Centre for Biochemistry and Microbial Sciences

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

M.Sc. Program in Life Sciences (Microbial Sciences)

(Academic Session 2015-16)

M.Sc. Life Sciences (Microbial Sciences)				
Semester - I				
Paper Code	**Course Title**	**L**	**P**	**Cr**
LSS.501	Research Methodology	2		2
LSS.502	Biostatistics	2	-	2
LSS.504	Microbiology	3	-	3
LSS.506	Biochemistry	3	-	3
LSS.508	Genetics	3		3
LSS.557	Elective course: Microbial Physiology	2		2
LSS.421	Inter-disciplinary Course: Basic Biochemistry-I	2		2
LSS.503	Biostatistics (P)	-	2	1
LSS.505	Microbiology (P)	-	2	1
LSS.507	Biochemistry (P)	-	2	1
LSS.509	Genetics (P)	-	2	1
LSS.558	Elective Course: Microbial Physiology (P)	-	2	1
	Total Semester – I	**17**		**22**

L: Lectures P: Practical Cr: Credits

Examination Pattern

A: Continuous Assessment: Based on Objective Type Tests (25 Marks)

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

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

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

LSS.501: Research Methodology. Credit Hours: 2. Semester I.

Unit 1 **8 Lectures**

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.

Unit 2 **10 Lectures**

Technical writing: Scientific writing that includes the way of writing Synopsis, research paper, poster preparation and presentation, and dissertation.

Unit 3 **4 Lectures**

Library: Classification systems, e-Library, web-based literature search engines

Unit 4 **14 Lectures**

Entrepreneurship and business development: Importance of entrepreneurship and its relevance in career growth, characteristics of entrepreneurs, developing entrepreneurial competencies, types of enterprises and ownership (large, medium SSI, tiny and cottage industries, limited, public limited, private limited, partnership, sole proprietorship) employment, self-employment and entrepreneurship, financial management-importance and techniques, financial statements-importance and its interpretation, and Intellectual Property Rights (IPRs).

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. Standard /Reputed Journal authors' instructions.

LSS.502: Biostatistics. Credits Hours: 2. Semester I.

Unit 1 **6 Lectures**

Overview of Biostatistics: Difference between parametric and non-parametric statistics, Univariant and multivariant analysis, Confidence interval, Errors, Levels of significance, Hypothesis testing.

Unit 2 **8 Lectures**

Descriptive statistics: Measures of central tendency and dispersal, Histograms, Probability distributions (Binomial, Poisson and Normal), Sampling distribution, Kurtosis and Skewness.

Unit 3 **8 Lectures**

Experimental design and analysis: Sampling techniques, Sampling theory, Various steps in sampling, collection of data-types and methods.

Unit 4 **14 Lectures**

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, Comparing two regression lines, Pearson Product-Moment Correlation Coefficient, Spearman Rank Correlation Coefficient, Power and sampling size in correlation and regression.

Suggested Reading:

1. Gookin, D. (2007). *MS Word 2007 for Dummies*. Wiley, USA.
2. Harvey, G. (2007). *MS Excel 2007 for Dummies*. Wiley, USA.
3. Johnson, S. (2009). *Windows 7 on demand*. Perspiration Inc. USA.
4. Norman, G. and Streiner, D. (2008). *Biostatistics: The Bare Essentials.* 3/e (with SPSS). Decker Inc. USA.
5. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*. W.H. Freeman publishers, USA.
6. Thurrott, P. and Rivera, R. (2009). *Windows 7 Secrets*. Wiley, USA.

LSS.504: Microbiology. Credits Hours: 3. Semester I.

Unit: 1 **16 Lectures**

Prokaryotic, Eukaryotic structure and function: Cell structure and function, Classifications. Bacteria, Fungi, Protozoa, Algae, and viruses, Structure of major viruses, and Viral replication.

Unit: 2 **16 Lectures**

Growth, nutrition & control: Phases in bacterial growth, Growth Curve, Calculation of G-time, Physical and environmental requirements of growth, Microbial nutritional requirements, Types of culture media. Physical and Chemical methods, Antimicrobial drugs, Antibiotic assays, Drug resistance in bacteria.

Unit: 3 **6 Lectures**

Microbial Genetics: DNA replication, Transcription and translation, Operon, Horizontal Gene Transfer.

Unit: 4 **16 Lectures**

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.Avian Influenza A/H5N1, A/H1N1 Swine Influenza, SARS, AIDS, Japanese encephalitis, Malaria and Tuberculosis, West Nile, Mechanisms of emergence and reemergence.

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. (1993). *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. (2004). *Microbiology*. McGraw-Hill Science, USA.
6. Strelkauskas, A., Strelkauskas, J. and Moszyk-Strelkauskas, D. (2009). *Microbiology: A Clinical Approach.* Garland Science, New York, USA.
7. Tortora, G.J., Funke, B.R. and Case, C.L. (2009). *Microbiology: An Introduction.* Benjamin Cummings, USA.

LSS.506: Biochemistry. Credits Hours: 3. Semester I.

Unit 1 **14 Lectures**

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 interaction, etc.

Unit 2 **14 Lectures**

Composition, structure and function of Biomolecules: Carbohydrates, Lipids, Proteins, Nucleic acids and Vitamins. Bioenergetics and metabolism of Carbohydrates, Lipids, Amino Acids and Nucleotides.

Unit 3 **14 Lectures**

Enzymology: Classification, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics, Enzyme regulation, Isozymes Clinically important enzymes.

Unit 4 **12 Lectures**

Protein Chemistry: Ramachandran plot, Secondary, Tertiary and Quaternary structure, Domains, Motif and Folds. Nucleic acids: A-, B-, Z-DNA, tRNA, micro-RNA, Stability of protein and Nucleic acid structures.

Suggested Reading:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2010). *Biochemistry.* W.H. Freeman & Company. USA.
2. Brown, T.A. (2006). *Gene Cloning and DNA analysis: In Introduction*. Blackwell Publishing Professional. USA.
3. Haynie, D.T. (2007). *Biological thermodynamics*. Cambridge University. UK.
4. Mathews, C.K., Van Holde, K.E. and Ahern, K.G. (2000). *Biochemistry*. Oxford University Press Inc. New York.
5. Nelson, D. and Cox, M.M. (2008). *Lehninger Principles of Biochemistry*. BI publications Pvt. Ltd. Chennai, India.
6. Ochiai, E. (2008). *Bioinorganic chemistry: A survey.* Academic Press. Elsevier, India.

7. Randall, D. J., Burggren, W. and French, K. (2001). *Eckert animal physiology*. W.H. Freeman & Company. USA.
8. Raven, P.H., Johnson, G.B. and Mason, K.A. (2007). *Biology*. Mcgraw-Hill. USA.
9. Shukla AN (2009). *Elements of enzymology.* Discovery Publishing. New Delhi, India.
10. Voet, D. and Voet, J.G. (2008). *Principles of biochemistry*. CBS Publishers & Distributors. New Delhi, India.

LSS.508: Genetics. Credits Hours: 3. Semester I.

Unit 1 **12 Lectures**

Introduction and scope of genetics, DNA as genetic material: The vehicles of inheritance, Chemical structure and base composition of nucleic acids, Double helical structure, Structure of DNA and RNA, Different types of DNA molecules, forces stabilizing nucleic acid structure, super coiled DNA, properties of DNA, denaturation and renaturation of DNA and Cot curves. **DNA replication:** Messelson and Stahl Experiment, Carins Experiment, Okazaki Experiment, Basic mechanism of DNA replication.

Unit 2 **14 Lectures**

Cell division and Cell cycle: Mitosis, Meiosis, Chromosomal basis of inheritance. Basic principles of Mendelian inheritance: Segregation and independent assortment, Alleles and multiple alleles, Human pedigrees and inheritance. Linkage analysis and gene mapping: Coupling and repulsion phase linkage, Crossing over and recombination**.** Population genetics: Application of Mendel's laws to populations, Hardy-Weinberg principle, inbreeding depression and heterosis, inheritance of quantitative traits.

Unit 3 **14 Lectures**

Gene Interaction: Sex determination and Sex linked inheritance, Sex determination in humans, *Drosophila* and other animals, Sex determination in plants, Sex linked genes and dosage compensation. Human genetics: pedigree analysis. Gene concept: Fine structure of gene and gene concept, Fine structure analysis – Benzer's experiments, Complementation analysis and fine structure of gene, Complementation and recombination, Concept of gene.

Unit 4 **14 Lectures**

Extra-chromosomal inheritance: Chloroplast and Mitochondrial inheritance, Yeast, *Chlamydomonas/Neurospora* and higher plants Chromosomal aberrations: Types of changes– deletions, duplications, inversions, translocations,Change in chromosome number: trisomy and polyploidy. Evolutionary history of bread wheat, Aneuploids–nullisomics, monosomics, and trisomics, Somatic aneuploids, Changes in chromosome structure, Properties of chromosomes for detection of structural changes. Mutations: Spontaneous and induced mutations, Somatic vs germinal mutation.

Suggested Reading:

1. Anthony, J.F., Miller, J.A., Suzuki, D.T., Richard, R.C., Gilbert, W.M. (1998). *An introduction to Genetic Analysis*. W.H. Freeman publication, USA.

2. Atherly, A.G., Girton, J.R., Mcdonald, J.F. (1999). *The science of Genetics*. Saundern College publication.
3. Snusted, D.P., Simmons, M. J. (2010). *Principles of Genetics*. John Wiley & Sons, New York.
4. Gupta, P.K. (2009). *Genetics*. Rastogi publications, Meerut, India.
5. Gupta, P.K (2008). *Cytology, Genetics and Evolution.* Rastogi publications, Meerut, India.
6. Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, USA.
7. Schaum, W.D. (2000). *Theory & problems in Genetics by Stansfield, out line series* McGrahill, USA.
8. Tamarin, R.H. (1996). *Principles of Genetics, International edtn.* McGrawhill, USA.

Elective Course

LSS.557: Microbial Physiology. Credits Hours: 2. Semester I.

Unit: 1 **6 Lectures**

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

Unit: 2 **10 Lectures**

Bacterial respiration: Bacterial aerobic respiration, components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain. Electron transport chain in some heterotrophic and chemolithotrophic bacteria. Bacterial anaerobic respiration: Introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria. Catalase, super oxide dismutase, mechanism of oxygen toxicity.

Unit: 3 **10 Lectures**

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

Unit: 4 **10 Lectures**

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

Suggested Reading:

1. Caldwell D.R. (1995) *Microbial Physiology and Metabolism* by Brown Publishers.
2. Moat A.G. and Foster J. W. (1999) *Microbial Physiology* by Wiley Sons.
3. Brun. Y.V. and Shimkets L.J. (2000) *Prokaryotic Development* by ASM Press.
4. A.H. Rose, *Advances in Microbial Physiology* by By. Academic Press, New York.
5. I.C. Gunsalus and Rogery Stanier *The Bacteria* by Academic Press.

Interdisciplinary Course

LSS.421. Basic Biochemistry-I. Credit Hours: 2. Semester-I

Unit-1 **9 Lectures**

Principles of biophysical chemistry, pH, Buffer, Reaction kinetics, Thermodynamics,

Unit-2 **9 Lectures**

Composition, structure and function of Biomolecules: Carbohydrates, Lipids, Proteins: Primary, Secondary, Tertiary and Quaternary structure, Nucleic acids: A-, B-, Z-DNA, tRNA, micro-RNA, Nucleic acids and Vitamins

Unit-3 **9 Lectures**

Primary Metabolic pathways

Unit-4 **9 Lectures**

Classification, Principles of catalysis, Mechanism of enzyme catalysis, Enzyme kinetics, Enzyme regulation

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.

Practical Courses

LSS.503: Biostatistics - practical. Credit Hours: 1. Semester I.

1. Experimental design and analysis.
2. Training on basic usage of Microsoft Word, Microsoft Excel, Microsoft PowerPoint and Internet Explorer.
3. Optimizing web search: Google advanced search, Boolean operators, Literature search using Google Scholar, HighWire.
4. Bibliography management and research paper formatting using reference software EndNote.
5. Performing statistics analyses using MS Excel Analysis toolpack.

6. Creating a functional website using HTML.
7. Basic programming using DOS batch files and Auto Hot Key.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.505: Microbiology – Practical. Credit Hours: 1. Semester I.

1. Isolation and pure culture techniques.
2. Staining methods: Simple staining, Negative Staining, Gram Staining, Acid-Fast stain.
3. Standard method for bacteriological water analysis: Presumptive test, confirmed test and completed test.
4. Microbial analysis: Analysis of food/dairy products.
5. Microbial growth studies.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.507: Biochemistry – Practical. Credit Hours: 1. Semester I.

1. Preparation of Solutions, buffers, pH setting etc.
2. Amino acid and carbohydrate separations by paper & thin layer chromatography.
3. Quantitative Estimation of Proteins, Sugars, total lipids and amino acids.
4. Assay and estimation of different enzymes e.g. invertase, amylases, acid and alkaline phosphatases in plant seeds.
5. Principle and application of electrophoresis, Native, SDS PAGE.
6. Estimation of total phenolic compounds.
7. Extraction and estimation of vitamins.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.509: Genetics - Practical. Credit Hours: 1. Semester I.

1. Calculation of allele frequencies.
2. Calculating recessive gene frequency, Calculating frequency of sex –linked alleles.
3. Karyotyping of normal & abnormal chromosome sets.
4. Monohybrid and dihybrid ratios, Multiple alleles, Epistasis – Problems.
5. Inheritance patterns in Man – Numericals on Pedigree analysis- Autosomal patterns, X–linked patterns, Y–linked patterns.
6. Mitochondrial inheritance patterns.
7. To test PTC tasting ability in a random sample and calculate gene frequencies for the taster and non–taster alleles.
8. Identification of inactivated X chromosome as Barr body and drumstick.
9. Blood group typing using haemagglutination tests.
10. Studies of a Model organism: Identification of normal and mutant flies (Drosophila melanogaster) & Preparation of Drosophila polytene chromosomes.

11. To study fingerball and palmar dermatogylphics and calculate indices.
12. To test for colour blindness using Ishihara charts.
13. Molecular Mapping of Genes.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

Elective Course Practical

LSS.558: Microbial Physiology (Practical). Credit Hours: 1. Semester I.

1. Isolation of Photosynthetic bacteria
2. Glucose uptake by E. coli / *Saccharomyces cerevisiae* [Active and Passive diffusion]
3. Effect of UV, gamma radiations, pH, disinfectants, chemicals and heavy metal ions on spore germination of Bacillus SP.
4. Determination of Iron Oxidation Rate of *Thiobacillus ferrooxidans*.
5. Determination of Sulfur Oxidation Rate of *Thiobacillus thiooxidans*.
6. Microbial degradation, decolorization and adsorption of organic dyes (by free and immobilized cells).
7. Estimation of calcium ions present in sporulating bacteria by EDTA method.
8. Demonstration of utilization of sugars by oxidation and fermentation techniques.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

Semester – II				
Paper Code	**Course Title**	**L**	**P**	**Cr**
LSS.510	Animal Physiology	3	-	3
LSS.512	Immunology	3	-	3
LSS.513	Plant Physiology	3	-	3
LSS.515	Ecology and Environment	3		3
LSS.517	Techniques in Life Sciences	2		2
LSS.565	Elective course: Industrial Microbiology	2		2
LSS.424	Interdisciplinary Course: Basics of Genetic Engineering	2		2
LSS.511	Animal Physiology (P)	-	2	1
LSS.514	Plant Physiology (P)		2	1
LSS.516	Ecology and Environment (P)		2	1
LSS.566	Elective Course: Industrial Microbiology (P)		2	1
LSS.599	Credit Seminar	1		1
	Total Semester - II	**19**		**23**

L: Lectures P: Practical Cr: Credits

Examination Pattern

A: Continuous Assessment: Based on Objective Type Tests (25 Marks)

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

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

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

LSS.510: Animal Physiology. Credit Hours: 3. Semester II.

Unit: 1 **14 Lectures**

Digestive system: Digestion, absorption, energy balance, BMR. **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, Blood corpuscles, Blood cell synthesis and Bone marrow, Haemopoiesis and formed elements, Plasma function, Blood volume, Blood volume regulation, Blood groups, Haemoglobin, Immunity, Haemostasis.

Unit: 2 **14 Lectures**

Respiratory system: Comparison of respiration in different species, Anatomical considerations, Transport of gases, Exchange of gases, Waste elimination, Neural and chemical regulation of respiration. 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.

Unit: 3 **12 Lectures**

Reproduction and Endocrinology: Endocrine glands, Basic mechanism of hormone action, Hormones and diseases, Reproductive processes, Neuroendocrine regulation.

Unit: 4 **14 Lectures**

Nervous system: Gross neuroanatomy of the brain and spinal cord, Central and peripheral nervous system, Neurons, Action potential, Neural control of muscle tone and posture. Sense organs: Vision, Hearing and Tactile response. Thermoregulation and Stress adaptation: Comfort zone, Body temperature – physical, chemical, Neural regulation, Acclimatization.

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.

LSS.512: Immunology. Credit Hours: 3. Semester II.

Unit: 1 **14 Lectures**

Immune system: Recognition of self and nonself, Humoral immunity-immunoglogulins, 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. Mechanisms of antibody diversity, class switching. Lymphocytes, cytokines, interferons, Interlukins, antigen recognition-membrane receptors for antigens.

Unit: 2 **14 Lectures**

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

Unit: 3 **12 Lectures**

Hypersensitivity: Types, features and mechanisms of immediate and delayed hypersensitivity reactions, immunity to microbes, immunity to tumors, AIDS and immunodeficiencies, hybridoma technology and vaccine, natural, synthetic and genetic, development of vaccine for diseases like AIDS, cancer and malaria.

Unit: 4 **14 Lectures**

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, immunoblotting and assessment of human allergic diseases.

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.
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.

LSS.513: Plant Physiology. Credit Hours: 3. Semester II.

Unit: 1 **14 Lectures**

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.

Unit: 2 **14 Lectures**

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.

Unit: 3 **14 Lectures**

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.

Unit: 4 **12 Lectures**

Stress physiology and Secondary metabolism: 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.

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.
6. Segel, I.H. and Segel, E. (1993). *Enzyme kinetics: Behavior and analysis of rapid equilibrium and steady-state enzyme systems.* Wiley-Interscience, USA.
7. Taiz, L. and Zeiger, E. (2010). *Plant physiology*. Sinauer Associates Inc., USA.

LSS.515: Ecology and Environment. Credit Hours: 3. Semester II.

Unit: 1 **14 Lectures**

The Environment: Physical environment, biotic environment, biotic and abiotic interactions. Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning and character displacement.

Unit: 2 **14 Lectures**

Ecosystem: Structure and function, energy flow and mineral cycling (CNP), primary production and decomposition, structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine). Types, mechanisms, changes involved in succession, concept of climax. Nature of communities, community structure and attributes, levels of species diversity and its measurement, edges and ecotones.

Unit: 3 **16 Lectures**

Population ecology: Characteristics of a population, population growth curves, population regulation, life history strategies (*r* and *K* selection), concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations. Types of interactions, interspecific competition, herbivory, carnivory, pollination and symbiosis.

Unit: 4 **10 Lectures**

Environmental pollution: Global environmental change, ozone depletion, biodiversity-status, monitoring and documentation, major drivers of biodiversity change, biodiversity management approaches, Carbon credit.

Suggested Reading:

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

LSS.517: Techniques on Life Sciences. Credit Hours: 2. Semester II

Unit 1 **8 Lectures**

Good laboratory practices: Sterilization techniques, Spectrometry: Colorimetry, mass, UV, IR, NMR and atomic absorption spectrophotometry, 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.

Unit: 2 **8 Lectures**

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.

Unit: 3 **10 Lectures**

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.

Unit: 4 **10 Lectures**

Flow cytometry: Cell sorting, Hybridoma technology/Production of antibodies, Histochemical and Immunotechniques, Immunochemical Techniques, Developing Monoclonal and Polyclonal antibodies, Immunocytochemistry, Radioimmunoassay (RIA), Enzyme Linked Immunosorbent Assay (ELISA) and Autoradiography. **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.

Elective Course

LSS.565: Industrial Microbiology. Credit Hours: 2, Semester-II

Unit: 1 **6 Lectures**

Bioreactors: Design of a basic fermenter, bioreactor configuration, design features, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices, probes for online monitoring, computer control of fermentation process, measurement and control of process. Reactors for specialized applications: Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors, their basic construction and types for distribution of gases.

Unit: 2 **10 Lectures**

Mass transfer in reactors: Transport phenomena in fermentation: Gas- liquid exchange and mass transfer, oxygen transfer, critical oxygen concentration, determination of Kla, heat transfer, aeration/agitation, its importance. Sterilization of Bioreactors, nutrients, air supply, products and effluents, process variables and control, scale-up of bioreactors. Downstream processing, Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration: Physical, chemical and enzymatic methods. Extraction: Solvent, two phase, liquid extraction, whole broth, aqueous multiphase extraction. Purification by different methods. Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

Unit: 3 **10 Lectures**

Fermentation process: Growth of cultures in the fermenter Importance of media in fermentation, media formulation and modification. Kinetics of growth in batch culture, continuous culture with respect to substrate utilization, specific growth rate, steady state in a chemostat, fed-batch fermentation, yield of biomass, product, calculation for productivity, substrate utilization kinetics. Fermentation process: Inoculum development. Storage of cultures for repeated fermentations, scaling up of process form shake flask to industrial fermentation.

Unit: 4 **10 Lectures**

Microbial strain improvement: Isolation, selection and improvement of microbial cultures: Screening and isolation of microorganisms, primary and secondary metabolites, enrichment, specific screening for the desired product. Strain improvement for the selected organism: mutation and screening of improved cultures, random and strategic screening methods, strategies of strain improvement for primary, secondary metabolites with relevant examples. Use of recombinant DNA technology, protoplast fusion techniques for strain improvement of primary and secondary metabolites. Production of recombinant molecules in heterologus system, problems associated with strain improvement programme, improvement of characters other than products and its application in the industry. Preservation of cultures after strain improvement programme.

Suggested Reading:

1. Stanbury, P.F., Whitekar A. and Hall. (1995), *Principles of Fermentation Technology* by Pergaman. McNeul and Harvey.
2. *Biochemical Engineering Fundamentals* by Bailey and Ollis, Tata McGraw Hill, N.Y.

3. T.K. Bhosh, A.Fiechter and N. Blakebrough. *Advances in Biochemical Engineering* by Springer Verlag Publications, New York.
4. Creuger and Creuger, *Biotechnology- A textbook of Industrial Microbiology* by Sinaeur Associates.
5. L.E. Casida, Wiley Eastern *Industrial Microbiology*.
6. Belter, P.A. Cussler, E.L. *Bioseparation: Downstream Processing for Biotechnology* by Wiley Sons

Interdisciplinary Course

LSS.424. Basics of Genetic Engineering. Credit Hours: 2. Semester -II

Unit-1: 10 Lectures

Cloning Vectors and Plasmid Biology

Types of cloning vectors viz. Plasmids, cosmids, ssDNAPhages, Yeast cloning vectors, Animal viruses, Ti plasmids. Structural and Functional Organization of Plasmids, Plasmid Replication, Stringent and Relaxed Plasmids, Incompatibility of Plasmid Maintenance.

Unit-2: 8 Lectures

Enzymes in Genetic Engineering

Type II restriction enzymes; enzymes for ligation of DNA, in vitro applications of *E.coli* DNA polymerase I and Klenow fragment, alkaline phosphatase; strategies for DNA cloning, labeling of DNA.

Unit-3: 8 Lectures

Cloning and sub-cloning strategies

Preparation of competent cell-Transformation, transfection, Making genomic and cDNA libraries in plasmids, PCR product cloning (TA cloning), Cloning strategies in yeast, *Escherichia coli*.

Unit-4: Transgenic Plant Technology 10 Lectures

Agrobacterium mediated gene transfer, Natural pathogen mode of infection, Ti/Ri plasmids, Auxin and cytokinin biosynthetic genes and mutants, Binary vector systems advantages, Features and basic protocol for construction of binary vector and DNA delivery into plant cell, Components and basic protocol, Advantages and disadvantages in comparison with Agrobacterium mediated methods. Regulatory issues with transgenic plants.

Suggested Reading:

1. Brown, T.A. (2015), *Gene Cloning and DNA analysis*. 7th Edition, John Wiley & Sons.
2. Old R.W. and Primrose S.B. (2012) *Principles of gene manipulation* 7th Edition Blackwell Science.
3. Bernard R. Glick & Jack J. Pasternak. (2010) *Molecular Biotechnology* 4th Edition ASM Press Washington.

Practical Courses

LSS.511: Animal Physiology – Practical. Credit Hours: 1. Semester II.

1. Determination of hemoglobin in the blood by various methods.
2. Measurement of Blood Pressure, Pulse rate and Heart rate.
3. Digestive enzymes analysis.
4. Respiratory function: Tidal volume.

5. Sense organs and muscle reflexes.
6. Urine analysis.
7. Blood glucose estimation.
8. RBC, WBC count from human blood.
9. Extraction and estimation of acid phosphatases from serum.
10. Electrophoresis of egg proteins.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.514: Plant Physiology – Practical. Credit Hours: 1. Semester II.

1. Osmosis, Plasmolysis, Relative leaf water content, Imbibition.
2. Growth Parameters: CGR, RGR. LAR, PAR etc.
3. Quantitative estimation of chlorophyll a, b, carotenoids and anthocyanins.
4. Measurement of Photosynthesis (Pn).
5. Membrane damage.
6. Quantitative estimation of proteins, sugars and amino acids.
7. Thin Layer Chromatography for separation of amino acids.
8. Application of centrifugation in isolation of plant cell organelles.
9. Assay and estimation of acid and alkaline phosphatases in plant seeds.
10. Assay and estimation of amylases from different plant tissues.
11. Principle and application of electrophoresis.
12. Effect of auxin, cytokinin, gibberellic acid on plant growth.
13. Stress measurement.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.516: Ecology and Environment – Practical. Credit Hours: 1. Semester II.

1. Ecosystem analysis: Quadrat method- Data collection Methods and species diversity estimations.
2. Field and Laboratory Investigations: Biomes study.
3. Biological Monitoring.
4. Air, water and soil analysis.
5. Determination of dissolved oxygen concentration of water sample.
6. Determination of biological oxygen demand (BOD) of sewage sample.
7. Determination of Chemical oxygen demand (COD) of sewage sample.
8. Isolation of xenobiotic degrading bacteria by selective enrichment technique.
9. Test for the degradation of aromatic hydrocarbons by bacteria.
10. Study on biogenic methane production in different habitats.
11. Eco-modeling.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

Elective Course Practical

LSS.566: Industrial Microbiology – Practical. Credit Hours: 1. Semester I.

1. Isolation of industrially important microorganisms for microbial processes (citric / lactic/ alpha amylase) and improvement of strain for increase yield by mutation.
2. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
3. Determination of growth curve of a supplied microorganism and also determines substrate degradation profile and compute specific growth rate (m), growth yield (Y).
4. Extraction of Citric acid/Lactic acid by salt precipitation.
5. Monitoring of dissolved oxygen during aerobic fermentation. 6. Preservation of industrially important bacteria by lyophilization.
7. Product concentration by vacuum concentrator
8. Cell disruption for endoenzymes by sonication.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.599: Credit Seminar (on emerging topic) – Credit Hours: 1. Semester II.

Semester - III				
Paper Code	**Course Title**	**L**	**P**	**Cr**
LSS.518	Molecular Biology	3	-	**3**
LSS.520	Evolutionary and Developmental Biology	3	-	**3**
LSS.521	Cell Biology	3	-	**3**
LSS.572	Elective Course: Environmental Microbiology	2	-	**2**
LSS.519	Molecular Biology (P)		2	**1**
LSS.522	Cell Biology (P)		2	**1**
LSS.573	Elective Course: Environmental Microbiology (P)	-	2	**1**
LSS.600	Dissertation		16	**8**
	Total Semester - III	**11**		**22**

L: Lectures P: Practical Cr: Credits

Examination Pattern

A: Continuous Assessment: Based on Objective Type Tests (25 Marks)
B: Pre-Scheduled Mid Semester Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25 Marks)
C: Pre-Scheduled Mid Semester Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type) (25Marks)
D: End-Term Exam (Final): Based on Objective Type Tests (25 Marks)

LSS.518: Molecular Biology. **Credit Hours: 3. Semester III.**

Unit: 1 **14 Lectures**

Structure, Conformation, Denaturation, Renaturation of Nucleic acids: Carrier of genetic information, Chemical structure of DNA and base composition, Watson-Crick model, Supercoiled DNA, Different forms of RNA: mRNA, tRNA, rRNA and other Types of RNA. Organelle DNA: mitochondria and chloroplast DNA. Chromosome Structure, Chromatin and the Nucleosome: Genome Sequence and Chromosome Diversity, Chromosome Duplication and segregation, The nucleosome, Chromatin structure: euchromatin, heterochromatin, Constitutive and facultative heterochromatin, Regulation of chromatin structure and nucleosome assembly, Nucleolus.

Unit: 2 **14 Lectures**

Gene & Genome organization: Split genes, Overlapping genes, Transposons & retrotransposons, Gene clusters, Histones, Non-histones, Nucleosome, Chromatin, Chromosome structure in prokaryotes & eukaryotes. Basic Processes, Replication of DNA: Prokaryotic and eukaryotic DNA replication, Mechanism of DNA replication, Enzymes and accessory proteins involved in DNA replication, Replication errors, DNA damage and their repair.

Unit: 3 **14 Lectures**

Transcription and mRNA processing: 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, Microarray.

Unit: 4 **12 Lectures**

Translation: Genetic code, Prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co-and post-translational modifications of proteins, Epigenetics.

Suggested Reading:

1. Fasman, G.D. (1989). *Practical Handbook of Biochemistry and Molecular Biology*. CRC Press, Taylor and Francis Group, UK.
2. Gupta, P.K. (2005). *Cell and Molecular Biology*. Rastogi publications, Meerut, India.
3. James, D.W., Baker, T.A., Bell, S.P., Gann, A. (2009). *Molecular Biology of the Gene*. Benjamin Cummings, USA.
4. Jocelyn, E.K., Elliott, S.G., Stephen, T.K. (2009). *Lewin's Genes X*. Jones & Bartlett Publishers, USA.
5. Johnson, A., Lewis, J., Raff, M. (2007). *Molecular Biology of the Cell*. Garland Science, USA.
6. Lodish, H., Berk, A., Chris, A.K. and Krieger, M. (2008). *Molecular Cell Biology*. W.H. Freeman, USA.
7. Sambrook, J., Fritish, E.F., Maniatis, T. (2000). *Molecular cloning: A laboratory manual*. Cold Spring Harbor Laboratory Press, New York.

LSS.520: Evolutionary and Developmental Biology. Credit Hours: 3. Semester III.

Unit: 1 **14 Lectures**

Emergence of evolutionary thoughts & Origin of life: Lamarckism, Darwinism, Concepts of variation, adaptation, struggle, Mendelism, Spontaneity of mutations, Theories of phyletic gradualism vs. punctuated equilibria, Modern evolutionary synthesis. Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers, Concept of Oparin and Haldane, Experiment of Miller (1953), The first cell, Evolution of prokaryotes, Origin of eukaryotic cells, Evolution of unicellular eukaryotes, Anaerobic metabolism, Photosynthesis and aerobic metabolism.

Unit: 2 **14 Lectures**

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

Unit: 3 **14 Lectures**

Basic concepts of development: Totipotency, Commitment, Specification, Induction, Competence, Determination and Differentiation, Morphogenetic gradients, Cell fate and cell lineages, Stem cells, Genomic equivalence and the cytoplasmic determinants, Imprinting, Mutants and transgenics in analysis of development.

Unit: 4 **12 Lectures**

Gametogenesis, fertilization and cell death: Production of gametes, Cell surface molecules in sperm-egg recognition in animals; Embryo-sac development and double fertilization in plants, Zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals, Embryogenesis and establishment of symmetry in plants, Seed formation. Hypersensitive response, functions, relevance with diseases, apoptosis, Caspases, Importance of PCD in plant development, role of PCD, model of PCD.

Suggested Reading:

1. Darwin, C.R. (1911). *On the origin of species by means of natural Selection, or preservation of favoured races in the struggle for life*. Hurst Publishers, UK.
2. Dawkins, R. (1996). *The Blind Watchmaker*, W.W. Norton & Company Jones and Bartlett Publishers.
3. Futuyma, D.J. (2009). *Evolution*. Sinauer Associates Inc. USA.
4. Hake, S. and Wilt, F. (2003). *Principles of Developmental Biology*. W.W. Norton & Company, New York, USA.
5. Hall, B.K. and Hallgrimsson, B. (2007). *Strickberger's Evolution.* Jones and Bartlett Publishers, India.
6. Lewin, R. (2004). *Human Evolution - An Illustrated Introduction*. Wiley-Blackwell, USA.
7. Scott, F. and Gilbert, S.F. (2010). *Developmental Biology*. Sinauer Associates, Inc. USA.

8. Slack, J.M.W. (2005). *Essential Developmental Biology*, Wiley-Blackwell, USA.

LSS.521: Cell Biology. Credit Hours: 3. Semester III.

Unit 1 **14 Lectures**

Introduction to the cell: Evolution of the cell, From molecules to first cell, From prokaryotes to eukaryotes, Prokaryotic and eukaryotic genomes, 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. 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.

Unit 2 **14 Lectures**

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.

Unit 3 **14 Lectures**

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

Unit 4 **12 Lectures**

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

Suggested 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.

Elective Course

LSS.572: Environmental Microbiology. Credit Hours: 2, Semester –III

Unit: 1 **6 Lectures**

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

Unit: 2 **10 Lectures**

Eutrophication: Water pollution and its control: Need for water management. Sources of water pollution. Measurement of water pollution, Eutrophication: Definition, causes of eutrophication, and microbial changes in eutrophic bodies of water induced by various inorganic pollutants. Effects of eutrophication on the quality of water environment, factors influencing eutrophication. Qualitative characteristics and properties of eutrophic lakes. Measurement of degree of eutrophication. Algae in eutrophication, algal blooms, their effects and toxicity, coloured waters, red tides, and cultural eutrophication. Physico-chemical and biological measures to control eutrophication.

Unit: 3 **10 Lectures**

Effluent treatment techniques: Microbiology of wastewater and solid waste treatment: - Waste-types-solid and liquid waste characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Anaerobic processes: Anaerobic digestion, anaerobic filters, and up-flow anaerobic sludge. Treatment schemes for effluents of dairy, distillery, tannery, sugar and antibiotic industries (Types, microbes used, types of Effluent Treatment Plants). Bioconversion of Solid Waste and utilization as fertilizer. Bioaccumulation of heavy metal ions from industrial effluents.

Unit: 4 **10 Lectures**

Bioremediation of Xenobiotics: Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behaviour, biomagnification and degredative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants and pesticides. Genetically Modified Organisms released and its environmental impact assessment and ethical issues. Global environmental problems, Ozone depletion, UV-B, green house effect and acid rain, their impact and biotechnological approaches for management. . Containment of acid mine drainage applying biomining [with reference to copper extraction from low grade ores].

Suggested Reading:

1. Baker, K.H. And Herson D.S. (1994). *Bioremediation*. MacGraw Hill Inc. N.Y.
2. Eldowney, S. Hardman D.J. and Waite S. (1993). *Pollution: Ecology and Bio-treatment* Longman Scientific Technical.
3. Ralph Mitchell. A (1974*). Environmental Microbiology* edited by John Wiley and Sons. Inc.

4. R. K. Trivedy (1998) *Advances in Waste Water Treatment Technologies*. Volumes II and I by Global Science Publication.
5. Lawrence, P., Wacekett, C. and Douglas Hershberger. (2000) *Biocatalysis and Biodegradation: Microbial transformation of organic compounds* ASM Publications.
7. Christon J. Hurst (2001). *A Manual of Environmental Microbiology*. 2nd Edition. ASM Publications.

Practical Courses

LSS.519: Molecular Biology Practical - Credit Hours: 1. Semester III.

1. Isolation of genomic DNA from bacteria (E.coli) and human blood, Quantification of DNA using spectrophotometric method.
2. RNA isolation.
3. cDNA synthesis.
4. RT-PCR.
5. Isolation of plasmid DNA from bacteria.
6. Transformation of bacteria using CaCl2 heat shock method-Competent cell preparation.
7. Digestion of DNA using restriction endonucleases, Resolution and molecular weight estimation of fragmented DNA using agarose gel electrophoresis.
8. Construction of restriction map by single and double digestion, Designing DNA probe, Southern blot hybridization (demonstration only).
9. Amplification of known DNA sequences by Polymerase Chain Reaction.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.522: Cell Biology – Practical. Credit Hours: 1. Semester III.

1. Preparation of mitotic & meiotic chromosomes.
2. Study of structure of cell organelles through electron micrographs.
3. Instrumental methods for cell biology-centrifugation, chromatography.
4. Bacterial staining and identification.
5. Sectioning of tissues (Plant and animal).
6. Histochemical techniques (Fixing, Processing, Staining).

*More practicals may be added/modified from time to time depending on available faculties/facilities.

Elective Course Practical

LSS.573: Environmental Microbiology (P) Credit Hours: 1, Semester –III.

1. Physical analysis of sewage/industrial effluent by measuring total solids, total dissolved solids and total suspended solids.
2. Determination of indices of pollution by measuring BOD/COD of different effluents.
3. Bacterial reduction of nitrate from ground waters
4. Isolation and purification of degradative plasmid of microbes growing in polluted

environment.

5. Recovery of toxic metal ions of an industrial effluent by immobilized cells.
6. Utilization of microbial consortium for the treatment of solid waste [Muncipal Solid Waste].
8. Biotransformation of toxic chromium (+ 6) into non-toxic (+ 3) by Pseudomonas species.
9. Tests for the microbial degradation products of aromatic hydrocarbons /aromatic compounds
10. Reduction of distillery spent wash (or any other industrial effluent) BOD by bacterial cultures.
11. Microbial dye decolourization/adsorption.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.600: Dissertation Research – Credit Hours: 8. Semester III.

Semester - IV				
Paper Code	**Course Title**	**L**	**P**	**Cr**
LSS.523	Bioinformatics and Computational Biology	3	-	3
LSS.525	Radiation Biology	3	-	3
LSS.524	Bioinformatics and Computational Biology (P)		2	1
LSS.526	Radiation Biology (P)		2	1
LSS.600	Dissertation		32	16
	Total Semester - IV	**6**		**24**

L: Lectures P: Practical Cr: Credits

Examination Pattern

A: Continuous Assessment: Based on Objective Type Tests (25 Marks)

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

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

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

LSS.523: Bioinformatics and Computational Biology. Credit Hours: 3. Semester IV.

Unit: 1 **12 Lectures**

Biological Databases: Nucleotide Sequence Databases, GenBank, DDBJ, EMBL, Sequence Flatfile and submission process, Protein sequence databases, UniProt in detail, Mapping databases, Genomic databases,. Protein structure databases, PDB in detail, 3D visualization softwares, Pathway and molecular interaction databases, and Data mining.

Unit: 2 **12 Lectures**

Analysis for nucleotide and protein sequences: Gene Prediction methods and programs, RNA secondary structure thermodynamics, Vienna RNAfold, Evolution and origins of sequence polymorphisms, SNP discovery methods and databases, Genotyping, International haplotype map project, 1000 genomes project. Predicting features of individual residues, Predicting function, Neural Networks, Protein structure prediction, Prediction algorithms for pathways and Molecular Interactions, Integrating gene expression data with pathway information.

Unit: 3 **14 Lectures**

Homology search and Phylogenetic Analysis: Global Vs. local sequence alignments, Dotplots, Scoring matrices, Pairwise sequence alignment, BLAST, Position-Specific scoring and PSI-BLAST, MegaBLAST, BL2SEQ, BLAT, FASTA Vs BLAST, Basics of phylogenetics, Nucleotide substitution models and selection, Distance-matrix-based methods, Neighbor-Joining, Fitch-Margoliash, Outgroups, UPGMA, Minimum Evolution, Maximum Parsimony, Maximum Likelihood, Bayesian Inference, Searching for trees, Rooting trees, Bootstrapping, Likelihood ratio tests.

Unit: 4 **16 Lectures**

Genomics & Proteomics: Comparative Genomics, Genomic alignments, Gene predictions in genomic alignments, Genome-wide association study, Phylogenetic footprinting, Gene annotation, Gene expression analysis using DNA Microarray, Annotation of array probes, Image processing, Normalizing expression measurements.Major proteomic approaches, Protein analysis by MALDI and SELDI methods, Time of Flight MS in protein analysis, Protein Identification by Mascot, Peptide Mass Fingerprinting, Comparative proteomics, Two-Dimensional Polyacrylamide Gel Electrophoresis.

Suggested Reading:

1. Baxevanis, A.D. and Ouellette, B.F.F. (2004). *Bioinformatics: A Practical guide to the Analysis of Genes and Proteins*. Wiley-Interscience, USA.
2. Hall, B.G. (2011). *Phylogenetic Trees Made Easy: A How-To Manual*. Sinauer Associates, Inc. USA.
3. Lesk, A.M. (2008). *Introduction to Bioinformatics*. Oxford University Press, UK.
4. Mount, D.W. (2005). *Bioinformatics: Sequence and Genome Analysis*. CBS Publishers, New Delhi, India.

5. Ramsden, J. (2010). *Bioinformatics: An Introduction* (*Computational Biology*). Springer, India.
6. Ye, S.Q. (2008). *Bioinformatics: A Practical approach*. Chapman & Hall/CRC, UK.
7. Zvelebil, M. and Baum, J. (2007). *Understanding Bioinformatics*, Garland Science, New York, USA.

LSS.525: Radiation Biology – Credit Hours: 3. Semester IV.

Unit: 1 **12 Lectures**

Interaction of radiation with matter: Different types of radiation, Ionization and excitation, Linear energy transfer, Direct and indirect effects of radiation Radiation chemistry of water. **Biological effects of radiations**: Whole body irradiation and sensitivity of tissue, Units of radiation measurement, and Radiation levels and limits.

Unit: 2 **12 Lectures**

Cell Survival: Reproductive integrity mechanism of cell killing, Survival curves in mammalian cells. **Radio-sensitivity and cell cycle:** Variation of sensitivity with cell age, Effect of X-rays and high let radiations, and possible implications in radiotherapy.

Unit: 3 **14 Lectures**

Heritable effects of radiations: Chromosomal and chromatid aberrations, Point mutations, oligomeric and multi-factorial human diseases, Genetic risk assessment, Doubling dose and mutation component. **Modification of radiation induced damage** Radio-sensitizers, Protectors, Normal tissue radioprotection, Mechanisms of action, Sulfhydryl compounds, WR series, Dose reduction factor (DRF). **Non targeted effects of radiations:** Bystanders effects, Chromosomal instability and Adaptive response.

Unit: 4 **16 Lectures**

Mechanisms for the repair of DNA. Repair of DNA breaks, Repair of base damage, photo-reactivation, Excision repair, Post-replication recovery, Base excision repair, nucleotide excision repair (NER), Transcription coupled repair (TCR) and bulk DNA repair. **Influence in signaling pathways:** Radiation - induced gene expression, Signaling abnormalities in cancer, Effects of signaling abnormalities on radiation responses. **Radiation and Cancer:** Initiation, promotion, Progression, Dose response for radiation - induced cancers, Importance of age at exposure and time since exposure, Second tumors in radiation therapy patients.

Suggested Reading:

1. Curran B.H. and Starkschall, G. (2012). *Informatics in Radiation Oncology*. CRC Press, USA.
2. Hall, E.J. and Giaccia, A. (2011). *Radiobiology for the Radiologist*. Lippincott Williams & Wilkins, USA.
3. Forshier, S. (2008). *Essentials of Radiation, Biology and Protection*. Cengage Learning, USA.
4. Nias, A. H. W. (1998). *An Introduction to Radiobiology*. John Wiley & Sons, USA.
5. Prasad, K. N. (2008). *CRC Handbook of Radiobiology*. CRC Press, Florida, USA.

Practical Courses

LSS.524: Bioinformatics and Computational Biology - Practical. Credit Hours: 1. Semester IV.

1. Introduction to NCBI Taxonomic Browser, NCBI BLAST & TreeBASE.
2. Primer design using PRIMER-3 and PrimerBLAST.
3. Data analysis of DNA Microarray experiments.
4. Multiple Sequence Alignment by MEGA, ClustalX.
5. Determination of genes mapped within a specific chromosomal locus using GeneLoc integration resource.
6. Gene orthologue prediction using Ensembl.
7. Determination of sequence similarity using BL2SEQ and structural similarity using PDB of convergently evolved proteins.
8. Phylogenetic analysis of molecular data using MEGA and PHYLIP (NJ, ML, UPGMA, MP and BI methods).
9. Secondary structure construction of rRNA using Vienna RNAfold.
10. Base calling of electropherograms and contig assembly using Manual/Phred/Phrap.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.526: Radiation Biology - Practical. Credit Hour: 1. Semester IV.

1. To determine the effect of UV rays on *E. coli*. and elucidate cell survival curve.
2. To demonstrate the effect of UV rays on cell division.
3. To determine the value of LD50 of UV radiation using MTT assay.
4. To detect the levels of Reactive oxygen species generated during irradiation.
5. To demonstrate the effect of UV radiation on Antioxidant enzymes, Proteins and DNA.
   a. Spectrophotometric methods
   b. Western blotting
   c. DNA ladder assay and Comet assay
6. To demonstrate the effect of radiation on cell membrane by spectrophotometric method (Lipid peroxidation).
7. To employ Trypan blue exclusion/light microscopy to evaluate healthy live (clear, bright), early apoptotic (irregular shape, shrunken nucleus), and end-stage apoptotic/oncotic (blue-stained) cells.

*More practicals may be added/modified from time to time depending on available faculties/facilities.

LSS.600: Dissertation Research – Credit Hours: 16, Semester IV.