures
1.	<p>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.</p> <p>Technical Writing: Scientific writing, Writing synopsis, Research paper, Poster preparation, oral presentations and Dissertations.</p>	18
2.	<p>Introduction and Principles of Good Lab Practices: Good laboratory practices, Biosafety for human health and environment. Biosafety issues for using cloned genes in medicine, agriculture, industry, and eco-protection, Biological containment and physical containment, CDC Biosafety levels, Biosafety in Clinical laboratories and biohazard management, Physical, Chemical & Biological hazards.</p> <p>Research ethics: Ethical theories, Ethical considerations during research, data manipulations, subject consent, Animal testing. Animal rights, Perspectives and methodology & Ethical issues of the human genome project, Plagiarism</p>	18
3.	<p>Fundamentals of computer: Parts of computer, Hardware, BIOS, Operating systems, Binary system, Logic gates and Boolean Algebra. Application software: Spreadsheet applications, Word-processing applications, Presentation applications, Internet browsers, Reference Management, and Image processing applications. Computer language: Basic DOS commands, AutoHotKey scripting language, HTML and basic structure of a webpage, Designing websites. World wide web: Origin and concepts, Latency and bandwidth, Searching the internet, Advanced web-search using Boolean logic, Cloud computing.</p>	18
4.	<p>Bioinformatics: Organization, management and analysis of biological data, use of computers in data analysis, biological databases - DNA sequence databases and protein sequence databases, BLAST, FASTA, multiple sequence alignment, <i>in silico</i> approaches for drug designing, primers in biology (design and types of primers) genome projects (human, <i>Arabidopsis</i> and other genome projects), NCBI, UCSC and other database searches.</p>	18

Suggested Reading:

1. Gupta, S. (2008). *Research Methodology and statistical techniques*. Deep & Deep Publications (P) Limited, New Delhi.
2. Kothari, C. R. (2014). *Research methodology (s)*. New Age International (p) Limited. New Delhi.
3. Sahay, Vinaya and Pradumna Singh (2009). *Encyclopedia of Research Methodology in life sciences*. Anmol Publications. New Delhi.
4. Kauda J. (2012). *Research Methodology: A Project Guide for University Students*. Samfunds literature Publications.
5. Dharmapalan B. (2012). *Scientific Research Methodology*. Narosa Publishing
6. Norman, G. and Streiner, D. (2008). *Biostatistics: The Bare Essentials.3/e (with SPSS)*. Decker Inc.

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USA.

7. Rao, P. P., S. Sundar and Richard, J. (2009). *Introduction to Biostatistics and Research Methods*. PHI learning.

8. Christensen, L. (2007). *Experimental Methodology*. Boston: Allyn & Bacon.

9. Fleming, D. O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.

10. Rockman, H. B. (2004). *Intellectual Property Law for Engineers and Scientists*. Wiley-IEEE Press, USA.

11. Shannon, T. A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.

12. Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases*. Oxford University Press, UK.

13. WHO (2005). *Laboratory Biosafety Manual*. World Health Organization. House ISBN: 978-81-8487-180-7.

LBM.702: Advanced Biochemistry

Part	Syllabus	Lectures
1.	Metabolism: Recent advances in amino acid, carbohydrate, lipid and nucleotide metabolism.	18
2.	Xenobiotic Metabolism: Chemical nature of xenobiotic; Transport of xenobiotic within the body; Fate of metabolism; Biotransformation; Detoxification; Examples of xenobiotic metabolism.	18
3.	Stress Biology: The stress response; Biomarkers of chronic stress and their role in diagnosis and therapy; Metabolic and neuroendocrine biomarkers; Exocytosis and ER Stress: Role of disruptive function of glycosylation/inter- and intra-molecular disulfide bond formation.	18
4.	Advanced Techniques and Their Applications: Metabolomics, Proteomics, protein-protein interactions, protein-metabolite interactions; Applications in Agriculture and Human Health	18
Suggested Reading: Research papers and reviews published in peer-reviewed international journals in the above areas.		

LBM.703: Advanced Microbiology

Part	Syllabus	Lectures
1.	Advanced Techniques to Study Microbial Pathogenesis: Host defense mechanisms such as phagocytosis, opsonization and complement, Nonspecific, innate and adaptive host defenses. Genetic, bioinformatic, proteomic and systems biology approaches to study host pathogen interactions.	18
2.	Mechanism of Microbial Pathogenesis: Microbial colonization and adherence strategies, Microbial invasion strategies, Bacterial secretion systems, Bacterial surface structures, Antigenic variation, Biofilms and quorum sensing, modulation of apoptotic processes and microbial toxins.	18
3.	Pathogenesis of Selected Organisms: Spirochetes such as <i>Treponema</i>	18

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	<i>pallidum</i> , <i>Borrelia burgdorferi</i> and <i>Borrelia hermsii</i> . Intracellular pathogens/ Gram-negative bacteria: <i>Salmonella</i> and <i>Helicobacter pylori</i> . Gram- positive bacteria: <i>Staphylococcus aureus</i> , <i>Listeria monocytis</i> . Myxobacteria: <i>Mycobacterium tuberculosis</i> .	
4.	Mechanisms of Interference with Pathogenesis: Mechanisms of action of antimicrobial agents and resistance; Recent advances in development antibiotics and vaccine. Human Microbiome and their role in therapeutics.	18
Suggested Reading: Research papers and reviews published in peer-reviewed international journals in the above areas.		

LAS.702: DNA Damage & Repair in Human Health

Part	Syllabus	Lectures
1.	Oxidative Stress: Chemical and biological effects, production and consumption of oxidants, antioxidants as supplements, metal catalysts and non-metal redox catalysts, and redox biology (response of various transcription factors (TFs) e.g., p53, NF-kB, AP-1, STAT3, HIF1 α , and Pax6/8).	18
2.	Oxidative Stress and Diseases: Contribution of oxidative stress towards development and progression of neurodegenerative diseases (Alzheimer's, Parkinson's, and Huntington's disease), cardiovascular diseases (Ischemia) and cancer (Lung and Pancreatic cancer).	18
3.	DNA Damage: Sources of DNA damage (endogenous and exogenous), types of DNA damage: [i) oxidation of bases, ii) alkylation of bases, iii) hydrolysis of bases, iv) bulky adduct formation, and v) mismatch of bases].	18
4.	DNA Repair: DNA damage-repair signalling mechanisms (role of PARP-1, XRCC1, BRCA1, p53, and DNA-PK). Single-strand break repair (SSBR): emphasis on base excision repair (BER) pathway. Doublestrand break repair (DSBR): emphasis on non-homologous end joining (NHEJ) pathway. DNA damage and human genetic diseases: Comparisons between nuclear vs. mitochondrial DNA damage and repair, and pathological effects of poor nuclear DNA repair and mitochondrial DNA repair. DNA repair modulation: Effect of herbals on DNA repair, small molecules for cancer therapeutics, and caloric restriction for DNA repair.	18

Suggested Reading:

- Lodish, H., Berk, A., Zipursky, SL., Matsudaira, P., Baltimore, D., Darnell, J. (2008), *Molecular Cell Biology*. Freeman, HW.
- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2007), *Molecular biology of the cell*. Garland publishing.
- Watson, J. D., Baker, TA., Bell, SP., Gann, A., Levine, M., Losick, R. (2008), *Molecular Biology of the Gene*. CSHL Press.
- DNA Repair and Human Health*. (2011), Edited by Sonya Vengrova, ISBN 978-953-307- 612-InTech.
- Heydari, AR., Unnikrishnan, A., Lucente, LV., Richardson, A. (2007), Caloric restriction and

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genomic stability. *Nucleic Acid Research*.

6. Hegde, ML., Mantha, AK., Hazra, TK., Bhakat, KK., Mitra, S., Szczesny, B. (2012), Oxidative genome damage and its repair: Implications in aging and neurodegenerative diseases. *Mech Ageing Dev.* 133(4):157-168.

7. Helleday, T., Petermann, E., Lundin, C., Hodgson, B., Sharma, RA. (2008), DNA repair pathways as targets for cancer therapy. *Nature Reviews Cancer* **8**, 193-204

LAS.703: Advances in Molecular Cell Biology

4 credits

Part	Syllabus	Lectures
1.	DNA Biology: DNA topology and chromatin structure which affects the processes of DNA replication, repair, and transcription. Alternative DNA structures; Triplex-, G-quadruplex, cruciform-DNA, how these DNA structures induces DNA damage, repair, and genetic instability and various diseases. The molecular mechanisms by which protein complexes repair different forms of DNA damage.	18
2.	RNA Biology: Types of RNAs and Non-coding RNA; miRNA, piRNA, long non-coding RNA, etc. Biological roles of non-coding RNAs and regulation of gene expression by non-coding RNA in cancer and other diseases. RNA binding proteins in cancer, Epigenetic mechanisms and how they affect gene expression which leads to disease conditions.	18
3.	Cancer & Signalling Pathways: Cancer associated Signalling pathways; Akt Signaling, MAP kinase Signaling, PARP, apoptosis, p53 signaling, Caspase Signaling, NF-kB Signaling, JAK, STAT3 pathways, PTEN, mTOR signaling pathway, Wnt signaling pathways, VEGF signalling pathway, Toll-like receptor signaling pathway.	18
4.	Advanced molecular cell biology techniques: Chromatin immunoprecipitation assays, DNA-footprinting, gel-shifts assays, Southern blotting, Northern blotting, Western blotting, antibody production, Co-immunoprecipitation, in vitro translation, yeast two hybrid system, DNA sequencing, PCR, genomics, microarrays, proteomics, cells transfection, RNA-Seq, Flow-cytometry, fluorescence microscope.	18

Suggested Reading:

1. Jan Barciszewski, (2003) *Non-Coding RNAs: Molecular Biology and Molecular Medicine*, Springer Publisher.

2. Ondrej Slaby, (2012) *MicroRNAs in Solid Cancer: From Biomarkers to Therapeutic Targets (DNA and RNA: Properties and Modifications, Functions and Interactions, Recommendations and Applications)*, Nova Science Publishers.

3. Lauren Pecorino (2012) *Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics*, Oxford Edition.

4. Bruce Alberts (2008) *Molecular Biology of the Cell*, Garland Science

5. Lewis C. Cantley, Tony Hunter, Richard Sever (2014) *Signal Transduction: Principles, Pathways, and Processes*, Cold Spring Harbor Laboratory Press

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LPS.703. Advanced Genomics

Part	Syllabus	Lectures
1.	Gene expression Microarray technology, Methodology and data mining tools, Applications of microarray. Next Generation sequencing Technology, Methodology, Generation of Tissue specific data, Data mining tools, Applications of NGS	18
2.	cDNA library construction, Subtractive Library EST database generation, Transcriptomics analysis targeted via NGS, Unravelling the genetic regulatory circuits.	18
3.	Molecular Markers, Generation of Molecular Markers, Molecular dissection of genetic relationships, Genetic basis of trait and trait dissection.	18
4.	Genomics and Comparative Genomics, Phenomics, Quantitative Trait Analysis and Marker assisted breeding, Molecular mapping, Genome sequencing.	18
<p>Suggested Reading:</p> <ol style="list-style-type: none"> 1. Lodish, H., Berk, A., Chris, A. K., Krieger, M. (2008), Molecular Cell Biology. W.H. Freeman. 2. Bruton E. Trop. (2008), Molecular Biotechnology: Genes to Protein. J&B Publishers. 3. David P. Clark. (2010), Molecular Biology. Elsevier. 4. Benjamin A. Pierce. (2008), Genetics: A conceptual approach. Palgrave Macmillan 		

LPS.704. Advances in Stress Biology

Part	Syllabus	Lectures
1.	Recent Advances in Stress Biology: Types of stresses, Stress factors and occurrence, Avoidance, acclimation and tolerance, Molecular mechanisms of Drought, Temperature, salt and heavy metals tolerance. Climate change and sustainability Perspectives: Impact and adaptation of multiple stresses. Antagonism and synergism in multiple stress tolerance, Factors supporting sustainable development, CO2 enrichment.	18
2.	Signal Transduction During Stress: Perception, Transduction and response trigger, Induction of specific gene expression, Convergence and divergence of signaling pathways, ROS signaling, Hydrogen peroxide; versatile molecule of the reactive oxygen species network. Management of stress: Secondary metabolites and stress, chemistry and functional genomics their biosynthesis and stress management.	18
3.	Oxidative Stress, Antioxidants and Stress Tolerance: ROS/NOX and their production, DNA damage, Control mechanisms, Glutathione	18

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	ascorbate pathway, Role of different antioxidants in stress management. Metabolomics of stress.	
4.	Gene regulation During Stress: Transcription factors involved stress tolerance, Stress proteins; Heat shock (HSP's) and cold shock proteins (dehydrins), CFB, ABRE and DREB proteins etc. RNA biology and stress: Cellular stress and RNA Splicing, Si, RNAi, Micro RNA their implications in oxidative stress tolerance	18

Suggested Reading:

1. Ahmad, S. (1995). *Oxidative Stress and Antioxidant Defenses in Biology*. 1st Edition Springer.
2. Brown, T.A. (2010). *Gene Cloning and DNA analysis: An Introduction*. Blackwell Publishing Professional. USA.
3. Buchanan, B.B. and Gruissem, W. (2005). *Biochemistry and molecular biology of plants*. IK International Pvt. Ltd. New Delhi, India.
4. Forman, H.J. and Cadenas E. (1997). *Oxidative Stress and Signal Transduction*. 1st Edition Springer.
5. Hensley, K. and Robert, A.F. (2009). *Methods in Biological Oxidative Stress*. 1st edition Academic Press.
6. Hopkins, W.G. (2007). *Plant Biotechnology*. Infobase Publications Inc.. USA.
7. Inze D. and Montagu M. V. (2001). *Oxidative Stress in Plants*, 1st Edition, CRC Press.
8. Nelson, D. and Cox, M.M. (2009). *Lehninger Principles of Biochemistry*. W.H. Freeman and Company, New York.
9. Orcutt, D.M. and Nilsen, E.T. (2000). *Physiology of Plants Under stress*. J. Wiley, USA.
10. Primrose, S.B and Twyman, R. (2011) *Principles of Gene Manipulation and Genomics*, 8th edn. Blackwell Publishing. Society of Plant Biologists, USA
11. Snusted, D.P. and Simmons, M. J. (2010). *Principles of Genetics*. John Wiley & Sons, New York.
12. Sunkar, R. 2012. MicroRNAs in Plant Development and Stress Responses (Signaling and Communication in Plants). Springer Publications. New Delhi.
13. Voet, D., Voet, J.G. and Pratt C.W. (2008). *Principles of Biochemistry*. 3rd Edition, CBS Publishers & Distributors, New Delhi.

LSS.705. Advanced Molecular Systematics

Part	Syllabus	Lectures
1.	General Introduction to Molecular Systematics: Evolutionary theory and Tree of Life, Tree thinking, Convergent Vs. Divergent evolution, Homologous and Analogous traits, Character states: Synapomorphy, Sympleiomorphy and Homoplasy, Types of Clades: Monophyly, Paraphyly and Polyphyly, Orthologous Vs. Paralogous Sequences, Phenetics Vs. Cladistics, DNA Barcoding, and Major Loci Used in Molecular Systematics	18

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2.	<p>Molecular Evolution: Neutral theory of molecular evolution, Models of nucleotide substitution, p-distance, poisson correction, Jukes-Cantor 69, Kimura-2-Parameter, Felsenstein 81, Hasegawa, Kishino and Yano 85, General Time Reversible (GTR), Rate heterogeneity (G), Rate Invariability (I), Model selection, Hierarchical Likelihood Ratio Test (hLRT), and locus selection.</p>	18
3.	<p>Sequence Analysis: Basics of DNA Sequencing, Base calling, Sequence Assembly and Contig construction, Consensus Sequences, Multiple Sequence Alignment, Concatenation of datasets and construction of supermatrix, Sequence annotation and deposition in Genbank, DNA Flatfiles, rDNA Secondary structure construction, and <i>in-silico</i> translation. NCBI BLAST and its variants, Vienna RNA Package and RNAalifold, Primer design using primer BLAST, CodonCodeAligner, Geneious, and MEGA.</p>	18
4.	<p>Computational Phylogenetics: Theoretical framework of phylogenetics, Distance Vs. Discrete methods, Minimum Evolution, UPGMA, Neighbour Joining, Maximum Likelihood, Maximum Parsimony, Bayesian Inference, reconstruction of phylogeny from morphological data, Gene Tree Vs. Species tree, and lineage sorting. Taxonomy: Morphometry using ImageJ, Specimens and Curation, Herbarium Voucher preparation, Typification, Geographical sampling design, Taxonomic literature survey, Species description, Taxonomic publication and codes, Rules of nomenclature</p>	18

Suggested Reading:

1. Describing Species, Judith Winston, Columbia University Press, 978-0231068253
2. Phylogenetic Analysis of Morphological Data (Smithsonian Series in Comparative Evolutionary Biology), John J. Wiens. Smithsonian Books, 978-1560988168
3. Phylogenetics: Theory and Practice of Phylogenetic Systematics, E. O. Wiley & Bruce S. Lieberman, Wiley-Blackwell, 978-0470905968
4. Phylogenetic Trees Made Easy: A How To Manual, Fourth Edition, Barry G. Hall, Sinauer Associates, Inc. 978-0878936069
5. Inferring Phylogenies, Joseph Felsenstein, Sinauer Associates, 978-0878931774
6. Phylogenetics (Oxford Lecture Series in Mathematics and Its Applications), Charles Semple & Mike Steel, Oxford University Press, 978-0198509424
7. Plant Systematics: A Phylogenetic Approach, Walter S. Judd, Christopher S. Campbell, Elizabeth A. Kellog, Peter F. Stevens & Michael J. Donoghue, Sinauer Associates, 978-0878934072
8. Bast, F (2013) Sequence Similarity Search, Multiple Sequence Alignment, Model Selection, Distance Matrix and Phylogeny Reconstruction. *Nature Protocol Exchange*. Nature Publishing

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Group. doi: 10.1038/protex.2013.065.

9. Bast, F (2015) Tutorial on Phylogenetic Inference Part-1. *Resonance* 20 (4) 360-367

10. Bast, F (2015) Tutorial on Phylogenetic Inference Part-2. *Resonance* 20 (5) 445-457

11. Tree Thinking 2015) An Introduction to Phylogenetic Biology. David Baum and Stacey Smith. Roberts and Company Publishers.